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(ISL 2015)

Reflections on Supply Chain Research and Practice

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INTRODUCTION

We are delighted to welcome our friends and colleagues, both old and new, to the 20th International Symposium on Logistics in the historic university setting of Bologna, Italy. Bologna was chosen as both an attractive venue, as it is home to the world's oldest university, as well as being a city with ongoing strong links to industry (especially in the automotive and metal fabrication sectors). To mark the occasion of our 20th symposium, we have chosen the theme of "Reflections on Supply Chain Research and Practice". We hope this gives participants the opportunity to reflect upon how logistics and supply chain management has changed since the symposium was held for the first time in Nottingham, UK in 1993. During this time, a great many changes have occurred in this discipline (ranging from technologies, processes and methods), affecting both industry and academia alike.

For us as event organisers, it is especially gratifying to see that this year's symposium will once again be a truly international event having attracted submissions from across the globe. This, together with the healthy balance of participants who have contributed regularly to the symposium over the years, combined with many first time participants who inject new ideas and points of view into the community, promises to make the event an enjoyable and valuable experience.

A particular strength of the ISL community is the enthusiasm of the participants. As the number of parallel sessions during the programme is kept low, many participants value the personal touch and community feeling that this engenders. Having the opportunity to receive personal feedback during the formal sessions, coupled with discussions and debates at the many informal events that the symposium offers, invariably results in a memorable experience.

As before, all abstracts and/or full papers were reviewed by two academic experts from the field of Logistics and Supply Chain Management. This book of proceedings containing the accepted papers, has been organised according the following categories:

- Risk, Disruption and Complexity Management
- Supply Chains and Networks
- Collaboration and Relationships in Supply Chains
- Environmental Sustainability and Green Logistics
- Transport and Distribution
- Maritime and Port Logistics
- Knowledge Management and E-Business in Supply Chains
- Decision Support Techniques, Technologies and Processes
- Service Supply Chains
- Food and Agriculture Logistics
- Supply Chain Performance Management
- Education and Training

To date ISL has been held in Europe, Africa, Australasia and Asia (please see full list below). Following last year's successful event in the emerging economy of Vietnam we are very much looking forward to meeting you all at this year's symposium in Bologna, Italy.

Last but not least we would like to take this opportunity to express our sincere thanks to all the presenters, delegates, reviewers, Advisory Committee members, invited guest speakers and local organising team for their interesting and worthwhile contributions. Finally, our special thanks go to Mrs Lesley Gray for her excellent administrative support and Mengfeng Gong for her support and help in preparing the proceedings.

Professor Kulwant S Pawar, Professor Helen Rogers and Professor Emilio Ferrari – July 2015

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Section 1: Risk, disruption and complexity management

RESPONDING TO THE DISRUPTIONS EFFECTIVELY – RESEARCH RESULTS ON THE SUPPLY CHAIN FLEXIBILITY

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ABSTRACT
The purpose of this paper is to discuss how to build the flexibility in supply chain. It presents the results of the survey conducted in 2013 among the companies operating in the B2B market. They can assist managers during decision making process on how to build the competitive supply chains in a turbulent environment of XXI century.

INTRODUCTION

Today, companies have to deal with an increasing number of internal and external uncertainties for supply chains [Simangunsong, Hendry and Stevenson, 2012]. The entrepreneurs were witnesses of many different situations that seriously disturbed supply chain processes, e.g. destruction of components in a small fire and lack of supplies [Chopra and Man Mohan 2004], powerful earthquake and destabilization of the automotive sector [Brennan 2011], heavy rains and a drastic increase in the price of hard drives [Hardy 2012], global financial crisis and domino effect of bankruptcies [Blome and Schoenherr, 2011], terroristic attacks [Sheffi 2001], cyber-attacks and losing customer trust [Bristow 2014]. Many different adverse events lead to a serious destabilization of both supply and demand areas in value chains. At the same time, increasing competition and customer driven markets mean the need of ensuring high product quality as well as the continuous and fast supplies. Simultaneously, companies have to deal with the emerging risk, which source are suppliers (e.g. late, incomplete deliveries, problems with components' quality) and clients (e.g. changing expectations and unpredictable demand especially for the products of the short life cycle). The enterprises can perform risk identification and prepare plans of risk reduction but unfortunately they cannot predict all potential problems. It means that they cannot prevent them all. The more that the risk is never zero. In fact, they cannot influence some of the uncertainties, especially these coming from macro-environment. This all brings the necessity of building the supply chain ability of adapting to the sudden changes while maintaining the proper customer service level, and the ability of returning to the pre-crisis balance effectively. The literature points that responding to the disruptions that are occurring in the internal or external environment requires *flexibility*. At the turn of the 19th and the 20th centuries the flexibility was primarily analyzed in terms of manufacturing flexibility. It was established that manufacturing flexibility consists of several different dimensions [Sethi and Sethi 1990, Gerwin 1993, Gupta and Somers 1996, Koste and Malhotra 1999, D'Souza and Williams 2000, Vokurka and O'Leary-Kelly 2000]. Some authors present more holistic analysis, because they refer to the strategic flexibility [Lau 1994, 1996] and the organizational flexibility [Sanchez 1995]. Finally, the latest papers describe the widest approach. They examine the flexibility in terms of supply chain management. In a dynamic environment of XXI century it turns out that building flexibility by a single link is insufficient. In turn, suppliers and clients can contribute to the manufacturing flexibility [Kayis and Kara 2005]. That is why, companies should involve their value chain partners in building it. Many papers point that supply chain flexibility is multi-dimensional [Vickery, Calantone and Dröge 1999; Duclos, Vokurka and Lummus 2003, 2005; Soon and Udin 2011]. On the other hand, there are not many research results [Candace, Ngai and Moon 2011; Fayezi, Zutshi and O'Loughlin 2014; Sokri 2014] on how enterprises prepare to the disruptions in the area of supply and demand. This paper fills this gap presenting the unique research on activities that are run by the enterprises to ensure supply chain flexibility. Additionally, it takes an attempt to relate supply chain flexibility to other concepts.

SUPPLY CHAIN FLEXIBILITY AND ASSOCIATED CONCEPTS

Supply chain flexibility is "the ability of an organisation to manage the internal (e.g. manufacturing) and interfacing (e.g. procurement and distribution) processes, as well as its key suppliers/customers to respond to expected changes in supply, product and demand in an efficient manner enabled by both technological and social platforms" [Fayezi, Zutshi

and O'Loughlin 2014]. Flexibility is "a key characteristic of an agile organization" (Christopher 2000), the basic concept of agility (Fan et al. 2007) and one of four agile supply chain capabilities: responsiveness, competency, flexibility, quickness [Lin, Chiu and Chu 2006]. "Agility is a business-wide capability that embraces organizational structures, information systems, logistics processes and in particular, mindsets" (Christopher and Towill 2001). Agile supply chain is market sensitive, virtual and bases on process integration and network (Christopher 2000). Supply chain flexibility is multi-dimensional. According to the literature analysis conducted by Stevenson and Spring (2007), the definition of supply chain flexibility should take into account robust network flexibility, re-configuration flexibility, active flexibility, potential flexibility and network alignment. The supply chain flexibility can also consists of four categories: supply network, supplier-purchaser relationships, supply chain design and inter-organisational information systems [Stevenson and Spring 2007]. According to the other authors [Duclos, Vokurka and Lummus 2003; Coronado, Andrew and Lyons 2007], supply chain flexibility contains six following components: operations system flexibility (connected with manufacturing and service, it allows to change resources in operational processes to react to the customer needs, as well as to switch production between plants and change production volume), market flexibility (quick new product development or improving existing one according to the technological changes), logistics flexibility (an ability to receive and deliver products in terms of changes in supply and demand cost effectively), supply flexibility (deals with volume, mix, delivery uncertainties [Tachizawa and Thomsen 2007] as well as with adjusting supplier base to the customer needs), organizational flexibility (involves human resources management that allows to change labor and workplaces in terms of different customer needs), information systems flexibility (refers to the supplier-purchaser systems integration, sharing customer demand data and adjusting IT systems to the changes in information needs to respond to demand changes). In turn, Fantazy et al. (2009) established that the literature refers to the twelve flexibility dimensions.
Flexibility influences the company's performance positively [Sánchez and Pérez 2005]. It is one of the four performance dimensions of operations and supply chains. The others are: time, costs and quality [Bozarth and Handfield 2008, pp. 29-31]. Sourcing flexibility, manufacturing flexibility and delivery flexibility together with a speed can also be regarded as supply chain agility that is necessary to deal with internal and external vulnerability (which are: demand and forecasting uncertainty and supply chain complexity) [Prater, Biehl and Smith 2001]. The flexibility can also be compared to the adaptability [Gattorna et al, p.126]. In turn, adaptability, agility and alignment create the best value supply chains [Lee 2004]. In certain circumstances, the adaptability approach can be used where the flexibility approach cannot be, for example, information sharing reduces the uncertainty impact but not always the business partners would like to share information with the company [Chan eta al 2009]. Some authors refer to the size of the flexibility. Narain et al (2000) indicates three types of flexibility: necessary, sufficient and competitive. Fayezi et al (2014) distinguish two types of flexibility: actual and required. The required one is defined as "the optimal amount and type of change necessary to respond to supply chain uncertainties". The uncertainty presents both risk and opportunity [COSO 2004, p.1], accordingly: the threat or the chance that some event will occur and bring certain (negative or positive) effects. Some authors point an important difference between risk and uncertainty. The risk can be calculated whereas uncertainty means that all potential scenarios cannot be predicted [Svensson 2002]. In turn, the AS/NZS ISO 31000:2009 standard points that risk is an "effect of uncertainty on objectives".
In recent 20 years, the concept of supply chain risk management has been developing very dynamically, due to the observed global disruptions. Many authors researched and described supply chain risk definition, risk factors and ways of dealing with them [G. Wieteska 2014]. The main aim of the risk management is the identification of all potential risks and choosing the best strategies to deal with their too high levels, e.g. avoiding, reducing (likelihood and/or effects), transferring (outsourcing, insurances) [AIRMIC/ALARM/IRM: 2002, 2003; COSO 2004]. The main sources of supply chain risk are following [Braithwaite 2003, pp. 6-7]:

- internal risk factors – processes (disruptions of assets and infrastructure), controls (problems with procedures, systems, applied rules that help control the processes); mitigation, i.e., focusing on the prevention and absence of plan in case an adverse event occurs.
- external risk factors – demand (all disruptions related to the flow of products, information and money between the customers and company), supply (disruptions of the flow processes in relations with suppliers), environmental (external factors, difficult to control, which may affect the company either directly or indirectly through the suppliers and purchasers)

What is interesting, these risk factors overlap with the four supply chain uncertainty areas which require developing the flexibility [Fayezi, Zutshi and O'Loughlin 2014]: supply (e.g. supplier non-compliance with orders), process (e.g. breakdowns), control (poor information systems) and demand (e.g. fluctuations, lack of marketplace transparency).

Flexibility can minimize the supply chain risk whereas contingency planning increases flexibility [Skipper and Hanna 2009]. Supply chain risk management is directed into the prevention especially while the business continuity approach – into reacting to the disruptions that have already occurred [BS 25999-2:2007]. Its goal is to maintain the proper level of the customer service when some supply chain resources are suddenly lost. Contingency planning introduces the term of supply chain vulnerability [Svensson 2002, 2004]. Vulnerability is "a condition that affects a firm's goal accomplishment depend upon occurrence of negative consequences of disturbance". This definition is similar to the risk definition. Risk is "a likelihood that the event occurs and influence objectives achievement" [COSO 2004]. Vulnerability is regarded as complementary to resilience and to be an opposite to robustness [Scholz, Blumer and Brand 2012]. Other studies say that resilience is "the ability of a supply chain to cope with change" and it has both proactive and reactive character. The former refers to the robustness and the latter to the agility [Wieland and Wallenburg 2013]. The resilient supply chain is able to "respond to and restore operations after an unexpected, major disruption occurs" through preparing particular business continuity plans [Rice and Caniato 2003], e.g. for the area of supply (avoid single sourcing; increase inventory buffers), area of manufacturing (use multiple plants), area of human resource (have cross-trained employees), area of communication (back up data).

Summing up, supply chain flexibility is closely related to other concepts, like risk management, business continuity, supply chain agility, vulnerability and resiliency. All these concepts are aimed at building responsiveness and adaptable supply chains.

METHODOLOGY

The post survey was conducted at the end of 2013. The paper-and-pencil option was chosen. This option in comparison with e-mail survey is more effective in Poland, where obtaining high response rates is very difficult. On the base on the previous experience it can be stated that companies are rather reluctant to take part in the researches in general. The study covered the companies operating in the B2B market in Poland. It was assumed that respondents should know the importance of building relationships with suppliers and clients. That is why, the main selection criterion was ISO 9001 certification. The source of the companies' data was an Internet Polish database HBI (http://www.hbi.pl). Out of the total of 3857 sent questionnaires and 182 properly fulfilled, unique and usable responses were included in the analysis. Although the structure of the questionnaire was simple, the return rate was relatively low. Unfortunately, this size of rate can be a limitation influencing the credibility of research results. One of the objectives of the study was to identify the activities that are performed by the companies to respond to the disruptions in the area of supply and demand effectively (Table 1). One of the hypotheses is that companies the most often use traditional buffers to ensure supply chain flexibility. The respondents had a possibility to mark a free number of standardized items placed under the question. The percentage of each answer was calculated. The simplicity of the questionnaire stemmed from the fact that supply chain flexibility is not a well-known and formalized approach in Polish companies. Moreover, the subject of the research was studied for the first time by the author. It was also certain that a too complex questionnaire can influence the response rate negatively. The answers were analyzed in terms of size of the company, spatial range, specific market on which products are offered and origin of capital of the company. The surveyed companies operate in different sectors. However, the results in terms of this criterion are not presented hear.

FINDINGS

The traditional way of dealing with uncertainties in supply chain is buffering [Giunipero and Eltantawy, 2004; Zsidisin et al., 2000]. According to the survey results, the most often, companies build the supply chain flexibility using multisourcing (92,82%) and higher safety stocks (77,90%). This ensures continuity of flow processes in the situation of lack of supplies or sudden demand changes. Interestingly, keeping spare production capacity/distribution in the supply chain is one of the least run activities (50,83%).

At the third place, there are regular supply market analysis (77,35%). Their conducting supports supply base optimization and the possibility of cooperating with many suppliers. Additionally, companies differentiate location of suppliers using both local and foreign suppliers (66,85%). Local suppliers can increase the flexibility in the face of a sudden foreign supply disruption [Prater, Biehl and Smith 2001]. Just behind there is sharing information with partners e.g. on demand and production plans (70,72%). Simultaneously, more than half companies focus on improving the accuracy of demand forecasts and joint planning in the supply chain. The companies should not only be buffer-oriented but also increase sharing information [Duclos, Vokurka and Lummus 2003]. Supply chain integration increases flexibility and dealing with supply chain uncertainties [Sezen 2008]. In order to improve information flow, respondents declare that they implement different strategies and solutions e.g. EDI, ERP, ECR, CPFR (56,35%). On the other hand they improve the flow of goods through the implementation of other solutions/strategies, e.g. cross-docking, RFID, VMI (49,17%). However, this activity has the last place among all presented in the survey questionnaire. According to around 60% of surveyed enterprises the flexibility is built by increasing product variety. Product variety requires flexibility and influences the competitive advantage when manufacturing and marketing are properly aligned [Wagner 2012]. 55,80% of companies stated, that they look for material substitutes. This activity is a proper, especially when supply risk is high [Kraljic 1983]. Simultaneously, nearly 57% of surveyed entities declare a close cooperation in the field of product quality and budget with suppliers. Involving suppliers in the product development determines market flexibility [Wieteska 2014]. Around 60% respondents marked in the questionnaire preparing business continuity plans and half of the companies declared conducting risk analysis and risk reduction plans. Risk management and contingency planning seem to be important activities related to the supply chain flexibility [Skipper and Hanna 2009]. Finally, switching production between plants determines operations system flexibility [Duclos, Vokurka and Lummus 2003; Coronado, Andrew and Lyons 2007]. It allows to move the orders from the areas covered by the crisis to the stable one [Rice and Caniato 2003]. Having more than one manufacturing plant declared 52,49% respondents.

SUMMARY

Summing up it can be stated, that gathered data confirm the hypothesis. However, except traditional buffering, enterprises run many other activities to deal with the supply chain disruptions effectively. All variables defined in the questionnaires were pointed by over a half of the companies who took part in the research. Comparing the particular segments it can be noticed that in most cases the big companies, entities with foreign capital, offering products on the foreign market and of international spatial range build supply chain flexibility more often than small/medium enterprises with Polish capital and national spatial range. This confirms that international environment is more dynamic and demanding, what brings the urgent need of increasing supply chain flexibility. There are some limitations of the empirical study. One is the small return rate. Although the research results come from a pilot, the article can support business practice during taking decisions on flexibility. According to the literature analysis, implementing supply chain risk management or business continuity management can be the first step of building supply chain flexibility. Further researches should concentrate on the identification of the activities ensuring particular types of flexibilities pointed in the literature and the role of other concepts in building supply chain flexibility.

Activities, that companies run to ensure the flexibility in responding to the disruptions in area of supply and demand.	Total	Number of employees			Spatial range		Products offered on specific market		Origin of capital	
		Under 50	51-500	Over 500	national	international	domestic	domestic and foreign	national	foreign
N the size of the segment	**182**	**42**	**93**	**47**	**142**	**40**	**37**	**145**	**87**	**95**
Multisourcing	92,82	90,48	94,62	89,36	90,80	89,86	86,49	93,79	92,96	90,00
Increased safety stocks materials/components/ final products	77,90	66,67	87,10	68,09	73,56	73,91	67,57	80,00	78,17	75,00
Regular supply market analysis	77,35	64,29	79,57	82,98	71,26	73,91	56,76	82,07	74,65	85,00
Sharing with partners information on e.g. sales, production plans	70,72	69,05	69,89	72,34	59,77	60,87	43,24	77,24	68,31	77,50
Differentiation location of suppliers (e.g. cooperating with local and foreign suppliers)	66,85	61,90	67,74	68,09	58,62	60,87	48,65	71,03	63,38	77,50
Increasing product variety	61,33	57,14	61,29	63,83	54,02	56,52	35,14	67,59	59,86	65,00
Preparing business continuity plans	60,22	54,76	59,14	65,96	55,17	56,52	48,65	62,76	59,15	62,50
Focusing on improving the accuracy of demand forecasts and joint planning in the supply chain	59,12	59,52	58,06	59,57	54,02	53,62	48,65	61,38	59,15	57,50
Close cooperation in the field of product quality and budget with suppliers	56,91	54,76	54,84	61,70	51,72	52,17	43,24	60,00	57,04	55,00
Improving flow of information through the implementation of solutions/strategies, e.g. EDI, ERP, ECR, CPFR	56,35	50,00	53,76	65,96	51,72	55,07	37,84	60,69	56,34	55,00
Looking for material substitutes	55,80	57,14	53,76	57,45	51,72	52,17	37,84	60,00	54,93	57,50
Conducting risk analysis and risk reduction plans	54,14	47,62	53,76	59,57	47,13	47,83	37,84	57,93	51,41	62,50
Having more than one manufacturing plant	52,49	50,00	50,54	57,45	48,28	47,83	37,84	55,86	50,00	60,00
Keeping spare production capacity / distribution in the supply chain	50,83	45,24	51,61	53,19	44,83	44,93	35,14	54,48	49,30	55,00
Improving flow of goods through the implementation of solutions/strategies, e.g. cross-docking, RFID, VMI	49,17	47,62	47,31	53,19	43,68	44,93	32,43	53,10	48,59	50,00

Table 1. Activities, that companies run to ensure the flexibility in responding to the disruptions in the area of supply and demand. The results from the study conducted at the end of 2013 in Poland. The comparison of segments for the following criteria: number of employees, spatial range of the company, products offered on specific market and origin of capital in percentages are presented.
Source: Own study (2013).

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ENHANCEMENT OF SHORT-NOTICE EMERGENCY EVACUATION RESPONSE DURING BUSHFIRE: A MULTI-OBJECTIVE EPSILON–CONSTRAINT OPTIMISATION APPROACH

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ABSTRACT
A bushfire is an important public health and safety issue in Australia. Late evacuation in bushfire is a crucial stage of emergency response, which requires a quick emergency response to potentially a life threatening condition. Inadequate time to evacuate residents has resulted 119 deaths in the Black Saturday 2009 bushfire in Victoria, which is 68 per cent of total fatalities. Hard constraint of limited evacuation time window (clearance time), uncertainty associated with the direction and intensity of bushfire, road disruption, and elderly and disabled evacuees pose challenges to timely evacuation of people. A decision support system, which is capable of computing timely allocation of resources, is thus required to enhance the capacity of fire services agencies. This paper develops a multi-objective optimisation model for assigning shelters and vehicles and evaluating routing options to transfer late evacuees from assembly points in bushfire affected areas to shelters. Three bushfire scenarios are generated to incorporate constraints of restricted time-window, potential road disruptions, the capacity and availability of rescue vehicles and shelters. The multi-objective problem is solved by ε-constraint technique. The objective functions are simultaneously optimised to maximise the total number of late evacuees by minimum assignment of rescue vehicles and shelters. This model develops a decision support system for fire agencies to minimise resource utilisation and maximise coverage of bushfire affected areas.

Keywords: Bushfire, Late Evacuation, Multi-Objective Optimisation, Emergency Management

INTRODUCTION
Bushfire is known as one of the most prevalent disasters in Australia. Bushfires are an inherent characteristic of Australia's environment. A bushfire is defined as *'a freely burning, uncontrolled and unplanned fire, which needs to be extinguished'*. It includes fires in woods, forest, scrub, grass or plantation. Bushfires are widespread and occur frequently throughout Australia and can damage and destroy houses, farms, crops, livestocks and infrastructures such as roads and rail. Bushfire's spread and direction are influenced by various environmental factors such as combustible materials, wind speed and ground slope. Bushfire propogation rate increases twice with every 10 degree increase in slope; doubles its intensity with a small change in wind speed and reaches a temperature of 800 degree celcius (Victorian Bushfires Royal Commission Report, 2009). In recent years, there has been a substantial increase in the number of bushfire around the world. Global warming and climate change have potentially increased the risk of bushfire, particularly in peak seasons in many countries including Australia, USA, Canada and Russia (Teague et al., 2009).

In the situation of a bushfire, the decision to stay or leave early is critical for community safety. Communities at risk may decide to leave early, or take shelter-in-home or shelter-in-refuge (Cova et al., 2011). Obviously, early evacuation is the safest option to protect life. However, some people stay and protect their properties. There are also those who are not able to evacuate such as people with special needs (disabilities), elderly, and parents with children. People with no personal vehicle were also need to be evaluated. Some leave at the late minute (Victorian Bushfires Royal Commission Report, 2009). Late evacuation often increases the risk of injury or death. The late evacuation also exposes the evacuees to radiant heat, which has been found a key factor in human fatalities (Teague et al., 2009). In the event of severe bushfire prediction, the emergency management agencies notify mandatory evacuation of late evacuees. The process is to transfer people from assemble points to safe shelters within the close vicinity. They key problem is *when, where and how to safely transfer the late evacuees from assembly points* within a short time window, road disruptions and capacity constraints of shelters and rescue vehicles.

Designing an effective evacuation plan to transfer people from bushfire-prone areas to shelters within the time windows using available facilities and resources has remained a key challenge for fire agencies. The emergency response becomes more difficult as a bushfire spreads and disrupts the emergency supplies and makes transportation networks less usable or even inaccessible. Road disruption increases the complexity of the evacuation planning process and delays the emergency evacuation response. Under such situation, the development of an evacuation system requires a modelling technique that is capable of simultaneously considering multiple objectives constraints and scenarios. This paper therefore develops a multi-objective mixed integer-programming model on the basis of optimization concepts to find solutions for a large scale evacuation problem of late evacuees during a bushfire. The ε-constraint method is implemented to solve the proposed multi-objective model.

The remainder of the paper is organized as follows. The Literature review section provides a summary review of relevant studies in the area of bushfire evacuation planning. Then, the problem statement is described followed by problem assumptions. The developed mathematical formulation is presented in the next section. Next section presents the solution approach. In the next section, the effectiveness of the proposed model will be assessed and discussed by the implementing a range of bushfire scenarios. Finally, the last section offers a summary and conclusion of this work.

LITERATURE REVIEW

"Relocation from areas at risk to areas of greater safety " is referred to evacuation(Southworth, 1991). The evacuation planning can be classified into two broad categories: socio-behavioural studies, which include evaluating the behavioural parameters (Lindell et al., 2005, Sorensen et al., 2004); and transportation studies comprising application of optimization methods to displace evacuees (Stepanov and Smith, 2009, Wolshon and Marchive III, 2007). There are few studies that incorporated both the behavioural and transportation factors in modelling emergency evacuation (Avella and Boccia, 2009, Yi and Özdamar, 2007).

Optimal allocation of shelters is also a critical element in emergency planning. To develop an effective plan, decision makers consider two important parameters – shelter's capacity and the distance to the shelters. However, there are other objectives that should be optimized simultaneously while satisfying several constraints. Cohon (2004), for example, has determined various substantial objectives such as behavioural decisions, policies and time factor that must be considered as critical criteria in analysis by the decision makers. While the evacuation modelling has substantially advanced, the emergency evacuation of late evacuees as a multi objective problem has relatively received much less attention.

Formally bushfire evacuation is classified into three orders as mandatory, recommended, and voluntary. Australian "Stay or Go" policy however places the responsibility and decision of staying and protecting the property or leave early. In similar way in the United States, "Ready, Set, Go!" (RSG) policy is in use, which educates people how to get ready to evacuate and when to evacuate or shelter in place in case of fire. This subject has attracted researchers to investigate the impacts of each of these policies. As an related research, Arnol (2007) has studied how the United States, Portugal, Spain, Italy, Greece and France manage bushfire. Among all the countries, France and Australia were comparable, because people are suggested to remain and protect their houses and possessions during a bushfire. The mandatory evacuation policy was applied in the rest of countries. Despite the evacuation order plays an important role in saving evacuees during emergency evacuation, there are other factors such as behavioural decisions that may impress the entire process. The people's decision during bushfires can be grouped in three categories: 'early evacuation': escape from affected area to safer places prior to facing the hazard; 'refuge in shelter': escape or stay in secure pre-established shelters along with the prone area; and 'shelter in home/place' (late evacuees): stay at home and defend the property against fire (Cova et al., 2011). Although shelter in refuge and early evacuation offer a higher level of protection, but these options are not always feasible especially when the time for evacuation is limited. Also, the current revised Australian 'Stay or Go' policy and the previous one as 'prepare', stay and defend, or leave early', has investigated by Paveglio et al. (2008). They have pointed out that leave early might be considered as an option to evacuate, however not in all interface fire situations.

The conclusion has drawn from reviewed literature signifies that only few studies have employed multi objective optimization models for evacuation problems(Shahparvari et al., 2015, Stepanov and Smith, 2009) Also the majority of literature has focused on minimizing the total evacuation time without considering other objectives. Therefore, this study aims to employ an optimization approach to deal with the multi-objective evacuation problem to fill the aforementioned gap in generating an appropriate evacuation plan applicable in bushfires.

MATHEMATICAL FORMULATION

The evacuation problem contains various objective functions, uncertainties and constraints, which makes the multi-objective programming much more appropriate method in dealing with late evacuation problems. Hence, in this paper a multi-objective (MP) method is utilised to model our problem in this study.

Modelling Assumptions

- The shelters are pre-designated by CFA (Country Fire Authority).
- Number and capacity of shelters and rescue vehicles are finite.
- The late evacuee population in each assembly point are known.
- Evacuee can be transferred to more than one shelter.
- Access to routes is restricted by bushfire.
- The transfer time between assembly points and shelters is known.

Objective Functions

- To maximise number of people transferred to a designated shelter
- To minimise the number of available resources (Number of assigned shelters and vehicles)

Notations

Sets and Indices

i index for assembly point (Origin townships);
j index for candidate shelter areas (Destinations);
k index for vehicle types;
I set of assembly points;
J set of candidate places of shelters;

Parameters

Cap_j Capacity of shelter j;
D_i Number of late evacuees in assembly point i to be evacuated;
α_j Binary variable; 1 if shelter j is accessible, 0 otherwise;

β_{ij} Binary variable; 1 if road is not disrupted between node *i* and shelter j, 0 otherwise.
t_{ij} Estimated evacuation transportation time between the assembly points *i* and shelter j;
p Total number of available shelters;
TV_k Total number of available vehicle type *k*;
VC_k Capacity of vehicle type *k*;
TW_i Time window for evacuation people from assembly point *i*;
Q_k Usage cost of vehicle type *k*;
W Weighted sum coefficient
TP Traffic congestion time factor
DW Time to Prepare, board and alight

Decision Variables
X_{ij} Number of transferred people from assembly point *i* to shelter *j*.
NV_{ij}^k Number of vehicle type *k* that is required to transfer evacuee from point *i* to shelter *j*
Y_j (Auxiliary variable) If it is the designated shelter *j* is available, 1 and 0 otherwise.
S_j (Auxiliary variable) If a shelter *j* is assigned to serve the evacuees, 1 and 0 otherwise.

Mathematical Model
The model is a multi-objective model, which comprises two objective functions and a range of constraints.

$$Max\ f_1 = \sum_i \sum_j X_{ij} \quad (1)$$

$$Min\ f_2 = W_1 \sum_j S_j + W_2 \sum_i \sum_j \sum_k Q_k NV_{ij}^k \quad (2)$$

The first objective function shown in (1), maximises the number of evacuee assembled in assembly point *i* which must be transferred toward shelter *j* in the minimum time and across shortest route. The second objective function (2) minimises the total number of designated shelters and rescue vehicles. This goal is set to decrease the expenditures of allocating new facilities and to distribute the evacuee by the utilisation of minimum available shelters and rescue vehicles. $w_1$and w_2 as auxiliary coefficients, are utilised in weighted sum method and are selected in the range of [0-1] to represent the weight of impression for each parameter (i.e. shelter and vehicle).

Constraints
The objective functions are subject to the following constraints:

$$\sum_j S_j \leq p \quad (3)$$

$$Y_j \leq \alpha_j S_j \quad \forall j \quad (4)$$

$$\sum_i X_{ij} \leq Cap_j Y_j \quad \forall j \quad (5)$$

$$X_{ij} \leq \beta_{ij} D_i \quad \forall i,j \quad (6)$$

$$X_{ij}\big((2 \times t_{ij} \times (1 + TP)) + DT\big) \leq TW_i \sum_k VC_k NV_{ij}^k \quad \forall i,j \quad (7)$$

$$\sum_i \sum_j NV_{ij}^k \leq TV_k \quad \forall k \quad (8)$$

$$\sum_j X_{ij} \leq D_i \quad \forall i \quad (9)$$

$$X_{ij}, NV_{ij}^k \geq 0 \quad \forall i,j,k \quad (10)$$

$$S_j, Y_j = 0\ or\ 1 \quad \forall j \quad (11)$$

First constraint ensures that the number of allocated shelters is less than the maximum number of available shelters. Next Constraint (4), determines if it is possible to designate a shelter (Y_j) among all possible candidate places S_j and the shelter remains available or not. Constraint (5) ensures that the people at affected point *i* will be evacuated and transferred to the shelter *j,* only if the shelter *j* is accessible and available. This constraint also measures the allocated and transferred people to the designated shelter *j* not to exceed the shelter capacity. Constraint (6) defines that people at assembly point *i* will evacuate and transfer to the shelter *j* if there is accessible and available road connection between the origins and destinations.

Constraint (7), states that the total numbers of evacuated people from assembly point *i* to shelter *j* should be transferred before the available time for evacuation considering available rescue vehicles and their limited capacities in trip toward shelters. Constraint (8) measures the numbers of designated rescue vehicle type *k* to transfer people from each assembly point *i* to shelter *j* will not exceed of the total number of available vehicles for all the evacuation process. Constraint (9) restricts the number of transferred peopled from assembly point *i* to the shelters *j* to not exceed their capacities. Constraint (10) expresses the negative numbers could not be considered for the mentioned parameters. Constraint (11) restricts the assignment of shelters and transferring issues to binary values, as S_j, Y_j are either allocated or not.

SOLUTION APPROACH

Ɛ-Constraint is a common mathematical approach for solving Multi-Objective Problems (MOPs) proposed by Haims and Freeman (1970).in this approach the main objective goal of problem will be selected to be optimized. All other objectives will be converted into form of inequality constraints by assigning an upper bond to each of them. Therefore, a two-steps approach is developed to solve the model as follows:

Step 1: This step aims to evacuate the entire evacuee population by minimising the number of assigned shelters and rescue vehicles within the bushfire prone areas. Hence, the model is solved by considering the objective function f_2 as hard constraint calculate preliminary optimal values for parameters of S_j as number of required shelters and NV_{ij}^k as number of required rescue vehicles. Therefore, the model formulation will be converted as follows:

$\boldsymbol{Max}\, f_1(x)$

s.t. Constraints (3, 4, 5, 6, 7, 8, 10, 11)

$$\sum_j X_{ij} = D_i \qquad \forall i \qquad (12)$$

Step 2: This step calculates the optimum minimised values of allocated resources while maximising the number of evacuated people. Therefore, the multi-objective model will be converted into the following single-objective problem:

$\boldsymbol{Min}\, f_2$(x)

s.t. $f_1(x) \geq \varepsilon_{\boldsymbol{p}}$ (13)

The value of $\varepsilon_{\boldsymbol{p}}$ is determined as follows:

$$\varepsilon_{\boldsymbol{p}} = \boldsymbol{\Omega}. \sum_i \sum_j X_{ij} \qquad (14)$$

Where $\boldsymbol{\Omega} \in [0,1]$indicates the maximum percentage of total fault. In this paper, $\boldsymbol{\Omega}$ value is selected randomly in the range of [0.4-0.9] at the discretion of the decision makers . The model was implemented using the CPLEX solver 12.3 in CPU Intel Core i7® 2310M 2.1 GHz, 4 Gb RAM, 64-bit operational system Windows7 ®.

Case Study

The proposed model is implemented in a real case study (Lake Eildon national park) as a bushfire-prone area in north-eastern region of Melbourne city (Murrindindi shire network) in Australia. The area of study contains 6 hazardous townships. The population of late evacuees in the network are considered to be 33% (Royal Commission and ABS) of the townships populations gained from ABS (Australian Bureau of Statistics).

Figure 1, illustrates the comprehensive what-if bushfire scenarios accompanied by bushfire isochrones to show the bushfire-spread scenarios pertaining to the evacuation time windows based on wind direction and bushfire severity. Therefore in consequence of the bushfire propagation, it has assumed that in scenario A routes between $\boldsymbol{i_1} \rightarrow \boldsymbol{j_1}$, $\boldsymbol{i_6} \rightarrow \boldsymbol{j_2}$, in scenario B Routes between $\boldsymbol{i_1} \rightarrow \boldsymbol{j_1}$, $\boldsymbol{i_2} \rightarrow \boldsymbol{j_2}$, $\boldsymbol{i_5} \rightarrow \boldsymbol{j_4}$, $\boldsymbol{i_6} \rightarrow \boldsymbol{j_2}$ and in scenario C, $\boldsymbol{i_1} \rightarrow \boldsymbol{j_1}$, $\boldsymbol{i_1} \rightarrow \boldsymbol{j_2}$, $\boldsymbol{i_2} \rightarrow \boldsymbol{j_3}$, $\boldsymbol{i_2} \rightarrow \boldsymbol{j_4}$, $\boldsymbol{i_5} \rightarrow \boldsymbol{j_1}$, $\boldsymbol{i_5} \rightarrow \boldsymbol{j_2}$, $\boldsymbol{i_6} \rightarrow \boldsymbol{j_2}$ are disrupted.

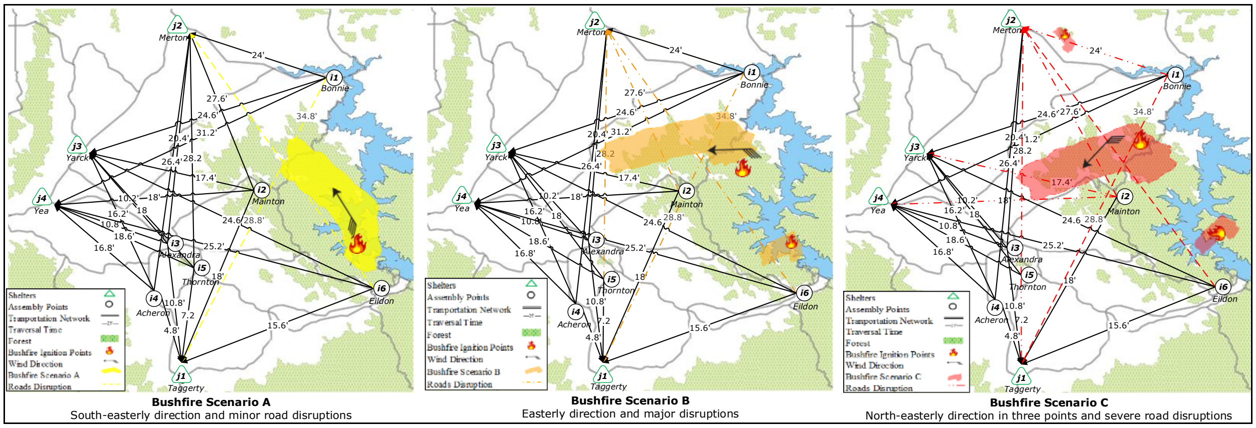

Figure 1 - Case study in 3 Bushfire Scenarios

Also, Table 1 summarizes the inputs of the case study.

	Hazardous Townships (Origins)	D_i (Population)	TW_i Time Windows
i_1	Bonnie	171	150 Mins
i_2	Mainton	29	90 Mins
i_3	Alexandra	398	105 Mins
i_4	Acheron	96	120 Mins
i_5	Thornton	120	75 Mins
i_6	Eildon	219	45 Mins

T_{ij} Traversal Time in Network (Mins)	j_1	j_2	j_3	j_4
i_1	28.8	14.4	24.6	31.2
i_2	18	27.6	17.4	18
i_3	10.8	20.4	10.2	10.8
i_4	4.8	26.4	16.2	16.8
i_5	7.2	28.2	18	18.6
i_6	15.6	34.8	24.6	25.2

	Shelters (Destinations)	Cap_j Capacity
j_1	Taggerty	350
j_2	Merton	450
j_3	Yarck	500
j_4	Yea	500
Total Cap		1800

I	Assembly points	6	
J	Candidate shelters	4	
TP	Inflation traffic congestion time	% 0.1	
DT	Dwell time(Preparation,boarding,alighting)	% 0.108	
K	Vehicle Type	**K_1**(Bus)	**K_2** (Van)
VC	Vehicle Boarding Capacity	40	10
TV	Total Available Vehicles	20	30
Q	Usage Cost of Vehicles	100	40

Table 1: Inputs of the case study

COMPUTATIONAL RESULTS

The output of the solving model indicates that by assigning 4 shelters (j_1,j_2, j_3,j_4) the model optimally is able to cover all the evacuees demand during the predefined time windows in all the scenarios. The higher number for assigned shelters increases the objective function value drastically. Thereby, In order to evaluate model performance in the next step, three scenarios are implemented.

In Scenario A as the simplest scenario, results indicate that the model could appropriately plan the evacuation process to transfer all the 1033 late evacuees. Regarding to time shortage, shelter’s capacity and distance and vehicle’s availability, 11 buses and 10 vans are optimally assigned to shortest available routes.

Bushfire Scenario A Minor Disruptions					**Bushfire Scenario B** Major Disruptions					**Bushfire Scenario C** Severe Disruptions				
Shelters Assignment (S_j)					Shelters Assignment (S_j)					Shelters Assignment (S_j)				
	j_1	j_2	j_3	j_4		j_1	j_2	j_3	j_4		j_1	j_2	j_3	j_4
	1	1	1	1		1	1	1	1		1	1	1	1
Evacuated people (X_{ij})					Evacuated people (X_{ij})					Evacuated people (X_{ij})				
	j_1	j_2	j_3	j_4		j_1	j_2	j_3	j_4		j_1	j_2	j_3	j_4
i_1	0	94	77	0	i_1	0	71	100	0	i_1	0	0	84	87
i_2	10	0	19	0	i_2	9	0	20	0	i_2	29	0	0	0
i_3	98	100	100	100	i_3	100	98	100	100	i_3	100	98	100	100
i_4	96	0	0	0	i_4	96	0	0	0	i_4	96	0	0	0
i_5	45	0	75	0	i_5	45	0	75	0	i_5	0	0	75	45
i_6	100	0	99	20	i_6	100	0	87	32	i_6	100	0	22	97
Sum	349	194	370	120		350	169	382	132		325	98	281	329
Uncovered	0					0					0			
Evacuated	1033					1033					1033			
Number of vehicles (NV_{ij}^k)					Number of vehicles (NV_{ij}^k)					Number of vehicles (NV_{ij}^k)				
	j_1	j_2	j_3	j_4		j_1	j_2	j_3	j_4		j_1	j_2	j_3	j_4
i_1	0	2V	1B	0	i_1	0	2V	1B	0	i_1	0	0	1B	1B
i_2	1V	0	1V	0	i_2	1V	0	1V	0	i_2	2V	0	0	0
i_3	1B	1B,1V	1B	3V	i_3	1B	1B,1V	1B	1B	i_3	3V	1B,1V	1B	1B
i_4	1V	0	0	0	i_4	1V	0	0	0	i_4	1V	0	0	0
i_5	1V	0	1B	0	i_5	1V	0	1B	0	i_5	0	0	1B	1B
i_6	2B	0	3B	1B	i_6	2B	0	3B	1B	i_6	2B	0	1B	3B
Total	11 Bus, 10 Van					12 Bus, 7 Van					13 Bus, 7 Van			
Number of Vehicle Trips					Number of Vehicle Trips					Number of Vehicle Trips				
	j_1	j_2	j_3	j_4		j_1	j_2	j_3	j_4		j_1	j_2	j_3	j_4
i_1	0	5	2	0	i_1	0	4	3	0	i_1	0	0	3	3
i_2	1	0	2	0	i_2	1	0	2	0	i_2	2	0	0	0
i_3	3	2B,1V	3	4	i_3	3	2B,1V	3	4	i_3	4	2B,1V	3	4
i_4	10	0	0	0	i_4	10	0	0	0	i_4	10	0	0	0
i_5	5	0	2	0	i_5	5	0	2	0	i_5	0	0	2	2
i_6	3	0	1	1	i_6	3	0	1	1	i_6	3	0	1	1

Table 2: Optimal evacuation plans for bushfire scenarios

For example, the evacuees population at the assembly point i_6 (Eildon township, 219 People) are planned to be transferred to the shelters j_1, j_3 and j_4. 100 evacuees are planned to be transferred to Taggerty (j_1), 99 evacuees to Yarck (j_3) and the rest of 20 evacuees to Yea (j_4). Hence, 2 buses are assigned to transfer 100 evacuees from Eildon (i_6) to Taggerty in 3 trips totally (first vehicle 2 times and second vehicle one more time). Respectively, 99 evacuees are transported to Yarck (j_3) by 3 buses in a single trip and the rest of 20 evacuees are evacuated by assignment of 1 more bus in 1 way trip between Eildon and Yea to meet the 45 minutes short time window for Eildon. Results prove that despite the close distance between Merton (j_2) to Eildon (i_6), evacuees could not be transferred to this shelter due to predefined route disruptions. In the same way, results indicate that the model could appropriately plan the evacuation of the assembly point i_3 at Alexandra with a large population of late evacuees (398 people). Interestingly, All the Acheron (i_4) late evacuees population are evacuated to Taggerty (j_1) by 1 van travels 10 times therefore, Acheron (i_4) population has more clearance time and could be evacuated by assignment of fewer vehicles that could do more return trips.

In the second scenario (B), it has assumed that bushfire has propagated slightly faster and causes more disruptions in the network infrastructure (Table 2). Therefore, transportation routes between Eildon (i_6) to Merton (j_2), Bonnie (i_1) and Thornton (i_5) to Taggerty (j_1) are no longer available. As the results show, based on scenario assumptions, all the late evacuees' population could be transferred to the safe shelters within the estimated time windows. Results indicate that the optimal numbers of assigned vehicles to serve the evacuation process are 12 buses 7 vans. In scenario C as most complex scenario of this study, severe bushfire situation causes several road disruptions in the transportation network. All the other inputs dataset are assumed to remain unchanged as the previous scenarios. Results show (Table 2) that all the 1033 late evacuees could be optimally planned to be evacuated to safe shelters by the assignment of 13 buses and 7 vans.

CONCLUSION

This study developed a Multi-Objective optimisation model to enhance the emergency situation response in an event of a bushfire. Key parameters and assumptions such as road disruption, time window, and resource availability and capacity were simultaneously considered in this study. The proposed model is formulated as a mixed integer multi-objective linear programming and is solved by the application of ε-constraint method. The results showed that all the late evacuees (a total of 1033) could be safely evacuated within the defined constraints. However, at least four shelters should be available at all time to transfer the late evacuees. Furthermore, the total number of required vehicles as well as their routes assigned to each was calculated. Our model can be extended to consider bushfire propagation scenarios, optimal placements of shelters and road's reliability.

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EXPLORING THE IMPLICATIONS OF NATURAL RESOURCE SCARCITY ON MANUFACTURING SUPPLY CHAINS

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ABSTRACT
The view of natural scarcity dates back to the work of Malthus in 1798 that considered scarcity as a constraint on economic growth. This paper develops a conceptual framework for understanding how manufacturing companies can respond to the issue of natural resource scarcity. The framework building on RDT identifies the key antecedents for buffering and buffering strategies, which in turn influence organisational performance. Our empirical results indicate that the importance of a resource will mainly lead to buffering strategies such as product and process (re-) configuration while a low number of suppliers and high switching costs favour bridging strategies such as relational mechanisms. Concerning discretion over scarce natural resources, companies are employing buffering and bridging strategies.

INTRODUCTION
Over the past 200 years, resource scarcity has been considered as a challenging topic among scientists, engineers and economists because it is a complex issue and there is a dependence of economies on a finite number of natural resources to produce consumer goods (Alonso, 2010). A study by PriceWaterhouseCoopers (PwC) in 2011 of manufacturing firms across the world concluded that more than half of firms are now affected by metals and minerals scarcity. Despite the wide recognition of natural resource scarcity, many companies still have not implemented any comprehensive strategies in order to address this issue (KPMG, 2012). Research into appropriate responses is also still insufficient in the field of supply chain management (Bell et *al.*, 2012). A systematic literature review by Matopoulos et *al.* (2015) highlighted that there is a need for further research on understanding the implications of resource scarcity on the supply chain relationships and also the impact on supply chain configurations.

This study aims to identify the implications of natural resource scarcity on supply chain strategies and on performance. A conceptual framework is proposed for explicating the contingent factors that lead to the adoption of specific strategies, which in turn have an impact on organisational performance. The conceptual framework is explored through 12 case studies conducted in different industries in order to include various scarce natural resources such as water, rare earth metals. The remainder of this paper is as follows: First, a brief literature review of the current state of the research about the issue of natural resource scarcity in the field of supply chain management is provided. Second, drawing upon Resource Dependence Theory (RDT) a conceptual framework is developed in order to address the implications of natural resource scarcity on appropriate manufacturing supply chains. The remaining sections describe the research methodology and findings from the case studies. The final sections include conclusions and further research opportunities.

LITERATURE REVIEW
Natural resources involve land, water, air, mineral, plants and animal elements (POST, 2011). Resources can be renewable (e.g. water, land, crops, timber, and fisheries) which can be reproduced and non-renewable natural resources (minerals,

metals, organic resources) that cannot be generated or cannot be generated in short periods and once they are depleted (exhaustion of natural resource), they cannot be available for future use. Thus, natural resources can be defined as any material that is provided by the nature and our main focus is on water, energy, metals, rare earth metals and oil.

In the field of supply chain management, there is limited research on the issue of natural resource scarcity and the implications for supply chain strategies and organisational performance. Bell et *al.* (2012) for example provided a typology with comprehensive mitigation strategies based on approaches such as logistics, resource recovery and resource protection to handle the issue of scarcity and highlighted the need of industry case studies to recognise and implement creative supply chain strategies to altering natural resource availabilities. Similarly, Bell et *al.* (2013) proposed a model based on the Resource Advantage (R-A) theory that explores how closed loop supply chain management enables competitive advantage.

However, one of the main issues with the research conducted so far is that it is conceptual and not empirically tested. In other words we do not seem to know whether companies acknowledge the relevance and the importance of natural resource scarcity for their companies and specifically the impact that this may have on their supply chain strategies and on organisational performance.

CONCEPTUAL FRAMEWORK AND ITS PROPOSITIONS

In this study RDT is chosen because the topic considers scarce natural resources which may be also of strategic importance and that are usually owned by countries, and companies that try to control them (Waters and Rinsler, 2010, p. 218). Based on this theory a conceptual model that is divided into three parts and its propositions are developed. The first part identifies the natural resource dependence level. Based on Pfeffer and Salancik (2003) the resource dependence level is determined by three dimensions namely the importance of the scarce natural resource, supplier substitutability and discretion over the scarce natural resource. The second part deals with the supply chain related strategies that companies may adopt to minimise the resource dependence level. RDT suggests that the above factors that determine the level of the natural resource dependence lead to either buffering and/or bridging strategies. The third part of the framework addresses how organisational performance can be affected by the adoption of supply chain strategies.

The framework and propositions are presented in Figure 1.

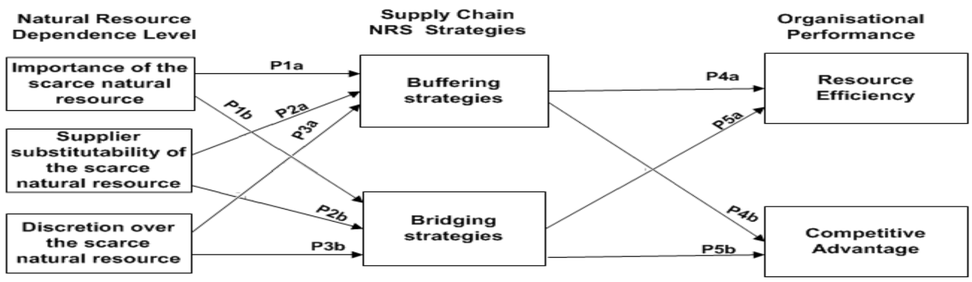

Figure 1 Conceptual Framework and its propositions

Importance of the scarce natural resource

When prices for a certain material are increased, firms are also searching for substitutes. Thus, companies that cannot find substitutes for this are altering the structure or inputs. This can be achieved by using buffering strategies such as recycling, inventories and by minimising the resource use. For instance there is no alternative for the natural resource of water. AnheuserBusch InBev that produces beer has as main element in their production phase water. The company tries to reduce water usage for beer and soft drinks plants. Thus, organisations may adopt resource efficiency strategies as they are related to a cost-saving process and product innovation.

Proposition 1a: The importance of the scarce natural resource has an impact on the adoption of buffering strategies.
Proposition 1b: The importance of the scarce natural resource has an impact on the adoption of bridging strategies.

Supplier substitutability of the scarce natural resource
When few suppliers sell the resources (concentration increases), uncertainty increases as dependence on a smaller number of suppliers that control most resources is increased (Pfeffer and Salancik, 2003). A firm is less dependent of a resource if it is easy available in diverse suppliers. Collaboration has become a new mantra to address the issue of volatility that derives from scarcity of natural resources. For example Novelis and Jaguar Land Rover (JLR) have had a long-time partnership in order to minimise the use of aluminium and closing the loop for this natural resource. Companies integrate and collaborate with suppliers as critical resources are becoming scarce, expensive and commodity prices are increasingly volatile. Hence, it is proposed:

Proposition 2a: Supplier substitutability has an impact on the adoption of buffering strategies.
Proposition 2b: Supplier substitutability has an impact on the adoption of bridging strategies.

Discretion over the scarce natural resource
The supply for specific resources such as rare earth metals becomes less available and governments try to protect domestic resources by imposing export restrictions. China reduced rare earth shipments by 9% in 2010 over 2009 and some heavy rare earths such as dysprosium and erbium will be prohibited from exporting after 2015. Philips developed a technology to minimise its reliance on rare earths in the production of light emitting diodes (LEDs). RDT takes also partnerships as a means of gaining access to resources from the environment. This point can be further illustrated by taking into account Toyota that has secured lithium supply for battery packs through a joint venture with lithium Australian mining company Orocobre. Based on the above, it is proposed:

Proposition 3a: Discretion over the scarce natural resource has an impact on the adoption of buffering strategies.
Proposition 3b: Discretion over the scarce natural resource natural resource has an impact on the adoption of bridging strategies.

Buffering Strategies and Organisational Performance
According to Hart (1995) product stewardship can contribute to firms’ business performance. For instance, Ford will replace its nickel-metal-hydride batteries with lithium-ion alternatives and the firm will cut 500,000 pounds of REEs from its manufacturing process annually. By avoiding the use of natural resource there will be minimisation of the consumption of nickel-metal-hydride batteries and there will be a reduction on purchasing cost. Honda Motor Company and Japan Metals & Chemicals Company will implement a world-first process to extract rare-earth metals from used parts and through this process Honda will gain a competitive advantage as it would be the first Japanese car manufacturer that will sale recycled parts. Based on the above:

Proposition 4a: The adoption of buffering strategies in order to minimise the dependence that is caused by critical scarce natural resources has an impact on resource efficiency.
Proposition 4b: The adoption of buffering strategies in order to minimise the dependence that is caused by critical scarce natural resources has an impact on competitive advantage.

Bridging Strategies and Organisational Performance
Resource sharing between supply chain partners can improve utilisation of the resources and reduce risk in their business environment (Barney, 2012). SABMiller faced a challenge in Colombia as they paid more to get good quality water. Recognizing the need to find a solution to escalating costs lay in the water catchment. For example, Bavaria, SABMiller's Colombian subsidiary, formed a partnership with some organisations that enabled 2 million tonnes of sediment from entering the water catchment which in terms of monetary value is about *$458,000 per year in treatment costs in the supply area*. Thus, these cost reductions have been passed to Bavaria which improved the organisational performance. Therefore:

Proposition 5a: The adoption of bridging strategies in order to minimise dependence that is caused by critical scarce natural resources has an impact on resource efficiency.
Proposition 5b: The adoption of bridging strategies in order to minimise dependence that is caused by critical scarce natural resources has an impact on competitive advantage.

RESEARCH METHODOLOGY AND DESIGN
Given the fact that very little research has been conducted on the appropriate strategies for minimising dependency from natural resources and uncertainty caused by the scarcity of natural resources in the field of supply chain management, there is a need to understand this subject area based on real-life practice. Accordingly, case study was the most suitable methodology and multiple-case studies approach is the most appropriate methods for theory creation. According to Yin (2003), the unit of analysis defines the subject in study. The theoretical constructs explored in this study were mainly related to the buying firm. A semi-structured interview protocol was used in order to get flexibility and to focus on what was unique (natural resources) at each of the companies. To ensure content validity, a group of academic experts and practitioners pre-tested the interview questionnaire. Guest et *al.* (2006) summarised guidance for the minimum non probability sample size from several studies. Based on their study our sample must be more than 15 key informants. Overall 23 interviews were conducted with 12 companies (automotive industry, chemical industry, electrical/electronic industry, food and beverages industry, mining and metals industry, and plastics industry). Suitable informants were persons with in-depth knowledge of the supply base, purchasing and sustainability issues. Each interview lasted between 30 minutes to 1 hour. All interviews, except two, were recorded. Secondary data are also used. The official corporate websites and organisational documents are based on valued secondary sources aiming to find new information or to verify the given information from key informants. We perform a cross-case analysis where we compare and contrast the responses of the informants who are discussing the strategies for different natural resources. The propositions developed in the previous section are also tested. We used content analysis to analyse interview data. Content analysis provides a reproducible method and structured analysis of the interviews which distil the conceptual content (Kunz and Reiner, 2012). The interviews were then transcribed and analysed using the NVivo qualitative data analysis software to assist with organisation of content, coding, and theme identification. Data analysis and coding are based on process of iteration between the parts of the framework and the data. For example for buffering strategies the themes developed are product and process redesigns, substitution,

recycling, and safety stock and plant relocation. Bridging strategies entail the relational mechanisms, transactional mechanisms and hierarchy mechanism. Identified meanings mainly in terms of natural resources (water, energy, rare earth metals (REE), metals (aluminium, steel) and oil are grouped into clusters of themes.

FINDINGS

By following the process described above the main themes clustered concerning the supply chain NRS strategies for all natural resources emerged and a tree map with the most cited strategies for each resource (Figures 2 and 3).

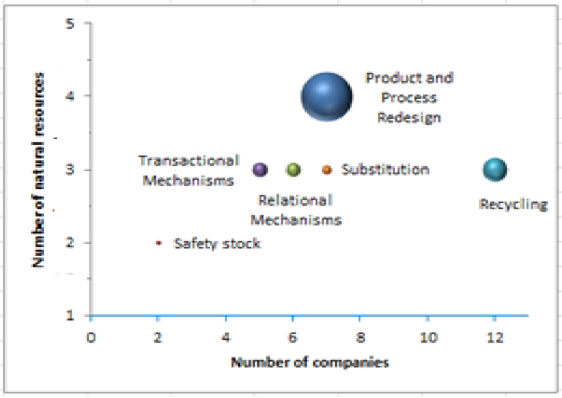

Figure 2 Strategies per resource and companies

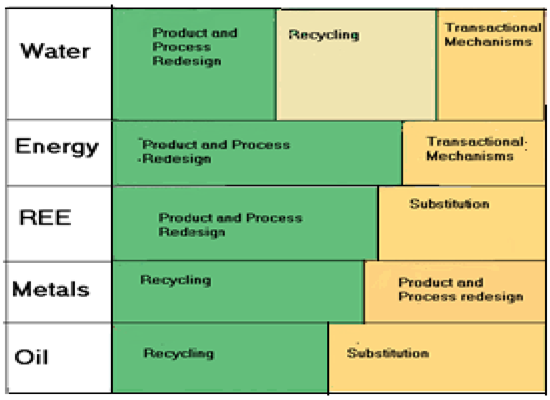

Figure 3 Tree Map for most widely used strategies per resource

Importance of the scarce natural resource

The case studies described above show commonalities in the strategies deployed by companies. Figure 2 shows that recycling is the most widely used strategy among the participant companies. *"It's all about recyclability. Isn't it?"* says the Production and Tooling Purchase Manager of one automotive company. However, differences exist on how the recycled materials are used. For example the Sustainability Manager in the brewery company stated that: *"we don't recover for the purposes of making more products but for other uses such as cooling*". Whereas resources such as aluminium do not decrease in quality and it can be recycled endlessly. "*We set up a system where the kind of waste elements goes back to our supplier and stays at our products"* says the Sustainability Manager of one automotive company. However, *"no one really recycles steel scrap because of its low value"* (Purchasing and Logistics Director, automotive company). In their sustainability report, it was highlighted that one specific car is using almost 40% recycled aluminium. New technologies are also introduced in order to minimise the usage of resources such as water, energy. For instance, the Director of Sustainability Programs and Enterprise Risk of one chemical company stated that they introduce the reverse osmosis technology *"to reduce the line of reverse osmosis elements that produce 30% better water purification with 40 % less energy"*. In the automotive company a Purchasing Manager says *"We change the cooling system and we will move from metal-halide to LED lighting in order to reduce annual energy consumption"*. Strategies involving alternative sources of energy (e.g. wind turbines) are also widely implemented to reduce energy usage (figure 3). Concerning oil, soy-based polyurethane foams was used as an alternative of polyurethane (oil based) foams, thus another strategy utilised was substitution. Moreover, relational mechanisms are used such as joint venture from one chemical company in order to secure *"plentiful and inexpensive raw materials"* says the Director of Sustainability and Enterprise Risk. Commodity price risk related to raw materials e.g. such as oil-related led a chemical company to sign medium-term contracts with certain key suppliers. Based on the above both propositions we can claim that P1a, P1b are valid.

Supplier substitutability of scarce natural resource

Except five companies that adopted transactional mechanisms, most of the companies closely collaborate with suppliers or are using coordination or cooperation (relational mechanisms). Some of them understand the need to move to long term agreements. For example, the European Purchasing Director for an automotive company states *"We didn't have a supply strategy here before now we have the global strategy and the global strategy will feature long term agreements with the key suppliers";* the Vice President of the Global Supply Chain of one electronic company says *"we have to engage much more closely as a partnership"*. There is one company which is vertically integrated with the suppliers for critical resources. Strategic partnership or collaboration that entails a high level of operational integration exists in the case of wiring connectors or for producing recycled aluminium. Specifically in the aluminium production *"there are not really many alternatives...most of our metal is coming from the long term strategic partner"* says the VP Strategic Sourcing. The Director Global Strategic Sourcing of metal for an aluminium company suggests that there are *"8-9 largest primary suppliers for metals, they are not easily replaced"* and they have *"done business with them for 20 years but usually contracts are for a year or three years"*. Apart from the number of suppliers, switching costs are important too. The Sustainability manager of one automotive company highlights that *"it's not an easy process we have to go through various steps to do that including you need a lot of verification test work to ensure particularly if it is a safety feature in the vehicle; you also need to make sure that a new supplier or a different supplier is able to meet our requirements and material standards."* In this context, the data shows an increased dependence when there are few suppliers of an important scarce natural resource that leads mainly to bridging strategies. However, for natural resources such as water and energy, most of the companies follow transactional relationships. *"Consumable contracts for water, gas, power will be reviewed normally under 2-3 years whilst fixed contracts for the utilities depended on the best deal we can get and later we will check the open market and may be change supplier"* (Purchasing and Logistics Director of an automotive company). Thus, the proposition 2b is verified; whereas there is no evidence that the small number of suppliers will lead to buffering strategies (P2a).

Discretion over the scarce natural resource

Results suggest that if the accessibility is hindered for a given natural resource, supply chain strategies vary but mainly recycling, substitution or close collaboration are followed. *"If you are going to lose 3 million dollars a day for not having the part you need you will find a way"* says a Purchasing Manager of one automotive company for rare earth metals. *"Specifically we try to use the minimum of a scarce natural resource such gold … and we mix it with other resources that are not considered to be scarce"* says another Purchasing Manager of the same company. Water shortages lead to recycling as an appropriate strategy used in order to continue production. Last but not least, the strategy of safety stock is mainly preferred for water from a brewery company *"Depending of the site of the facility and the stress of the given community we can reduce or increase those reserves"* (Sustainability Manager of the brewery company). The other companies keep small quantities of safety stock of resources such as palladium as these resources cost a lot and the price volatility of those resources make them too risky to be stockpiled. Most companies agreed that they will not relocate their plants due to scarcity. "In *15-20 years you will not be able to relocate anywhere else",* says the Sustainability Manager from the brewery company. Another reason for not relocating is that a company that operates in one region for many years has more advantages in terms of water rights. Another aluminium company faced energy shortages in India but *"we try to live with that and set buffers of energy to assure business continuity"* says the VP Strategic Sourcing. However, one chemical company found through secondary data that had to shut down their factory due to scarcity of water and power. Also most companies will try to closely collaborate with suppliers. For instance one company in the automotive industry stated that there are two aluminium suppliers in Europe and one steel supplier in the UK and maybe other three steel suppliers on the continent. Thus, the company established long-term contracts that usually are equal to the general life cycle of a vehicle that is about seven years. The data enabled validating propositions P3a and P3b.

Supply chain NRS strategies and Organisational performance
Companies that are using any buffering or bridging strategies may achieve resource efficiency and a competitive advantage. According to the European Purchasing Director of an automotive company they want to *"cut actually more from a cost point of view to stay competitive"*. Most companies have achieved a reduction in the usage of natural resources. Two companies collaborate in the automotive industry in order to produce a car that entails 75% recycled aluminium of which 45% comes from recycling strategy of scrap utilisation. Thus, these companies will face a reduction in cost for aluminium raw materials through the recycling process. One Group MP&L Manager from an automotive company stated that they *"get about quarter a million a month"* from recycling. Specifically by the blank reduction program they achieve savings £660 million. Apart from cost reductions, CO_2 emissions are also minimised. This means that the investment for new technologies pays off. The annual reports from an automotive company highlight that they produced $225 million in new revenue from recycling of scrap metals. Dysprosium usage was also reduced which minimises the cost and can save up to 500,000 pounds of rare earth metals annually. Moreover, companies can also achieve a competitive advantage. For example companies that collaborate closely with a supplier (e.g. for aluminium) can help the company to access this resource more easily than competitors. The new innovation engine of the company in the chemical industry is driving energy solutions that provide a competitive advantage. A manager from a chemical company from our sample indicated that they collaborate with the city to deliver sustainable water and make the company to remain a reliable supplier during times of drought and achieve a competitive advantage. This will result in minimising water usage by 2,500 gallons per minute with a saving about $20 million annually. Concerning energy, another chemical company in 2020 wants *"to achieve 35 % reduction in energy consumption per unit of production"* and *"in 2013 we already achieved like 5.6 % reduction"* says the Supply Chain Manager. Therefore, the results support that the supply chain strategies can enhance the resource efficiency and competitive advantage of one organisation. Concerning the propositions for the organisational performance, the collected data are in line with both propositions P4a, P4b, P5a and P5b.

CONCLUSIONS AND FUTURE DIRECTIONS

This research contributes to theory development as it provides a more comprehensive theoretical basis in understanding the relationships between the dependence that derives from natural resource scarcity, supply chain strategies and organisational performance. Specifically, RDT was utilised to develop a conceptual framework that provides reliable and valid antecedents associated with these strategies (buffering or bridging strategies). Thus, the first theoretical implication is the identification of the antecedents that leads to specific supply chain NRS strategies. The findings are in line with the RDT showing that the importance of a resource will mainly lead to buffering strategies and when there will not be a high number of suppliers bridging strategies will be employed. Concerning the third dimension, when companies face a difficulty to own, access, use scarce natural resources then they will follow either buffering or/and bridging strategies. By applying these strategies, organisational performance can be improved such as minimising water and energy use, and gaining competitive advantage. For instance, a future study could examine the product and process (re-)design as response to NRS by employing the Natural Resource Based View theory or to explore the implications of natural resource scarcity on a specific industry and thus natural resources.

This research offers a systemic perspective in multiple natural resources and shows that it is not wise to wait passively until disruptions due to natural resource scarcity occur. This study provides a useful framework for manufacturing firms that want to determine a successful supply chain strategy for overcoming the issue of natural resource scarcity. Managers must understand the advantages and disadvantages of those strategies and incorporate them accordingly in strategic planning. This study revealed a list of supply chain strategies that manufacturing companies are following to reduce dependence on other actors that provide them with critical scarce natural resources. The outcomes discussed in this paper also provide direction to managers in relation to performance metrics, which could be developed to assess the success or failure of managing natural resource scarcity. The data and results cannot be generalised for other sectors or companies within the studied sector. Further qualitative testing of the conceptual model is needed in order to achieve literal or theoretical replication.

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THE EFFECTS OF DIFFERENT SUPPLY CHAIN INTEGRATION STRATEGIES UNDER DISRUPTIONS: A SIMULATION STUDY

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ABSTRACT
Complex and tightly coupled supply chains are more vulnerable to disruptions. To alleviate the harmful impacts, supply chain integration (SCI) has been highlighted by recent literatures. However, such literatures primarily focus on a general or mixed view of SCI rather than separately looking at SCI strategies with different dimensional focuses. Therefore, we are motivated to investigate the dynamics of SCI strategies with different dimensional focuses, test the evolutionary perspective of SCI, and provide target suggestions for supply chains using different SCI strategies in the context of disruption recovery. The research plan is presented.

INTRODUCTION

Globalization and rapid development of information technology are changing today's inter-organizational relationships. Firms increasingly depend on a complicated network of global partners to deliver products in the right quantity, at the right place and time, and under persistent cost pressures (Datta & Christopher, 2011). However, long and complex supply chains are usually slow in responding to changes, and hence, they are vulnerable to supply chain disruptions. One way to solve this problem is to successfully manage supply chain integration (SCI), which requires cross-firm business processes with appropriate levels of information sharing, operational coordination, and partnerships (Leuschner, Rogers, & Charvet, 2012).

Most literature suggests that SCI has a positive impact on performance. However, in Fabbe-Costes & Jahre (2008)'s literature review, 12 out of 31 reported papers present non-significant or opposite results. One reason may be the different dimensions of SCI that are considered. For example, Swink, Narasimhan, & Wang (2007) proposed that information and knowledge sharing is not consistently related to effective coordination of manufacturing activities across firms. Relational mechanisms (e.g., trust and commitment) are needed to reinforce partner cooperation and mitigate risks arising from unanticipated events. An evolutionary perspective of SCI shows that information integration may have given firms a competitive advantage in the early- to mid-1990s. It constituted a first step in SCI, but may not be sufficient to excel. Working as partners, rather than simply transferring information, leads to the greatest benefits (Kulp, Lee, & Ofek, 2004).

Prior research on SCI has usually drawn on survey-based studies (e.g., Flynn, Huo, & Zhao, 2010). They primarily focus on a general or mixed view of SCI rather than separately looking at SCI strategies with different dimensional focuses. Furthermore, empirical research methods are static while supply chain disruptions always deal with dynamic events that develop over time (Akkermans & Van Wassenhove, 2013). The complexity of supply chains, especially those which encompass several actors, warrants a perspective that considers the supply chain structures and the feedback inherent in these structures, which is provided by system dynamics modelling (Wilson, 2007).

The contribution of this paper is to investigate the effects of SCI strategies with different dimensional focuses under disruptions. Our purpose is to understand the dynamics of different SCI strategies, test the evolutionary perspective of SCI, and provide target suggestions for supply chains using different SCI strategies in the context of disruption recovery.

This paper is structured in the following way. We will first review the literatures of SCI and supply chain disruptions. The next section illustrates simulation models for a cheese supply chain. In the end, the research plan is presented.

LITERATURE REVIEW

SCI

Although there is an extensive body of research on SCI, its "conceptual vagueness" has remained for more than a decade (Fabbe-Costes & Jahre, 2008). When defining SCI, researchers made the distinction among different aspects of integration. Explicitly focusing on the operational aspect, Frohlich & Westbrook (2001, p. 187) defined SCI as "the development of shared operational activities with customers and/or suppliers". Vickery, Jayaram, Droge, & Calantone (2003, p. 525) added one aspect – "technologies that facilitate the free flow of information both within and between companies". Emphasizing the strategic nature of SCI, Flynn et al. (2010, p. 59) proposed SCI as "the degree to which a manufacturer strategically collaborates with its supply chain partners and collaboratively manages intra- and inter-organization processes". To define SCI in a comprehensive way, we recommend to align these divergent aspects and give our definition: *SCI is the degree to which supply chain partners strategically collaborate with each other to manage intra- and inter-organizational information flows and operational processes*.

Based on our definition, three dimensions of SCI are identified to further develop different scenarios for our simulation. The fundamental dimension of SCI is relational integration, which refers to the adoption of a strategic connection between firms in the supply chain that characterized by trust and commitment (Leuschner et al., 2012). The other two dimensions of SCI are built on and intertwined with this attitudinal aspect. When firms engage in SCI, they first share data and information (Frohlich & Westbrook, 2001). Information integration refers to the coordination of information transfer, collaborative communication, and supporting technology among firms in the supply chain (Leuschner et al., 2012). The flow of information directly impacts production plans, inventory control, and distribution plans. The quality of information integration heavily depends on the appropriateness of information for exchange, which is based on trust and inter-dependence among supply chain partners (Zhou & Benton, 2007). The next dimension is generated when firms integrate operational activities in addition to information sharing (Kulp et al., 2004): operational integration refers to joint activity development, collaborative work processes and coordinated decision making among firms in the supply chain (Leuschner et al., 2012). Re-organization of outsourcing, packaging customization, agreements on delivery frequency, and common use of logistical equipment have a high impact on cost, quality, and speed. It is not easy to break down departmental and business barriers to adopt a strategy of operational integration, which depends on the mutual interest of integrated firms (Lambert, Emmelhainz, & Gardner, 1999).

Supply chain disruptions

Supply chain disruptions are defined in the literature as unplanned and unanticipated events that disrupt the normal flow of goods and materials within a supply chain (Wagner & Bode, 2008). Based on the definition, Wagner & Bode (2008) proposed five different sources of disruptions: demand side, supply side, legal/regulatory, infrastructure, and catastrophes. Although these sources do not often occur independently, all the disruptions will finally lead to one or several disruptions on supply side, own side, or demand side. Thus our simulation model will be based on these three types: supply-side, own, and demand-side disruptions. For supply-side and own problems, only capacity shortages are considered in our model, because the impact of transportation disruptions on supply chain performance has been demonstrated by Wilson (2007) through simulation. For demand-side problems, we only consider the situation of customer demand that is far below the available capacity, as the situation of customer demand that is far beyond the available capacity is similar to the bullwhip effect (Lee, Padmanabhan, & Whang, 1997), of which solutions have been well discussed.

THE SIMULATION MODEL

Industry background

The focus of this paper is on the cheese industry. From a supply chain's point of view, the cheese industry is special: production start-up is pull, i.e. demand driven. The main inbound resource is milk, of which supply is usually abundant. Once started, however, the process becomes push. After milk is pasteurized, it is curdled and gets its typical molded shape. Next, it is salted, which takes one to five days. The entire process takes around a week. However, most of the production lead time involves waiting. Depending on the type of cheese, the product has to mature for two to sixteen weeks. Despite its long production time, cheese is perishable. If it is not delivered to customers in time, it does not have value any more.

Simulation assumptions, types of disruptions, and scenarios

The cheese supply chain in our model consists of three actors: a producer, a logistics service provider (LSP), and a retailer. Infinite milk and other resources are assumed to be infinite for the producer. The producer produces a cheese product with six weeks' production time and the finished products are immediately delivered to the LSP. When ready, the cheese product has a remaining shelf life of six weeks. The LSP keeps inventory, but it is the ordering policy of the retailer and the production volume pushed by the producer that determine the actual inventory level. This is beyond control of the LSP. The LSP serves multiple retailers and will ration when facing capacity shortages. The retailer sells the products to consumers. The sales time is one week.

Table 1 shows the initial simulation inputs. Please note that, for "Real customer demand rate", the value is a normal distribution with mean of 1.28E6 kg/week and standard deviation of 1.00E5 kg/week.

Simulation input	Value
Producer order backlog	7.68E6 kg
Production time	6 weeks
Alpha, Beta	0.5
Producer base capacity, LSP base capacity	1.28E6 kg/week
Producer surge capacity, LSP surge capacity	3.20E5 kg/week
Order backlog, LSP inventory, Cumulative demand	1 kg
LSP target shipment time, Retailer sales time	1 week
Retailer inventory	2.56E6 kg
Time to adjust backlog	2 weeks
Normal delivery reliability	0.95
Real customer demand rate	N(1.28E6, 1.00E5) kg/week

Table 1: Simulation inputs with value

There are three types of disruptions that we will simulate: a producer capacity disruption, a LSP capacity disruption, and a demand disruption. For each disruption, we simulate a process in 24 weeks: in the first 9 weeks, all the variables are stable; at the end of Week 9, a disruption happened and caused a base capacity or demand reduction of 6.40E5 kg/week; at the end of Week 12, the base capacity or demand recovers 3.20E5 kg/week; at the end of Week 15, the base capacity or demand recovers another 3.20E5 kg/week -- back to the starting level, until the end of simulation.

With reference to three dimensions of SCI, we apply three scenarios in our simulation. As relational integration can hardly serve as a single variable, we intertwine relational integration with the other two integrations. The first two scenarios are information integration with low relational integration (Scenario 1) and information integration with high relational integration (Scenario 2). Scenario 3 is operational integration, for which we use Vendor Managed Inventory (VMI) model to simulate (Wilson, 2007). Operational integration requires the highest level of relational integration, as shown in a VMI partnership, the vendor, usually the manufacturer but sometimes a reseller or distributor, makes the main inventory replenishment decisions for the consuming organization. Transactions customarily initiated by the buyer (e.g., purchase orders) are now initiated by the vendor (Waller, Johnson, & Davis, 1999). In our simulation, the LSP serves as "the vendor".

Model structures

The structure of how the producer organizes production for Scenario 1 is illustrated in Figure 1. It consists of two information delays (for "Perceived channel demand rate" and "Perceived real customer demand rate") and one material delay (for "Producer order backlog"). We assume that the producer can only realize "Real customer demand rate" one week after its managers receive "Channel demand rate" from the LSP, because they need time to analyze "Channel demand rate" with other information they get to perceive "Real customer demand rate". We set "Alpha" as 0.5, which means that one half of "Product demand rate" is from "Perceived channel demand rate" and the other half (equals 1–"Alpha") results from "Perceived real customer demand rate". "Product shipment rate" is the minimum value between "Producer desired shipment rate" and "Producer base capacity". The producer's production simulation model for Scenario 2 is different from that for Scenario 1 in "Product demand rate". Now "Product demand rate" is only from "Perceived real customer demand rate". In the producer's production simulation model for Scenario 3, the producer directly receives "Real customer demand rate" from the retailer without an information delay. The rest structure is the same as the model for Scenario 1 and 2. In the simulation model of a producer capacity disruption for all three scenarios, "Producer base capacity" will be replaced by "Producer base capacity" plus "Producer surge capacity".

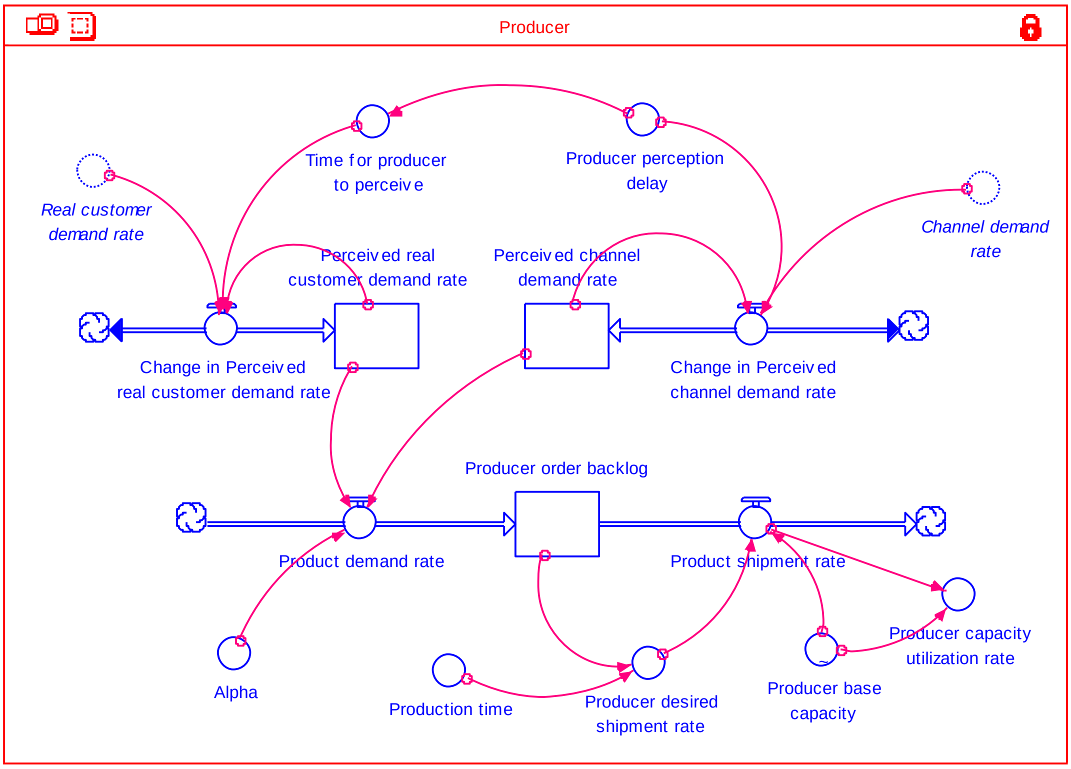

Figure 1: Producer's production simulation model for Scenario 1

Figure 2 presents the structure of the LSP's operation simulation model for Scenario 1 and 2. There are two material delays (for "Order backlog" and "LSP inventory"). "LSP shipment rate" is the minimum value of "LSP base capacity", "LSP desired shipment rate", and "LSP inventory"/"LSP target shipment time". "Workload" will be used by the retailer to judge the LSP's ability to deliver order on time in the retailer's order fulfillment simulation model. "Workload" equals "LSP inventory"/"LSP target shipment time"/"LSP base capacity". "LSP shipment time" will be used in the retailer's order fulfillment simulation model. "LSP shipment time" is equal to "LSP inventory" divided by "LSP shipment rate". In the LSP's operation simulation model for Scenario 3, the LSP does not attend the information sharing process, so there is no calculation for "Order backlog", "Workload", or "LSP shipment time". Now "LSP desired shipment rate" equals "LSP inventory"/"LSP target shipment time". "LSP shipment rate" is the minimum value of "LSP desired shipment rate" and "LSP capacity". The rest structure is the same as the model for Scenario 1 and 2. In the simulation model of a producer (or LSP) capacity disruption for all three scenarios, "LSP base capacity" will be displaced by "LSP base capacity" plus "LSP surge capacity".

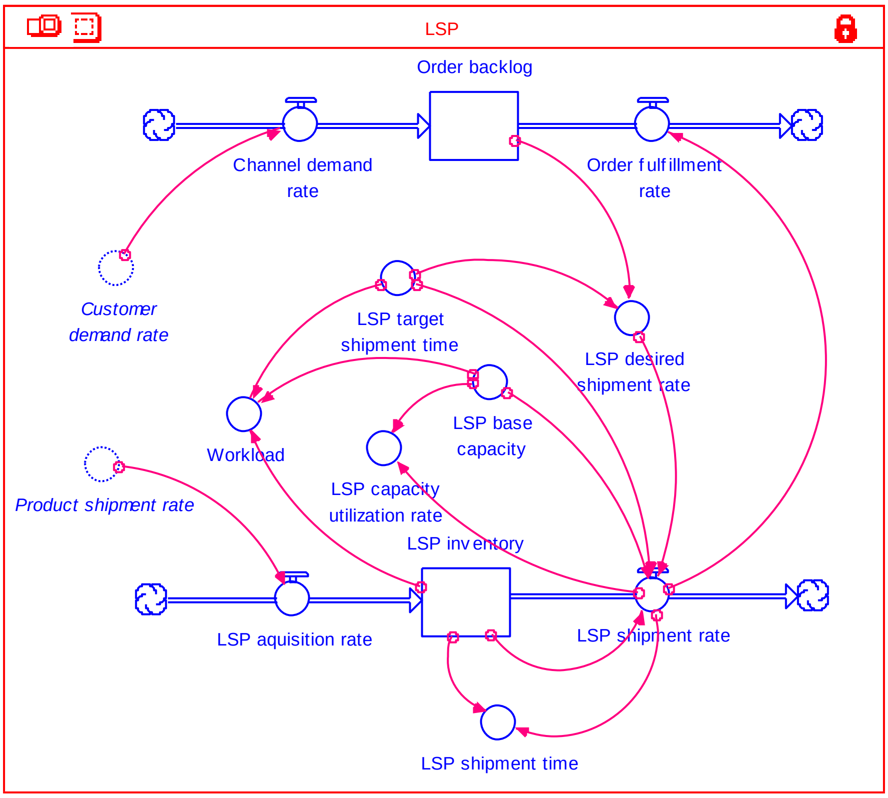

Figure 2: LSP’s operation simulation model for Scenario 1 and 2

Figure 3 shows the structure of the retailer’s order fulfillment simulation model for Scenario 1. It consists of two material delays (for “Retailer inventory” and “Cumulative demand”) and two information delays (for “Communicated lead time” and “Perceived delivery reliability”). “Customer demand rate” is a sum of “Real customer demand rate” and “Customer backlog adjustments”. The retailer’s managers will align the actual backlog with what they want it to be (“Desired channel backlog”), over a certain delay (“Time to adjust backlog”). “Desired channel backlog” is equal to “Real customer demand rate”*“LSP lead time expectation”. The calculation of “LSP lead time expectation” is similar to that of “Product demand rate” in the producer’s production simulation model, so the value of “Beta” is also set to be 0.5. “Inferred lead time” is equal to “LSP target lead time”*“Inferred capacity shortage”. “Inferred capacity shortage” equals 1/“Perceived delivery reliability”. “Current delivery reliability” is equal to “Normal delivery reliability” divided by the maximum value between 1 and “Workload”. We also assume that the retailer can only realize “Workload” one week after its managers perceive “LSP shipment time” from the LSP. The retailer’s order fulfillment simulation model for Scenario 2 is different from that for Scenario 1 in “LSP lead time expectation”. Now “LSP lead time expectation” is only from “Inferred lead time”. In the retailer's order fulfillment simulation model for Scenario 3, there are no processes for “Desired channel backlog” forecast or “Customer demand rate” generation, as the retailer just needs to provide “Real customer demand rate” to the producer and let the LSP manage its inventory. The rest structure is the same as the model for Scenario 1 and 2.

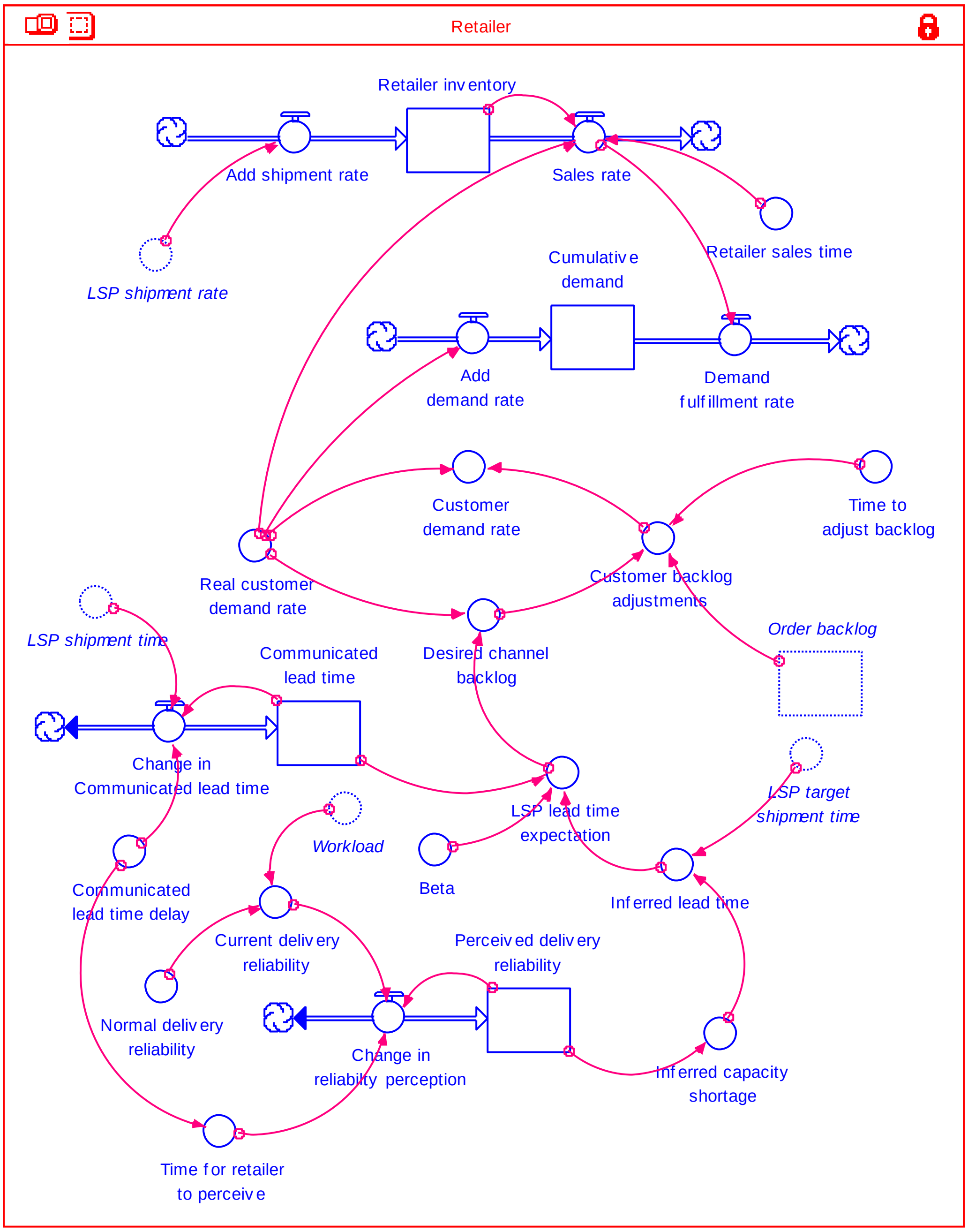

Figure 3: Retailer's order fulfillment simulation model for Scenario 1

RESEARCH PLAN

We will use a multiple analysis of variance (MANOVA) to compare the average of performance measures across three scenarios after different disruptions. We select two performance measures as the dependent variables for each actor: one focuses on supply efficiency, the other focuses on order fulfilment (quality and quantity). The selected six performance measures are: "Producer capacity utilization rate", "Producer order backlog", "LSP capacity utilization rate", "LSP shipment time", "Retailer inventory", and "Cumulative demand". The relative-precision procedure is used for sample size determination (Bienstock, 1996). Ten runs for each of the three scenarios at 5% relative-precision level are suitable. A Duncan test will be used to identify significant differences in the mean values of a performance measure when more than two scenarios are compared (Nutt, 2008).

The model behavior is highly sensitive to the assumptions. In particular, our model is sensitive to (1) "Producer perception delay" and (2) "Communicated lead time delay", which reflect the speed of information sharing. To test the "robustness" of our model and further provide target suggestions for supply chains using different SCI strategies, we will apply two post hoc sensitivity analyses by changing the above-mentioned two variables from 1 week to 3 weeks separately. The sensitivity analyses are not applied to Scenario 3, as there is no information delay in this scenario.

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THE IMPACT OF THE SOURCE OF DISRUPTION IN A MULTI-STAGE SUPPLY CHAIN

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ABSTRACT
This paper assesses the impact of the source of disruption in a multi-stage supply chain and studies the effectiveness of mitigating policies implemented to minimize the impact. The end customer demand is random and supply disruptions can occur at any stage (either upstream or downstream) in the supply chain. Two types of mitigating policies – proactive versus reactive – are proposed, where a proactive measure may lead to a reduction in disruption frequency and a reactive measure facilitates a faster recovery to a normal state. An analytical framework of supply disruptions and mitigating approaches is provided, and numerical experiments are conducted to assess the effectiveness of the two streams of policy. Results from the paper primarily show the effectiveness of disruption mitigating policies with respective to business continuity measures and provide insights on the relevance of the source (i.e., the relative position within the supply chain) of disruptions in selecting the right mitigating approach. In terms of product availability measures (e.g., fill rates, service levels, and average quantity stocked out), proactive policies tend to provide greater protection when disruptions occur upstream in the supply chain, whereas, reactive policies show effectiveness when disruptions take place downstream and their impacts are limited to local retail locations.

Keywords: supply chain disruptions; mitigating policies; source of disruption; simulation

INTRODUCTION
One of the major trends observed in global supply chain since the late 20th century is the emphasis on the awareness of supply chain risk management both in business practice and academic research. While potential impacts of disruptions are well documented, the actual business preparedness for disruptive events does not appear to be in alignment with the magnitude of the threat of the real risk. According to an annual survey conducted by Business Continuity Institute (2014) on business awareness of supply disruptions, over 75% of respondents experience at least one instance of supply disruption (information, technology, natural disaster, security, fire, health safety, etc.) per year. However, only 18% of firms surveyed are increasing the level of investment in their business continuity programs, and 11% have indicated they are, in fact, reducing their investment in business continuity initiatives. In another industry assessment conducted of 185 companies by A. T. Kearney (2011), more than 80% of 185 companies indicate that they are a natural disaster away from a major supply chain disruptions. Chopra and Sodhi (2014) state that in the context of disruptive supply chain risks, managers have both incentive and tendency to underestimate the likelihood of disruptive risks, which proves to be much costlier in the long run than overestimating the likelihood. For managers with fixed budgets, upfront investment to prepare for disruptive events is clearly not an attractive option. Thus, heightened awareness of potential supply chain risk does not necessarily lead to preparedness for business continuity.

Disruptive incidents in global supply chain are increasing both in frequency and severity of impacts as evidenced by a series of devastating natural disasters, plant shutdowns, port lockouts, industrial accidents, IT failures, health-related disruptions, and global recessions, all of which are capable of exposing global supply network to a serious level of vulnerability (Craighead, Blackhurst, Rungtusanatham, and Handfield, 2011). Studies in supply chain risk management over the last decade point to a number of reasons that explain the increased vulnerability of global supply chains to disruptive events. Tang and Tomlin

(2008) suggest that increased vulnerability can be attributed to significant increases in product variety, distribution channels, new product introductions, and outsourcing practices. Christopher and Lee (2004) summarize the reasons based on the proliferation of global business practices such as lean operations, global outsourcing, and consolidation and reduction of supply base. These practices, which are more or less natural results of dramatic advances in the speed and the complexity of business transactions along with leap in information technology have, in fact, become primary sources of supply disruptions (Son and Orchard, 2013). Staying in balance in the global supply network is now a mandate for businesses in assessing their priorities with respect to efficiency versus resilience. Along the same logic, businesses are being asked to evaluate their balance between preparing for recurrent risks versus disruptive risks (Chopra and Sodhi, 2014). That is, companies should have the capacity to constantly weigh clear benefits of global sourcing against risks associated with the practice (Handfield 2007).

Research on supply chain risk management generally approaches the issue from either demand-side uncertainty or supply-side disruptions. Literature on demand-side uncertainty is abundant with decades of classical inventory-based research discussing optimal ways to manage organization's inventory under various demand settings. Earlier works in the inventory-based literature that discuss demand-side uncertainty include Eppen (1979), Lariviere and Porteus (2001), and Martha and Subbakrishna (2002) among others. Analytical models studying supply-side disruptions include research of EOQ-based models when suppliers are not reliable. They treat disruptions with on-off periods following different distributions with a single supply source (Berk and Arreola-Risa, 1994; Parlar and Berkin, 1991) or multiple sources (Gürler and Parlar, 1997). However, a vast majority of existing literature on supply-side disruptions has come out since the late 1990s, which coincides with dramatic increases in disruptive events in global supply network. Academic articles strongly support the importance of building resiliency into the supply chain (Ponomarov and Holcomb, 2009; Schmitt and Singh, 2012) as well as identifying appropriate mitigating strategies to minimize the impact of disruptions (Chopra and Sodhi, 2014). Other papers identify and categorize supply disruptions based on two dimensions: the likelihood and the impact of disruptions (Engelhardt-Nowitzki and Zsifkovits, 2006; Manuj and Mentzer, 2008). This paper is based on a similar assumption used by Manuj and Mentzer (2008) that the likelihood of supply disruption and the impact of the disruption in combination determine the level of risk faced by businesses. This paper studies two types of policies – proactive and reactive – proposed to mitigate supply disruptions that may occur at any stage (either upstream or downstream) in supply chain. The primary contribution of this paper lies in capturing dynamics of both the demand-side uncertainties and the supply-side disruptions via numerical experiments and providing insights on identifying the right mitigating approaches to minimize the impact based on the *source* (or the origin) of supply disruptions. This paper is the first research to have investigated the impact of the *source* of disruption in a multi-stage supply chain.

OBJECTIVE AND RESEARCH QUESTIONS

The purpose of this paper is two-fold: to assess the impact of the source of disruption in a serial supply chain and to identify the right approach – proactive or reactive – in mitigating the impact contingent on the source (either upstream or downstream) of disruption. In particular, the paper evaluates the effectiveness of mitigating policies with respect to service levels, fill rates, and average stockout quantity under different scenarios where sources of disruption can range from a primarily upstream to an evenly distributed to a primarily downstream-based one. The paper presumes that the impact of any disruptive events can be explained in terms of the scope and the duration of the disruption. The likelihood of occurrence of a disruptive incident at a given location is determined by the type of disruptions, which can be categorized as minor (MI), moderate (MO), major (MA), and catastrophic (CA) as per Engelhardt-Nowitzki and Zsifkovits (2006). This classification is further applied in designing settings for the simulation experiment, which will be conducted to answer the following research questions:

- How effective are proactive measures and reactive measures in mitigating the impact of supply disruptions in a multi-stage supply chain?
- How does the *source* (i.e., the origin) of disruption affect supply chain performance in terms of product availability (service levels, fill rates, and average stockout quantities)?
- What are settings under which different approaches perform effectively in mitigating the impact of disruptions contingent on various scenarios?

SUPPLY DISRUPTIONS IN A MULTI-STAGE SERIAL SUPPLY CHAIN

The paper studies a multi-stage supply chain consisting of a single vendor (manufacturer) supplying multiple retailers, each of whom faces market demand, independent and normally distributed. Each retailer is treated as a location subject to supply disruption, just as the manufacturer could be subject to disruption as well (Figure 1).

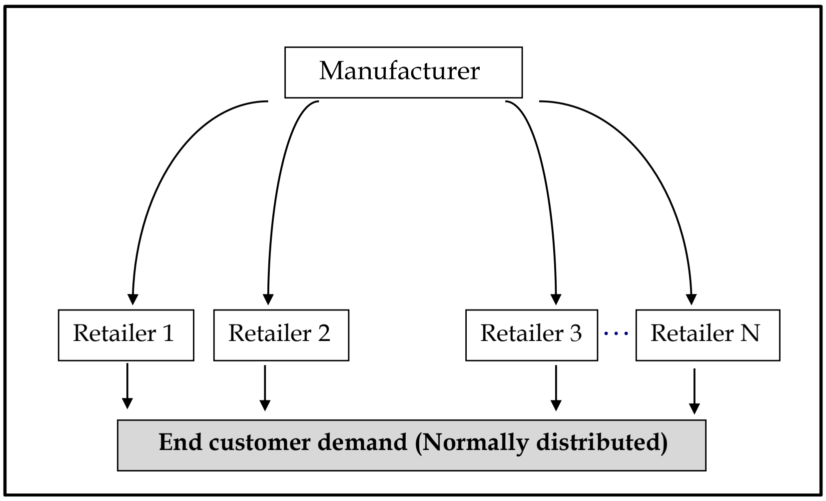

Figure 1. Serial supply chain: One manufacturer – multiple retailers

As mentioned earlier, supply chain risk can be characterized by the probability of an event and its impact (Manuj and Mentzer, 2008). Disruptive events may occur at any point in time either upstream (at the manufacturer level) or downstream (at the retailer level) according to a Poisson distribution with an average frequency of λ (per year). If the disruptive incident occurs locally at the retailer level, some or all of retail locations could be disrupted depending on the severity (type) of disruption. However, if the disruption happens at the manufacturer level, it ends up disrupting the supply to the whole system at lower levels by delaying the replenishment downstream until the recovery and restoration process is completed back to the normal state (Figure 2).

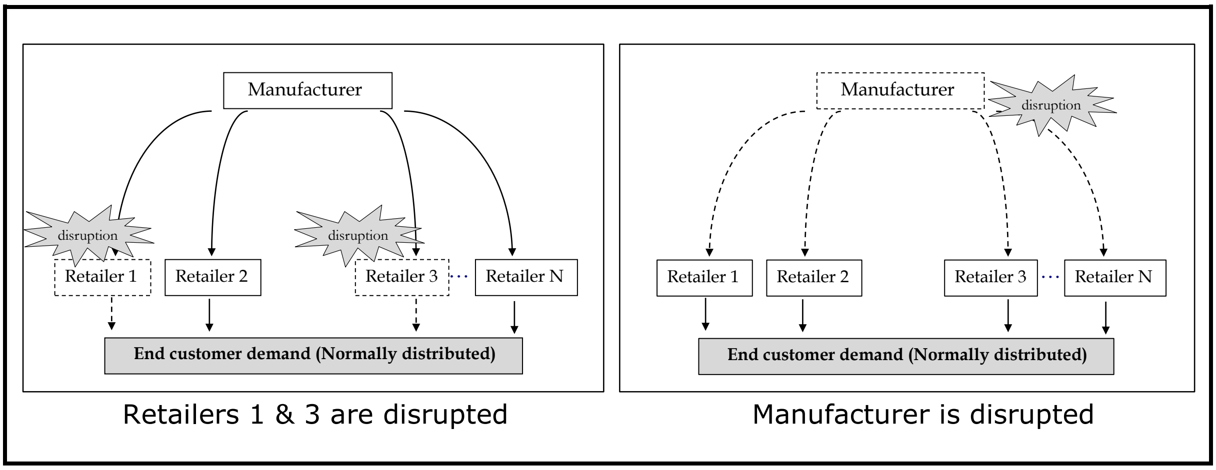

Figure 2. Supply disruptions at manufacturer and retailers

The recovery process will be under way as soon as a disruption occurs, and the subsequent restoration to the normal state will take on average $1/\mu$ time units (years) according to an exponential distribution. Depending on the length of disruption and on-hand inventory at the time of disruption, each party may experience stockout situations. Shipments from the manufacturer and replenishments at each retailer resume as soon as the normal state is restored. Under a disruptive state, whether a location is disrupted or not depends on the disruption type (minor, moderate, major, or catastrophic) and the source of disruption.

The supply disruption process studied here can be easily approximated by a single server capacitated queuing system, *M/M/1/K*, where the system capacity *K* is set as 1 as in Son and Orchard (2013), implying that restoration efforts are concentrated to fully return to the normal state before other disruptions occur. As shown in Gross and Harris (1985), the operating characteristics for an *M/M/1/K* system are based on (i) the disruption frequency, λ, and (ii) the recovery rate, μ, to the normal state. State probabilities, p_0 (no disruption) and p_1 (disruption), are obtained by setting the system capacity, *K* to 1, as follows:

$$p_0 = \frac{1-\rho}{1-\rho^2} = \frac{\mu}{\lambda+\mu} \tag{1}$$

$$p_1 = \frac{(1-\rho)\rho}{1-\rho^2} = \frac{\lambda}{\lambda+\mu} \tag{2}$$

Note that $\sum_{n=0}^{1} p_n = p_0 + p_1 = 1$ by definition for this single server finite capacity system.

Each retailer maintains a target safety stock based on the desired cycle service level, demand variability (standard deviation) at each location, and the fixed supply leadtime from the manufacturer, which could significantly increase in case of a disruption. Safety stock at each retail location as well as in the entire retailer locations combined can be expressed as in (3) and (4):

Safety stock at location *i*: $SS_i = Z_{SL} \cdot \sqrt{LT} \cdot \sigma_i$ (3)

Aggregate safety stock (N points): $SS_{Agg} = \sum_{i=1}^{N} SS_i$ (4)

where,
σ_i = standard deviation of demand over time,
LT = supply leadtime, and
Z_{SL} = standardized normal value corresponding to the desired service level.

It should be noted that safety stock at each location is maintained to protect against the demand side variability from the market, but is considered insufficient to cover stockout situations in case of disruptive events.

NUMERICAL EXPERIMENTS AND MANAGERIAL INSIGHTS

Simulation Settings

Parameters used for the simulation experiments of the disruption model are selected based on results from a number of recent industry surveys (BCI Supply Chain Resilience 2014; PwC & MIT Supply Chain and Risk Management Survey 2013; Gatepoint Research 2012) conducted on supply disruptions. Main results from surveys indicate that majority of disruptions are caused by unplanned demand, weather-related disruptions, transportation disruptions, and critical parts shortages, many of which can be categorized as a minor (MI) disruption type, recoverable within a short duration, and that the origin of disruption could start just about equally from anywhere in the supply chain (tier 1 or 2 suppliers, or at demand points). Disruption classes and their characteristics summarized in Table 1 are chosen based on results from the representative industry surveys.

Disruption type	% of disruption	Prob. (a given location) is disrupted	Average length of disruption
No Disruption	N/A	N/A	N/A
Minor (MI)	60%	25%	MDD*
Moderate (MO)	25%	50%	2*MDD
Major (MA)	10%	75%	3*MDD
Catastrophic (CA)	5%	100%	4*MDD
* MDD: Mean disruption duration ($1/\mu$)			

Table 1. Disruption types and characteristics

Disruption types are assumed to be independent of each other with minor ones accounting for roughly 60%, and catastrophic disruptions comprising about 5% of overall disruptions. For each occurrence of disruption in the system, the actual disruptive event at any given location follows a binomial distribution with a set probability. With a minor disruption, the probability that a given location is disrupted will be 25% (which does not mean that exactly 25% of locations will be disrupted). It will take longer to recover from a major or a catastrophic disruption than a minor one as indicated in Table 1. As for the source of disruption, the paper investigates five disruption scenarios where the origin or the source can range from "primarily upstream (PU)", "upstream (U)", "evenly distributed (E)", "downstream (D)", to a "primarily downstream (PD)" as summarized in Table 2 with corresponding percentage breakdowns for the source of disruption in each scenario.

Source of disruption	Scenarios				
	Scenario 1 (PU)	**Scenario 2 (U)**	**Scenario 3 (E)**	**Scenario 4 (D)**	**Scenario 5 (PD)**
Manufacturer	90%	75%	50%	25%	10%
Retailers	10%	25%	50%	75%	90%

Table 2. Source of disruption: Five disruption scenarios

Total aggregate market demand is set at 1,000/week, with each retail location facing normally distributed demand with variability defined by the coefficient of variation of 0.3. Disruption rates (λ = 0.5 1, 2, 4, 6 per year), recovery rates (μ = 13, 26, 52, 104 per year), and the number of retail locations (1, 2, 4, 10) are varied along with each of the five disruption scenarios defined above for a total combination of 400 disruption settings for simulation experiments. The simulation package, Crystal Ball Professional® was used to run numerical experiments. For each setting, simulation runs are conducted and summarized for 500 cycles and over 1,000 replications. Demand and disruption parameters used for the simulation are shown in Table 3:

Demand & design parameters	Disruption parameters
Aggregate demand = 1,000/wk	Disruption frequency (λ) = 0.5 1, 2, 4, 6 (per year)
Coefficient of variation (cv) = 0.3	Recovery rate (μ) = 13, 26, 52, 104 (per year) OR Mean disruption duration (MDD) = 4, 2, 1, 0.5 wks
Service level = 75%	
Supply leadtime = 1 week	Number of retail locations assessed = 1, 2, 4, 10
# of cycle = 13/year ($\therefore$52 wks)	Disruption scenarios: Scenarios 1 through 5

Table 3. Demand and disruption parameters for supply disruption simulation

Each simulation replication conducted over 500 cycles goes through the following sequence in each cycle as depicted in Table 4.

Sequence in each cycle	
Steps	**Occurrence of disruption in the supply chain**
SC-1	Determine if a disruptive event occurs based on disruption rate λ
SC-2	If disruption occurs, the disruption type is identified - The length of recovery to the normal state is determined - The source of disruption is identified (either upstream or downstream)
SC-3	If no disruptions occur, supply LT is set to 1 week
Steps	**Occurrence of disruption at each retail location**
R-1	If no disruptions occur, proceed to determine the demand during LT and stockouts if any
R-2	If disruption occurs in step SC-2 and the source is the manufacturer - All retail locations are disrupted. - Determine the demand during LT and stockouts if any
R–3	If disruption occurs in step SC-2 and the source is at the retail level, determine if the given location is disrupted - If disrupted, determine the demand during LT and stockouts if any. - If not disrupted, determine the demand during LT and stockouts if any.

Table 4. Sequence of simulation run in each cycle

Reactive Approach vs. Proactive Approach

As illustrated in aforementioned surveys (BCI 2014; A.T. Kearney 2011) conducted of business awareness and preparedness for possible disruptive incidents, businesses tend to show reluctance to fully invest in business continuity programs to protect against potential supply disruptions which may never materialize. Thus, instead of proactively investing to build long-term resilience in one's supply chain, which could be financially taxing to smaller entities, many choose to respond to disruptive events once they occur (Chopra and Sodhi, 2014). Some examples of possible reactive measures to facilitate restoration to the normal state are increasing inventory via emergency ordering, increasing short term production, and adding production capacity. Shao (2012) proposes a number of possible demand-side reactive strategies (e.g., backordering, upgrading and downgrading, compensating, and mixed strategy) for supply disruptions. Proactive measures could include actively implementing robustness and flexibility by building multiple routes, multi-modal transportation, and flexible supply base among others (Tang 2006). For the purpose of discussing supply disruption and designing simulation settings, this paper identifies any policies that contribute to expediting the restoration process (i.e., increasing μ) as being reactive measures of disruption mitigation, whereas policies that lowers the potential occurrence of disruption (i.e. decreasing λ) as being proactive.

Three supply chain performance measures – fill rates, cycle service levels, and average stockout quantities - are selected to assess product availability and business continuity under demand uncertainty and supply disruption. In general, upstream disruptions tend to lead to lower values of fill rates and cycle service levels, but higher average quantities stocked out for all possible combinations of λ and μ. This is an anticipated result based on the presumption that the upstream disruption will have a global impact, whereas the downstream disruption may only have local impacts. As for the effectiveness of different approaches, it is apparent that reactive measures are highly effective in improving the fill rates than the cycle service levels under disruption as in Figure 3, implying that once a disruption occurs, the likelihood of a lengthy restoration process could significantly undermine fill rates and average quantities stocked out.

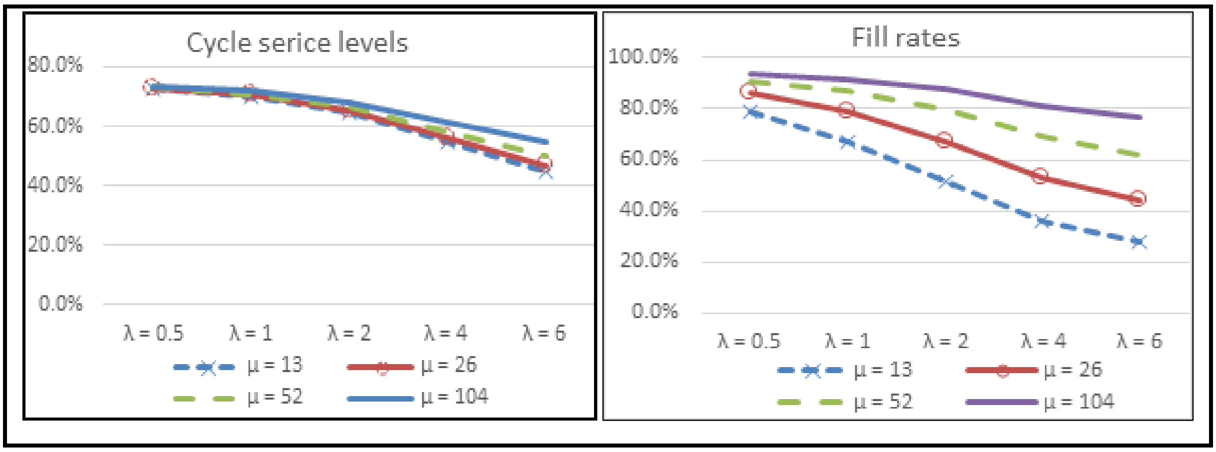

Figure 3. Cycle service levels vs. fill rates under primarily upstream (PU) disruptions

This result is consistent for scenarios with downstream or an evenly distributed source of disruption. That is, reactive approach with an increase in μ proves to be far more effective in improving fill rates (or stocked out quantities) than service levels.

As for the results of implementing proactive approaches to disruption mitigation (also shown in Figure 3), service levels show more significant improvement when disruption frequency (λ) is decreased for a given recovery rate (μ), implying that building resilience is more instrumental than responding to disruption with respect to reducing stockout situations. However, fill rates and average quantity stocked out still display a better improvement than service levels when proactive approaches are implemented.

Impact of the Source of Disruption

The main discussion of this research focuses on the impact of the source of disruption, and identifying the right approach to mitigate the impact based on the source. Both detailed and general results obtained from the simulation point to a conclusion that, compared to reactive approaches, proactive ones show an overall superior protection for business continuity against disruption as they lower the likelihood of disruption occurrence in the first place, resulting in even greater improvements in case of an upstream disruption, which could be a far more damaging scenario than a downstream disruption. However, for cases where disruption impacts can be limited locally, reactive measures show a slightly but consistently better improvement over proactive measures, especially in terms of the fill rates (Figure 4). That is, reactive approaches show greater effectiveness in terms of protecting fill rates by quickly facilitating the recovery process to the normal state when the disruption impact can remain at local level under a downstream disruption scenario.

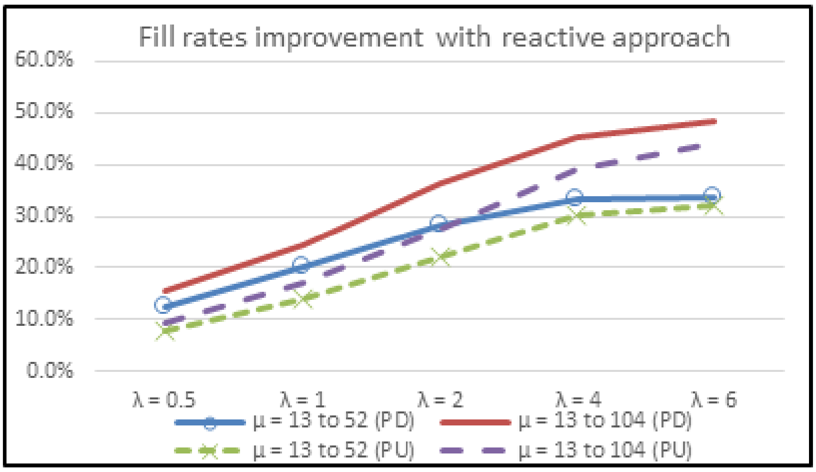

Figure 4. Fill rates improvement: upstream vs. downstream disruptions

CONCLUSION

This paper studies the relevance and the impact of the source (i.e., the relative position within the supply chain) of supply disruption and provides business insights on selecting the right disruption policies to minimize the impact. This research investigates the effectiveness of two mitigating approaches contingent on different scenarios via discussions of simulation results. Proactive approaches to disruption mitigation provide a greater protection and resilience when disruptions occur upstream in the supply chain, whereas, reactive policies show better effectiveness when disruptions take place downstream and their impacts can be limited locally. This study can be extended to incorporate financial implications of building supply chain resilience (proactive) versus responding to disruptions after the occurrence (reactive). Conceptually similar approaches can be found in the study of total quality management, where quality is embedded and built in, not inspected and corrected. Further, the study of disruption mitigation approaches with respect to the logistics design and structures could also be relevant research agenda.

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BUILDING A CASE FOR COLLABORATIVE RISK MANAGEMENT WITH VISIBILITY OF RISKS ACROSS SUPPLY NETWORKS: INVESTIGATING THE EFFECT OF SUPPLY NETWORK CHARACTERISTICS

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ABSTRACT
The purpose of this paper is to analyse the need for collaborative risk management in supply networks with visibility of risks across firms in the network. The paper aims to identify the factors which need to be considered by firms in a supply network to manage risks using a collaborative approach and the impact those factors have on the choice of appropriate coordination mechanisms for risk management in networks. The objectives of the research are achieved by conducting a review of the literature on supply networks, supply chain risk management, supply chain collaboration and information sharing. This research underscores the need for collaborative risk management for managing risks in a supply network and proposes that the appropriateness of a collaborative approach will depend on the specific roles of the focal firm and the suppliers, the degree of network dynamics (Harland et al., 2001), the degree of balance in the buyer-supplier and supplier-supplier relationships (Choi and Wu, 2009) and the extent of endogeneous and exogeneous uncertainties faced by network firms (Trkman and McCormack, 2009).

INTRODUCTION
Supply networks consist of inter-connected entities with the primary objective of procurement, use and transformation of resources to provide goods and services (Harland et al., 2001). In an integrated supply chain, risks in one link are more likely to affect other links in the chain (Normann and Jansson, 2004). Integrated supply chains themselves have higher risk exposure (Wieland and Wallenburg, 2013) and companies which are part of a network become more dependent on each other. This leads to risk transfer and risk sharing within networks. Processes in a tier II supplier may create risks for a tier I supplier and in turn for the OEM or the end customer. Moreover, some tier II suppliers may also directly supply some parts to the OEM or other customers creating a complex network. The recent horsemeat scandal in the UK and the disruption in the supply of onboard computer chips within the automotive supply chain during the Japanese Tsunami depict the risks within supply networks. Contingent factors such as position of the firm in the network, geographical dispersion of the supply chain (Stock et al., 2000), responsibility of suppliers, degree of dependence of the suppliers on the customers and vice versa, extent of flow of information, type and length of contracts (Lindroth and Norrman, 2001) play a significant role in risk propagation as well as risk mitigation in the supply network. A deeper understanding is needed of the above factors and their influence on the type and extent of risks faced by the firms within a network and how some of these can be influenced to develop risk mitigation plans.
The research questions proposed for this paper are:

1) Is there a need to ensure visibility of risks across firms in a supply network and to develop a collaborative process to manage risks in the network?
2) How do the supply network characteristics influence the need for ensuring visibility of risks and for developing a collaborative process to manage risks in a supply network?

Risk Management in Supply Networks

As companies engage in inter-firm cooperation to achieve sustained competitive advantage, research in risk management has begun to examine risk management at the level of inter-organizational relationships and supply chains (Harland et al., 2003). For handling supply chain risks consciously, and for achieving a contribution to supply chain goals, risks have to be managed by a cross-company collaborative risk management approach, which should be aligned with the entire supply chain (Go¨tze and Mikus, 2007). Risk management within supply chains focus on three main areas (Kaju¨ter, 2003): (1) Risk management with supply chain orientation: a single company identifies, assesses and manages risks within the supply chain, (2) Risk analysis in the supply chain: a collaborative identification, assessment and management of risks within different companies take place. (3) Supply chain risk management: the focus lies on the entire supply chain where risk management is integrated into the aims and planning processes of a supply chain. There are limited studies on assessment, analysis and management of risks at the entire supply network level. Cheng and Kam (2008) use agency theory to analyze differential risks embedded in alternative network structures and explore the differential dynamic of risk (i.e., risk precondition, risk event, risk footprint, and risk propagation) amongst the collaborators, depending on their functional roles and their relationships with other collaborators within a network and with other networks. Although, the above study outlines approaches for assessing risks at network level it does not provide insights on how supply network characteristics can influence management of risks in the network either by firms individually within the network or collaboratively.

Collaboration and information sharing in supply networks

The interdependent nature of supply chains makes coordination of the various entities an imperative. Collaboration is characterized by a higher level of interaction and requires investment in the relationship that includes mutual understanding, a common vision, shared resources, and achievement of collective goals (Mentzer and Kahn, 1995). Skipper et al. (2008) used coordination theory (Malone and Crowston, 1994) and interdependence theory (Thompson, 1967) to study supply chain coordination. Supply networks may exhibit one or more of the different forms of interdependence– pooled, sequential and reciprocal (Skipper et al., 2008). Coordination by plan requires involvement of a coordinating agent which plans the flow of products and information and enables the components to adapt to changes in their environment (Thomson, 1967). Mutual adjustment is another level of coordination mechanism which adds the transmission of new information during the process of action and fits best in situations involving higher levels of variability and unpredictable situations. The difference between coordination by plan and coordination by mutual adjustment is the implication of joint problem solving and decision-making rather than having a central planner. This often results in mutual group-based, decision making (van de Ven and Delbecq, 1976). There is limited research on coordination mechanisms in the context of risk management in supply networks. This research is an attempt to bridge this gap and to understand the effect of supply network characteristics on the choice of coordination mechanisms for risk management.

DISCUSSION

Risk management in supply networks require detailed characterization of the network and the different forms of uncertainties experienced by the network. Complexity of a supply network can be operationalized using two separate factors, node complexity (i.e. number of nodes) and flow complexity (i.e. number of interconnections between nodes). Node complexity has strong negative effect on network reliability while flow complexity has a positive effect (Adenso-Diaz et al., 2012). As a network becomes vulnerable due to risks, it is important to understand the impact of node and flow complexity on risks and how those can be influenced for managing risks. Geographical dispersion of the supply chain

(Stock et al., 2000), number of suppliers and differentiation of suppliers (Choi and Krause, 2006) also determine the node complexity. The extent of flow of information between suppliers within and across levels and between suppliers and customers determines flow complexity. Another factor which influences risk management is the degree of coupling between network members. The type and length of contracts (Lindroth and Norrman, 2001), the level of detail in the exchange of specifications determines the degree of coupling in the network. Once the node, flow complexities and the degree of coupling are ascertained, their impact on transparency and traceability need to be determined before risk management actions can be planned. Supply network complexity is negatively related to transparency as higher complexity makes it difficult to ensure visibility of information and to maintain transparency while coupling in a supply network has an inverted U shape relationship with transparency, increasing upto some point and then levelling off as coupling becomes increasingly tighter(Skilton and Robinson, 2009). The degree of tight coupling in a supply network raises flow complexity but is positively related to traceability (Skilton and Robinson, 2009). Node complexity, flow complexity, degree of coupling in the network will vary with the different types of interdependencies within a supply network. These together with an understanding of the extent of risk propagation will help in determining the appropriate coordination strategies. Thus, a supply network that operates in an environment of sequential interdependence with high propagation of risks is expected to manage this interdependence by utilizing coordination by plan with a central planner, having visibility of risks across the network. A network operating in an environment of reciprocal interdependence will need coordination by mutual adjustment with multiple firms in the network. In such an arrangement, the entities with the largest number of couplings can assume to play the central role with visibility of risks across the couplings it has while the others may manage the risks of their own as well as with their immediate partners. For example, a food processor getting raw materials from multiple suppliers who in turn may supply to each other and to other food processors down the chain should play the central role to ensure visibility and traceability while food retailers can manage risks with all the food processors. The appropriate collaborative mechanisms for risk management are shown in Table 1.

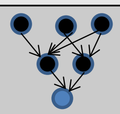
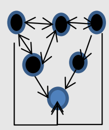
	Network complexity	**Coupling**	**Interdependence**	**Traceability**	**Risk propagation**	**Type of coordination for risk management**
	High	Loose	Sequential	Low	High	Coordination by a central planner with visibility of risks across the network
	Very High	Loose	Reciprocal	Very Low	Very High	Coordination by mutual adjustment with the entity with highest number of couplings assuming a central role

Table 1: Choice of coordination mechanisms for risk management based on network characteristics

Thus, firms within a network need to assess the suitability of the approach and should refrain from either following a purely internal risk assessment and mitigation or making it completely collaborative.

CONCLUSION

There are limited studies on assessment, analysis and management of risks at the supply network level. The existing literature does not provide guidance on how companies in a supply network can develop a common understanding of the risks and reach a mutual agreement of mitigating those risks. It is also unclear whether visibility of risks across member firms and using a collaborative approach for managing risks in the supply network utilizing the better visibility can help manage risks better in a network. This research identifies the above gaps through an analysis of the literature and develops a start point for further empirical analysis.

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TOWARDS A SUPPLY CHAIN CYBER-RISK AND RESILIENCE RESEARCH AGENDA – A SYSTEMATIC LITERATURE REVIEW

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ABSTRACT
The increased dependence of supply chains on information technology has exacerbated the impact of cyber risks (Dedrick et al., 2008), ranging from the breach of data confidentiality, to the destruction of data and the disruption of supply operations.

There is a robust body of knowledge, which has allowed the development of models, frameworks, tools and techniques to understand and manage supply chain risk (Khan et al., 2007). However, the evaluation of cyber risks and resilience in the supply chain has been less explored.

The purpose of this paper is to contribute to the gap in theory through a systematic review of the literature (Tranfield et al., 2003). Specifically the focus is on 1) developing a definition for cyber resilience in the supply chain, and 2) suggesting a research agenda for this area.

INTRODUCTION
Cyber-risk has been defined by the Institute for Risk Management as "any risk of financial loss, disruption or damage to the reputation of an organization from some sort of failure of its information technology systems" (IRM, 2015). The ISO 27005:2008 defines information security risk as "the potential that a given threat will exploit vulnerabilities of an asset or group of assets and thereby cause harm to the organization"(ISO, 2008). Both of these terms are being widely used in industry, and this work will consider these terms as equivalent.

In recent years, cyber-attacks have affected national financial systems (Richards, 2014), electric power grids (Poulsen, 2009), nuclear facilities (Kushner, 2013), the movie and entertainment industry (Allen, 2014), and the retail industry (Reuters, 2014a) to name a few, making this an issue for many areas of the economy. Cyber-attackers have been able to render inoperable and even tilt a floating oil rig and delete records of containers at the destination port for purposes of smuggling drugs (Reuters, 2014b).

Cyber-attacks can cause considerable economic costs on the companies that suffer these breaches, although the costs may not be noticed until after the damage is done! Informed estimates place the likely annual costs from cyber-crimes anywhere from US$ 375 billion to US$ 575 billion in losses (Security & Mcafee, 2014). Furthermore, supply chain disruptions can, on average, reduce shareholder value by 7%, with effects even before formal announcements are made to the market by the affected company (WEF, 2013).

This is compounded by the increasing complexity of global supply chains and the speed and connectivity of operations required by companies to stay competitive. Furthermore, the growing skill of the attackers to find novel ways of accessing crucial data (Reuters, 2012), and the limited information and tools available to manage these threats, requires organizations to be more resilient to cyber-attacks that can cripple their supply chains. However, little is known about the methods for managing cyber risk and resilience in the supply chain.

Additionally, there has been a lack of managerial action to acknowledge the relevance of the problem and find solutions (Burnson, 2013; Deloitte, 2012, 2013). It has been stated that "only a few CEOs realize that the real cost of cyber-crime stems from delayed or lost technological innovation" (Bailey, Miglio, & Richter, 2014) and "countries, like companies have likely underestimated the risk they face" (Security & Mcafee, 2014). This is, either by delayed decision-making or by lack of awareness, the resulting inaction is leading to higher organizational costs from cyber-crimes.

METHODOLOGY AND RESULTS

A systematic literature review was conducted, based on documented guidelines (Tranfield et al., 2003) through which a comprehensive, explicit and reproducible method is followed. This consists of a series of ten steps that can be grouped into five main phases, namely planning, searching, screening, extraction and synthesis, and reporting.

Planning

The planning phase requires the definition of a review question to guide the search, identified as: "Do the current supply chain risk and resilience frameworks incorporate cyber-risk?". This question therefore considers the aspects that can be expressed in the following sub-questions:

- What are the current supply chain resilience frameworks?
- Do these frameworks incorporate cyber-risk?

Searching

The searching phase was guided by the identification of the relevant databases where the search was to be done, the keywords to be used during these searches, and the appropriate time frame for the resulting documents to be included in the research.

The databases considered were Scopus, Web of Science, ProQuest and Google Scholar.

The search keywords were determined from a knowledge domain analysis around the concept of cyber-resilience for the supply chain. The four main knowledge domains to be scanned were identified as "supply chain management", "information technology management", "risk management", and "resilience management". This analysis allowed us to determine the main keywords which would participate in the systematic literature search. The different keyword combinations used are shown in Table 1.

Supply Chain		Information Technology		Risk		Resilience
Supply Chain OR		IT OR		Risk		Resilience OR
Supplier OR	AND	Information Technology	AND		OR	Resilient OR
Supply Network						Resiliency

Table 1: Search keywords

Since the first articles about supply chain resilience were produced in the early 2000's, the literature research would consider relevant papers between the years 1985-2015.

Screening

An initial broad literature search was carried out of articles and according to preliminary analysis of the document title and abstract, if available. This was followed by a detailed analysis of the document abstracts, in the case of papers, and extended content in other cases, following explicit inclusion/exclusion criteria, to identify a refined selection of documents for this analysis. Finally, the references of this refined set of articles were reviewed to identify relevant documents that might not have been identified through our initial broad search.

Our broad literature review delivered 277 documents, considering peer-reviewed journal articles, specialized magazine articles, postgraduate theses, and reports by specialized agencies. These were reviewed according to the exclusion/inclusion criteria, as shown in Table 2 , and duplicates were eliminated, creating the final refined document list with which the analysis was performed.

	Rationale
Inclusion Criteria	
Publication in Peer Reviewed journals, postgraduate university theses, specialized journals in the area of Business Management, Operations Management and Supply Chain Management, and reports by specialized agencies.	Peer reviewed journals will very likely be of a higher quality than non-peer reviewed journals. However, since cyber risks and security is a rapidly evolving issue, there might be relevant information absent from peer reviewed journals due to the journal review cycle times. Specialized journal papers, postgraduate theses and reports by specialized agencies will contribute to this dimension.
Papers have to have Supply Chain as a theme in their content	This research is focusing on the cyber risks for supply chains, so this focus is required, even if the main theme of the article is not supply chain
Empirical studies, qualitative or quantitative papers, as well as theoretical papers	This research should cover the different approaches that have been proposed to the problem.
Risk Analysis has to be one of the main themes	This research is focusing on the cyber risks for supply chains, so this focus is required, even if the main theme of the article is not risk management
Exclusion Criteria	
Editorial Comments	Editorial comments served as an additional guide to the documents identified, but were not specifically peer-reviewed or considered in the analysis
All studies and publications in any language other than english	English is the language in which this research could be most easely reproduced.

Table 2: Inclusion criteria

This refined list consists of 213 documents (24 articles, 137 peer-reviewed journal papers, 51 reports by specialized agencies and 1 thesis) in the areas of supply chain risk management (SCRM, 131 documents) supply chain cyber-risk management (SCCRM, 38 documents), and information technology (IT) risk management (ITRM, 44 documents), ranging from the years 1998 to 2015.

Extraction and synthesis

The articles were analysed by using a spreadsheet format that contained categories for each document. Given the diversity of the methodological approaches, contexts and outcomes of the refined list of documents, some generic descriptors were created to better categorize these documents. The list of descriptors used can be seen in Table 3. The reporting phase is developed for this paper in the analysis of results section, next.

ANALYSIS OF RESULTS

Consistent with the research questions set out during the planning phase of the literature review, the analysis of the literature for this paper was directed mainly towards identifying the different supply chain resilience frameworks, as well as determining any existing gaps for the suitability of these frameworks to consider cyber-risks.

Our research appears to show three main sources for the development of supply chain resilience frameworks: 1) the academic development of frameworks both qualitative or quantitative, based on case studies from industrial partners, 2) the institutional development of models through organizations such as the World Economic Forum (WEF) or national state agencies, and 3) international standardization agencies such as the International Standards Organization (ISO).

Name	Type	Description
Type	"Paper" OR "Thesis" OR "Article" OR "Report"	Descriptor for the type of document, and following the inclusin/exclusion indications. This descriptor can either be a peer-reviewed journal paper ("Paper"), a postgraduate thesis ("Thesis"), an article in a specilaized magazine or non-peer-reviewed journal ("Article") or a report by a specialized agency ("Report")
Year	Number	Year of publication
Title	Text	Complete title of the document
Case	Boolean (1 or 0)	Marker to identify case study documents
Literature Research	Boolean (1 or 0)	Marker to identify literature research documents
Metrics	Boolean (1 or 0)	Marker to identify articles which propose measuring parameters or procedures for cyber resilience
SCM	Boolean (1 or 0)	Marker to identify articles about supply chain management
RM	Boolean (1 or 0)	Marker to identify articles about risk management
ITM	Boolean (1 or 0)	Marker to identofy articles about information technology management
Field	"SCRM" OR "SCCRM" OR "ITRM"	Descriptor for the field of the document, either Supply Chain Risk Management (SCRM), Supply Chain Cyber Risk Management (SCCRM) or Information technology risk management (ITRM)
RESILIEN	Boolean (1 or 0)	Marker to identify the occurence of the word 'RESILIEN' in the title of the document
SUPPLY CHAIN	Boolean (1 or 0)	Marker to identify the occurence of the word 'SUPPLY CHAIN' in the title of the document
VULNERAB	Boolean (1 or 0)	Marker to identify the occurence of the word 'VULNERAB' in the title of the document
CYBER RISK	Boolean (1 or 0)	Marker to identify the occurence of the word 'CYBER RISK' in the title of the document
CYBER	Boolean (1 or 0)	Marker to identify the occurence of the word 'CYBER' in the title of the document
CYBER SECURITY	Boolean (1 or 0)	Marker to identify the occurence of the word 'CYBER SECURITY' in the title of the document
RISK	Boolean (1 or 0)	Marker to identify the occurence of the word 'RISK' in the title of the document
SUPPLIER NETWORK	Boolean (1 or 0)	Marker to identify the occurence of the word 'SUPPLIER NETWORK' in the title of the document
CASE	Boolean (1 or 0)	Marker to identify the occurence of the word 'CASE' in the title of the document
LITERATURE	Boolean (1 or 0)	Marker to identify the occurence of the word 'LITERATURE' in the title of the document

Table 3: Descriptors

The earliest evidence in literature where supply chain resilience was found explicitly, was in the work of Professor Martin Christopher and his team at Cranfield University (Christopher et al., 2004). This work is derived from his earlier research on supply chain agility as a way of counteracting for uncertainty in the demand (Christopher et al., 2001) and emerged after the foot-and-mouth disease event in the UK, and the 9/11 terrorist attacks in US, both during 2001. Christopher proposed a reference model for the characterization of resilience in the supply chain. The main aspects contributing to supply chain resilience were hereby identified as re-engineering, organizational culture, agility and collaboration.

A team at the MIT led by Professors Yossi Sheffi and Jim Rice, published in 2005 the influential article titled "A supply chain view of the resilient enterprise" (Sheffi et al., 2005). This work presented a disruption model based a proposed disruption theory for production systems (Asbjornslett, 1999) where this model was represented as a transient decrease in process performance. MIT's model built upon this initial model by identifying eight specific sequential phases describing a disruption event. These phases were identified as: preparation, disruptive event, first response, initial impact, time of full impact, preparation for recovery, recovery, and long-term impact. This work goes on to propose an enterprise "vulnerability map", through which the different disruption event probabilities and consequences are compared and ranked for prioritization.

Their work identified product demand as the main source of uncertainty in the supply chain, and acknowledged the increase in global uncertainty due to increased customer expectations, more global competition, longer and more complex supply chains, greater product variety and shorter product life cycles. This group considered organizational resilience as a strategic initiative to reduce vulnerability and therefore reduce likelihood of occurrence of a disruption. The most important factors identified by their work as relevant for resiliency building in an organization are three: redundancy, flexibility and cultural change.

Furthermore, a number of other resilience frameworks have been suggested in literature. Linkov (Linkov et al., 2013) proposed a resilience matrix representing a process for the event management cycles of disruptions. These steps are identified as plan/prepare, absorb, recover and adapt. Each of these phases are described for different domains within the organization, i.e., physical, information, cognitive and social. This same group has further suggested how to measure resilience according to this matrix.

A team from Ohio State University (Pettit et al., 2010) has proposed the SCRAM framework, i.e., supply chain resiliency assessment and management. This was based on the framework proposed by Christopher (Christopher et al., 2004), as well as case studies to identify vulnerabilities and capabilities within organizations. This team proposed an active relationship between the capabilities and the vulnerabilities in an organization, and its resulting resilience. They argue that the level of resilience that a company has to aim for is a balance between developing too many vulnerabilities (due to a lack of investment in capabilities) which could result in disruptions with undesirable economic effects, and the investment in too many capabilities, which would erode profitability. Hence, they enunciate an economic trade-off between investments (capabilities) versus risk (vulnerabilities).

A team led by Jeniffer Blackhurst (Blackhurst et al., 2011) at Iowa state university has proposed a global resiliency framework based on systems theory and the framework proposed by the MIT team. This team identified "resilience" enhancers and "resilience reducers". These are organizational attributes which either increase or decrease the ability of a firm to recover quickly and efficiently from a disruptive event. Their work identifies thirteen resiliency enhancers within three categories, and seven resiliency reducers, also within three categories. Their work is a valuable contribution as it derives these attributes from an industrial setting, and can serve as basis for further research in the empirical confirmation of these or other resilience attributes.

At an institutional level, some initial supply chain cyber- resilience frameworks have been proposed. The WEF (WEF, 2012a) created in 2012 an initiative called "Partnering for cyber-resilience" led by Elena Kvochko, as a response to the increasing importance of cyber-security. With more than 100 organizations involved, this initiative has created a series of reports describing principles for cyber-security, recognizing interdependence, leadership, integrated risk management, and uptake by partners in the supply chain, as crucial aspects for resilience building. Kvochko has proposed a maturity model for organizational resilience. Additionally Kvochko has recently published an initial framework for the measurement of cyber-threats, through the calculation of a "cyber-value at risk", and by combining eight factors grouped in three categories: vulnerability, assets, and profile of the attacker (WEF, 2015).

At a national state level, there are several initiatives in place concerning cyber-risk and cyber-security. In 2003, the United States government published the "National Strategy to Secure Cyberspace" (White House, 2003), and as part of a wider strategy from the Department of Homeland Security as a response to the 9/11 terrorist attacks and in line with Presidential Directive 63, which provides a framework for the protection of critical infrastructure (White House, 1998). In 2005, Germany started the "National Plan for Information Infrastructure Protection", with its main objectives being prevention, preparedness, and sustainability of the information infrastructure through the setting of international standards (German Federal Ministry of the Interior, 2005). By 2015, all EU member states except Portugal had published national cyber-security strategies, with Estonia having been the first in 2008 (ENISA, 2015).

Some standards have also been suggested frameworks for supply chain resilience. The US National Institute of Standards and Technology (NIST) developed in 2003 the special document series 800, also known as NIST 800, laying out guidelines for information security services. In particular NIST 800-161 (NIST, 2014) deals with supply chain risks management practices. In 2013, the United States government released Presidential Policy 21 and Executive Order 13636 to focus national attention on cyber-infrastructure resilience, establishing a risk-based standard to protect critical infrastructure against cyber-threats in collaboration with industry partners. There has been, however, documented debate around this approach, as standards based on risk assessment do not necessarily create resilience (Linkov et al., 2013).

The ISO has issued some standards which are applicable to resilience in the supply chain. From the point of view of Information Technology, the ISO 27036 (ISO, 2014) is a standard that has been proposed as general guidelines for the implementation of information security within supplier relationships. From the supply chain operations perspective, the ISO developed the ISO 28000 standard (ISO, 2007) as a specification for the security of operations in the supply chain, and the ISO 31000 (ISO, 2009) with principles and guidelines for risk management. More recently, the ISO 28002 (ISO, 2011) was published as guidelines specifically for the development of resilience in the supply chain.

CONCLUSIONS AND RECOMMENDATIONS

Our research found several definitions for supply chain resilience (Christopher et al, 2004, Sheffi et al., 2005), yet, the only documented definition found for cyber resilience is the one given by the World Economic Forum (WEF, 2014). As a result of the research in this paper, we propose that supply chain cyber-resilience can be understood as "the evolving characteristic of an organization to withstand disruptions to the information systems essential for supply chain operations, through capabilities that allow it to react with adaptability (agility, flexibility, and learning), limiting the disruption effect on customers".

Additionally, our systematic literature review seems to show that there is limited literature and no specific frameworks for cyber-resilience in the supply chain, despite the increasing relevance of the topic. We found that the existing supply chain resilience frameworks could be extended to consider cyber-risks through aspects such as cultural change (Sheffi et al., 2005) or collaboration and organizational culture (Christopher et al., 2004).

Finally, the main gaps found during the systematic literature review have given rise to a proposed research agenda. These suggestions are largely paths to descriptive and diagnostic analysis (i.e., what happened and why) as a first step, to then facilitate for the development of predictive analysis tools (i.e., what will happen), and eventually allow the development of prescriptive analysis tools (i.e., how can we make it happen).

Develop a systemic understanding of the problem: Literature on supply chain cyber-resilience is embryonic despite it being a relevant topic involving different areas within a company and actors within the society. There is a requirement for the development of a systemic understanding of the problem of cyber-risks in the supply chain, identifying major stakeholders, the relationships between these stakeholders, as well any feedback loops that might be involved in the evolution of this problematic.

Investigate the nature of cyber-attacks: Our research found no empirical studies on the ways in which cyber-attacks are affecting the supply chain through, for example, case studies. Studies should examine the attack goals (e.g., data theft, data modification, data falsification), the technical nature of attacks (e.g., tools, physical or digital barriers, verification procedures, data integrity), as well as human dimensions (e.g., cyber-attacker motivation, incentives).

Propose ways to quantifying cyber-resilience: Cyber-resilience theory can be advanced through the empirical quantification of the cyber-resilience of an organization, through case studies and stress testing of organizations with techniques such as non-invasive games (Gerencser et al., 2012), and based on a quantification of the organization's resilience which is comparable and actionable.

Quantify the dynamic effects of cyber-attacks: Additional to the systemic description of relationships, it is necessary to describe and quantify the dynamic effects present in the system, such as learning and reaction times, implementation delays or strength of cultural practices, to name a few.

Identify the data that is being collected or that has a potential of being collected on the supply chain processes concerning cyber-attacks, as it is very likely that organizations are under-utilizing data to which they have access, and which could lead to applications for prescriptive analytics.

Propose strategic ways of managing cyber risks: For example, academia may suggest portfolio investment to hedge risk by diversifying the business structure, where different areas counterbalance the effect of cyber-attacks. Other suggestions include establishing appropriate key performance indicators or reviewing organizational culture and leadership, such as roles or functions, which should be empowered for proactive management of supply chain cyber-resilience.

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QUALITATIVE IMPACT ASSESSMENT OF DISRUPTIONS (POLITICAL DISRUPTIONS) ON THE TEXTILE SUPPLY CHAIN PERFORMANCE

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ABSTRACT

This paper explore how political disruptions impact on the performance of supply chain by directly disrupting the supply chain networks of the textile industry in Pakistan. A qualitative methodology is adopted to explore a deeper understanding of the relationships between political disruptions and textile supply chain performance. Semi-structured interviews are conducted at 25 different textile manufacturing firms. The results of this study confirm the severe impact of political disruptions on supply chain performance. Political disruption however is perceived as a key factor that directly disrupts a supply chain through increased production and delivery lead time, caused transportation delays, interrupted raw material supplies to plants and distributors and constraint access to workers.

1. INTRODUCTION

With increased globalisation and the consequent decentralisation of production systems necessitates us to improve our understanding the relationships between political disruptions and supply chains. The impact of supply chain disruptions on supply chain performance has been the focus of recent studies. However, the role of political disruption as a key source of supply chain disruptions and the resultant impact on supply chain performance are yet to be theorised and empirically validated. Using the textile supply chains in Pakistan, this paper explores the relationships between political disruption and supply chain disruption and the way they are linked to supply chain performance.

Supply chains are becoming increasingly global, complex and competitive to meet the increased volatility, ubiquity and Just-in-time customer demands (Tang and Musa, 2011). Globalisation could also mean increased vulnerability of supply chains to disruptive events including economic, political and social unrest. Studies have shown that political disruptions have negative impacts of supply chain performance (Musa 2012). Political disruptions measure by cabinet changes, riots and street demonstrations, coups and revolutions and politically-motivated violence. Pakistan has a history of political disruptions (Safdar Ullah Khan 2011). This has significantly slowed down the economic growth and thwarted the future of democracy in Pakistan. Recent disruption, as claimed by the Government has resulted a loss of Rs547 Billion and Rs5 Million worth of public property in Islamabad. The impacts of these events on supply chains is severe. This economic and political uncertainty discourages international buyers to explore opportunities in other markets, The long-term impacts of political disruption is an exodus of skilled and trained workers to overseas labour markets, this in turn create labour and skills shortages. Textile industry also faces huge shortages in the supply of raw materials, and constant threat to transport and production disruptions (Shahbaz Rana 2004). The urgency of this issue is also acknowledge by the World Bank, which reports that Pakistan has roughly lost 2.1 percent of the GDP during sit-ins organised by political parties (Shahid Imran 2014). This paper addresses some of the key issues in linking political disruption and supply chain disruption. This is the first study that investigates the complex relationships between political disruption and supply chain disruptions and the resultant impact of performance in the textile industry in Pakistan. Three interrelated research questions were set out to answer this aim. These include:

- What is a political disruption?
- How does political disruption linked to supply chain disruption?
- How does political disruption impact supply chain performance?

2. LITERATURE REVIEW

A supply chain disruption is *"Unplanned events that may occur in the supply chain which might affect the normal or expected flow of materials and components"* (Svensson 2002). A supply chain disruption is an event that could take place at one point in the chain and can badly affect the performance of one or more elements located elsewhere in the supply chain and the normal flow of goods and materials within a supply chain (Craighead 2007; Melnyk 2009).Today's textile supply chain has become more complex than ever before due to globalisation, outsourcing and spatial fragmentation of production or consumption systems. As a result, there is an increased susceptibility to the global supply chain disruptions (Albayrakoglu 2007). The expected exposure of a supply chain to the potential impact of disruptions is usually considered by the possibility of disruption and the impact of disruption if it take place (Zsidisin 2005). Considering a supply chain as a network, a disruption can occur in any node or link of the chain. The source of the disruption maybe located inside or outside the chain. For instance, an interruption in the expected flow of material from one supplier can be because of economic failure of the supplier itself or might be caused by natural disasters like earthquake or flooding in the suppliers region. The performance of a supply chain is generally analyzed in terms of customer service level (e.g. unpunctuality, number of late orders), financial aspects (e.g. profit or operational cost) or a combination of both (Beamon 1999).

This study therefore proposed a conceptual framework, which explores the complex relationships between political disruption and supply chain disruptions and the resultant impact of performance in the textile industry in Pakistan (see figure 1). Direct and indirect impact of political disruptions on supply chain performance will be investigated by using this conceptual framework.

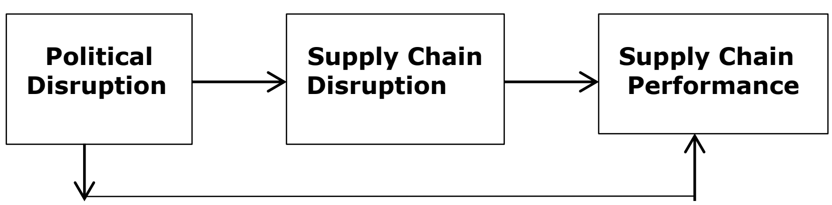

Figure 1: The conceptual framework

Pakistan is the 8th largest exporter of textile products in Asia. This sector contributes 9.5% to the GDP and provides employment to about 15 million people or roughly 30% of the 49 million workforce of the country. Pakistan is the 4th largest producer of cotton with the third largest spinning capacity in Asia after China and India, and contributes 5% to the global spinning capacity (Tribune 2013). In Pakistan, political, socio-institutional, national and international security have become the most crucial challenge for efficiency of textile supply chain (John Langley 2011) . According to Kobrin (1977) *"Political disruption we mean activities which are irregular (outside of the bounds expectations) in the context of a given society, typically violent and directed against the governing regime or its policies".* William (2008) also define political disruption as *"Political disruption refers to a situation in which conditions and* *mechanisms of governance and rule are challenged as to their political legitimacy by elements operating from outside the normal operations of the political system*." Different forms of political disruptions are, political violence, terrorism, military coups, riots and street demonstrations, revolutions, assassinations and guerrilla warfare (Kobrin 1977). Political violence, terrorism, coups and street demonstrations are the major forms of political disruptions effecting on supply chain performance in Pakistan. Political violence and terrorism are responsible for killing and distracting businessmen (Sher Ali Khan 2014). These are the amount of people (civilians and security personnel's) killed by terrorism from 2003 to April 19, 2015 in Pakistan.

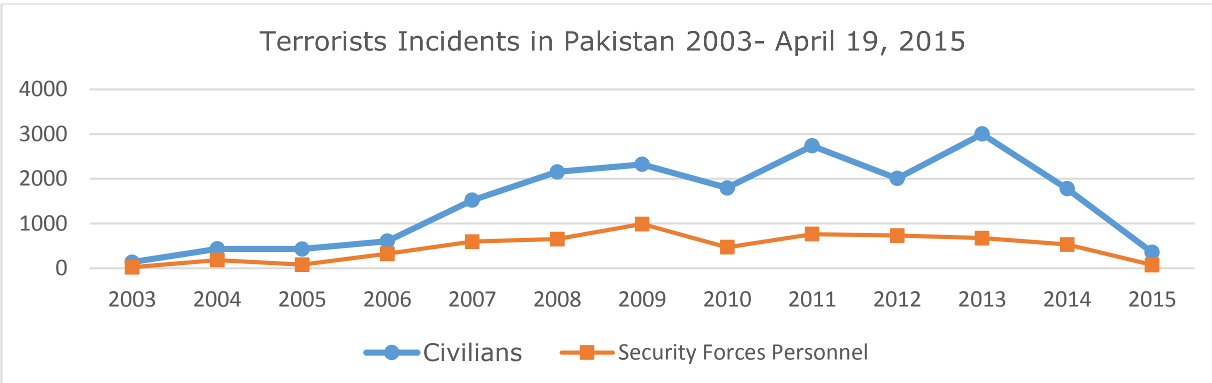

Figure 2: Terrorism Incidents in Pakistan 2003-April 19, 2015 (Satp.org 2015)

3. RESEARCH METHODOLOGY

Qualitative methodology was chosen to investigate the relationships between supply chain disruptions and political disruptions impact on supply chain performance. The study was carried out in the following steps. At first, interview questions were drafted on the basis of previous studies such as (Hilmola 2012; Kevin B 2012; Musa 2012; Wallace J. Hopp 2012), however the focus was placed on gathering in-depth understanding of political disruptions. Four key themes were developed and investigated through the interview process. These themes include, meaning of political disruptions, political disruptions relationship with supply chain disruptions, impact on supply chain performance and cross-theme analysis using vicious cycle. Interviews were conducted in Pakistan by 25 key personal of major textile manufacturers. They are chosen to represent their organization and all interviews were designed for 30 to 60 minutes. NVivo 10 was used in this study as qualitative data analysis tool and to establish the relationship between political disruptions and supply chain disruptions. Semi-structured interviews were conducted because they consist of several key questions that help to define the areas to be explored, but also allows the interviewer or interviewee to delve into an idea or theme to generate a more comprehensive and deeper response (Britten 1999). Collected data was analysed in this paper by coding the data in NVivo 10, the primary search feature utilized in this paper was Matrix Intersections (can be called as Matrix Query) method, which is a Boolean search, was used to explore the relationship between political disruptions and supply chain disruptions impact on supply chain performance.

4. RESULTS AND FINDINGS

This section presents the results and summarise the key findings. Results are presented using the key themes: a) meaning of political disruptions; b) political disruptions relationship with supply chain disruptions; c) impact on supply chain performance; and d) cross-theme analysis using vicious circle.

4.1 MEANING OF POLITICAL DISRUPTIONS

Supply chains have become more vulnerable to disruptions and frequency of supply chain disruptions seems to be increased with recent world events. Political disruptions considered as main source of supply chain disruptions and causing labour strikes, raw material quality problems, transportations delay, production delay, delivery lead time and supply chain performance. Political disruptions defined by several textile industry participants during interviews. According to textile spinning manufacturer;

"Political disruption we can say that the condition under which government fails to maintain law and order"

Textiles and garment industry is important in two respects of foreign exchange earnings and employment creation. Textile and garments constitutes around 60% Pakistan's total exports, and garments share gradually growing (Momoe Makino 2012). Textile garments manufacturer's required stable political environment to maintain their supply and demand. Political disruptions mainly effect garment manufacturers because most of the garment products manufactured for European markets and garment manufacturers badly impact by current political disruptions. Pakistan has a great deal of political disruptions emanating from the premature dismissals of governments, assassinations of party leaders, frequent government changes and martial laws. Such political conditions seriously harms the implementation or continuation of government policies. One textile exporter defined the political disruptions;

"All actions or events against government regime or government politicise called political disruptions"

Political disruptions seems as major threat to supply chain performance in Pakistan. The evidence presented above underscore why political disruptions and its impact on supply chain performance important to understand in context of Pakistan textile industry. Political disruption causes the decline in Pakistan textile industry. It's important to understand that, what is political disruption? And how this link to supply chain disruption resultant impact on supply chain performance.

4.2 POLITICAL DISRUPTIONS RELATIONSHIP WITH SUPPLY CHAIN DISRUPTIONS

This section inspect the political disruptions relationship with supply chain performance by analysing production planning and execution and delivery lead time.

4.2.1 PRODUCTION PLANNING AND EXECUTION

Textile is the sector where planning and execution is important because textile manufacturing consist of series of processes inter connected with each other. If any of the process is delayed or disturbed by any reason it will effect on whole supply chain performance. Political disruption has its influences differently on textile industry. Textile manufacturers are required to plan their production strategy and execute as per order requirement, but in Pakistan because of unstable political system, manufacturers are struggling to execute their plans. One textile spinning manufacturing industry participant argue that;

"With frequent changes in government and their policies are hindering us to plan and prepare for further improvements"

Planning and execution is one of the most important part of textile manufacturing because, competition are no more only with individual firms also with their supply chains. Manufacturers may focus and maintain their production by proper planning and goal settings. For this, they need to know what kind of problems they can face if they are working in disrupted political conditions. On the one hand, uncertainty associated with unstable political environment may reduce investment and the speed of textile business development in the country. On the other hand, poor planning and execution may leads to long delivery lead time resultant effect on supply chain performance. One garment manufacturer argue that;

"We consider political disruption as a high risk factor while preparing for any new order or new product manufacturing"

Stable political conditions more suitable for manufacturers to improve their supply chain performance. With unstable political conditions, textile manufacturers may face raw material shortages that may leads to production uncertainty.

4.2.2 DELIVERY LEAD TIME ISSUES

Delivery lead time important and discussed because of Pakistan's current political conditions. Textile supply chains are more vulnerable to disruptions when the lead time is long. Delivery lead time starts with customer's order placement and end at delivery of particular product to customer. In textile industry, delivery lead time is important because product manufacturing process is quite longer than any other industry and chances of delay in production, raw material delivery and machine shutdown are higher.

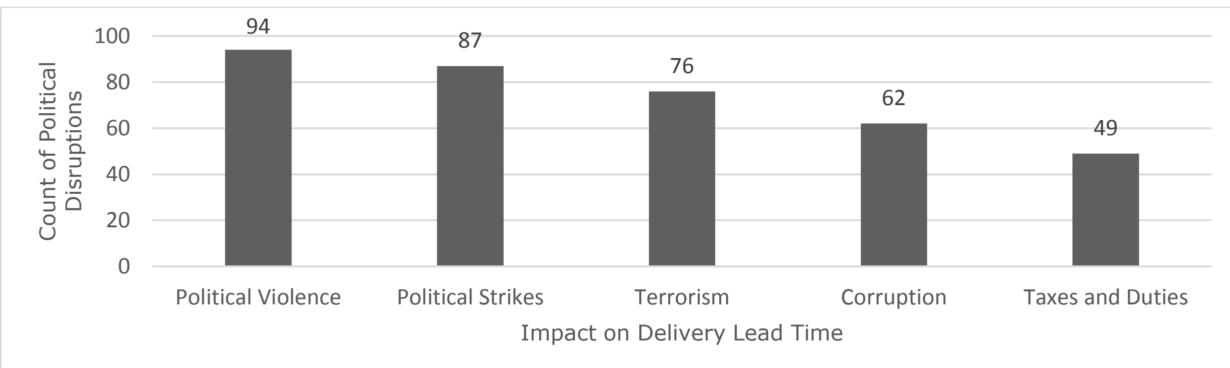

Figure 3: Political Disruption Impact on Delivery Lead Time

Results indicate that, more manufacturers where worried about problems from political side or associated with government. According to one textile apparel manufacturing participant;

"Pakistan having big problems in political system and getting serious because of clashes between parties to get in power and this situation affect us to maintain our production"

In today's textile world, manufacturers and retailers are looking for shorting the delivery lead time by any possible way. One way to improve delivery lead is by improving the supply chain performance and to manage disruption in their supply chains. With bad supply chain and disrupted political conditions, delivery lead time may not be able to reduce. According to one textile producer;

"Delays in production is the main issue that we are facing at the moment due to governments non serious behaviour towards handling textile industry problems totally disappointing for us"

Terrorist attacks, political violence, political strikes and transportation delays are causing long delivery lead time in Pakistan. Textile manufacturers are required raw material from different part of the country to maintain their production, but due to unstable political conditions, they are mostly unable to meet delivery lead time.

4.3 IMPACTS ON SUPPLY CHAIN PERFORMANCE

Supply chain disruptions are unplanned events such as, road accidents, natural disasters and labour strikes impacting on supply chain performance. Results (see figure 4) represent all major disruptions (other than political disruptions) defined by textile industry people during data collection. In this part, transportations delay and production delay got higher reference count that represent their effect on supply chain performance.

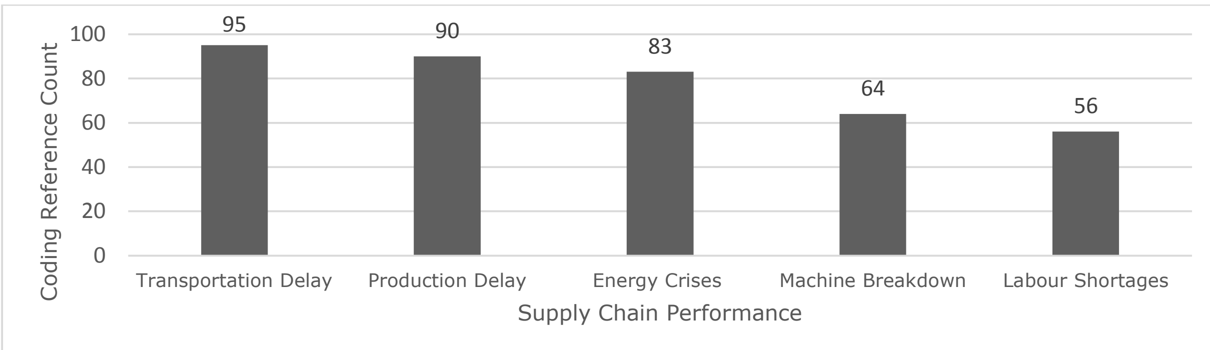

Figure 4: Disruptions impact on Supply Chain Performance

In Pakistan, most of textile industry based on horizontal integrated units and few of them are based on vertical integrated units. Because most of the industry based on horizontally integrated units, textile manufacturers requires raw material from different manufacturers located elsewhere in the country. For example, textile yarn manufacturers require cotton bales from ginning, and ginning mills are located for away from spinning facilities. Supply chain disruptions has serious impact on supply chain performance due to which they are interrelated to each other. One textile hosiery manufacturing industry participant argue that;

"We are manufacturing for international firms and disruptions in our operations can badly impact that's the reason why we are concerned about supply chain performance"

Textile organizations are facing these disruptions and working to find immediate solutions because these disruptions are impacting on their supply chain as well as business.

4.4 POLITICAL DISRUPTION IMPACT ON SUPPLY CHAIN PERFORMANCE

Results (see figure 5) shows that, the impact of political disruptions (all forms of political disruptions) on textile supply chain performance are more badly than other disruptions. There are five forms of political disruptions coded and presented in graph to find the impact of each political disruption form on supply chain performance. In last few years, political disruption were raised because of raging in last election claimed by opposition parties. They started long march, blocked roads, shutdown whole cities one by one and started civil war against government. In the result, whole supply network for all kind of textile manufacturers where disturbed. Textile manufacturers where out of workers and raw material supply. One textile apparel manufacturer argue that;

Political disruption badly effects our supply chain network because strikes and political conflicts delaying our production as well as delivery"

Pakistan is located where neighbour countries like India and china politically stable and their manufacturers are growing their business because of their mature political system, international relations and strong supply chain networks. According to one yarn manufacturing industry participant,

"Textile industry required stable political conditions to compete in international market but current political disruptions are hindering to achieve our goals"

Stability in political system facilitate manufacturers to get more business but unstable political system creates many issues for instance, investors stop their investments, businessmen and buyers move to other countries and country face huge economic loses. Therefore, ignoring problems is not the solution and government should introduce new policies, maintain law and order situation, provide full security to business community and provide facilities to access into international market. According to textile manufacturer,

"Terrorism, political strikes and targeted violence are causing supply chain network issues"

Finding of this study makes a convincing case that ignores the effects of political disruption on supply chain can have serious negative effects. Results (see figure 5) show that disruption in supply chain not only impact on performance also impact on planning and execution and delivery lead-time. Internal and external sources to the supply chain including natural disasters, transport failure, labour dispute, terrorism and political disruptions are all causes of supply chain disruptions. These events can create different levels of disruptions in supply chain from the upstream to downstream stages. Political disruptions, in its nature, cause the supply chain disruption that interrupts the material flows in the supply chain, resultant effecting of supply chain performance. Higher the uncertainty in political system, lower the material flow and resultant the effect on supply chain performance.

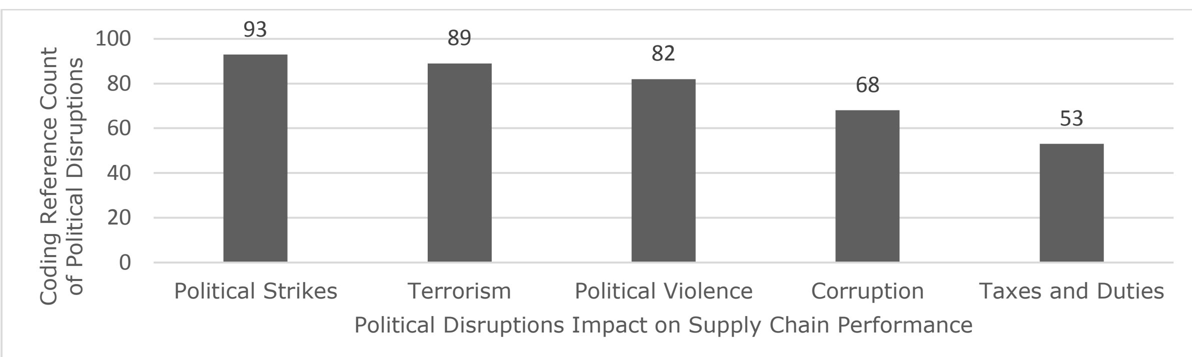

Figure 5: Political Disruption Impact on Supply Chain Performance

4.5 CROSS-THEME ANALYSIS – VICIOUS CYCLE

The following vicious cycle (see figure 6) was design based on political disruptions impact on supply chain performance in Pakistan's textile industry. According to vicious cycle situation, political strikes are the form of political disruptions initiating delays in transportation, which leads to delays in production resultant effect on delivery lead time and, long delivery lead times are tends to create severe effects on supply chain performance. At this point, supply chain performance needs to be improved by, re-scheduling it by breaking cycle from vicious to virtuous cycle. As we discussed in conceptual framework (see figure 1), major problem is that the various supply chain disruptions are result of political disruptions that intend to effect on supply chain performance. According to textile industry participant;

"Most of disruptions we are facing in daily operations directly or indirectly because of current political system"

The findings give strong and consistent support to the argument of political disruptions are directly and indirectly impacting on supply chain performance by linking with supply chain disruptions. Political disruptions has negative effects on components of supply chain resultant supply chain disruptions. These political disruptions by interrupting on normal material flow that initiating production delays. A stable predictable political environment allow manufacturers to sustain their supply chain performance.

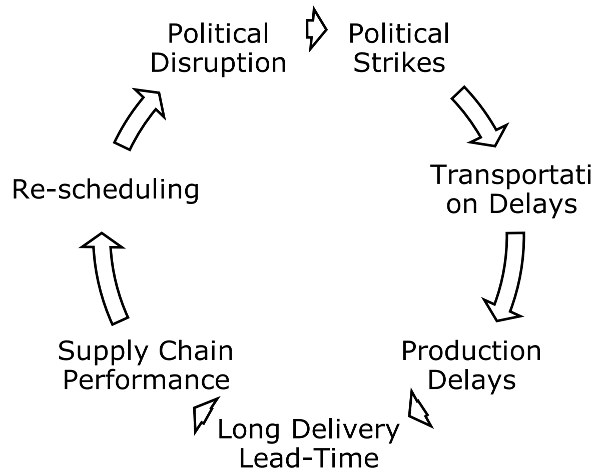

Figure 6: Vicious Cycle of Political Disruptions Impact on Supply Chain Performance

5. CONCLUSION

This paper explored the relationship between Political disruptions on supply chain performance in Pakistan. The findings suggest that political disruptions often are not directly impact of supply chain performance, however their impact is mediated through supply chain disruptions. In other words, political disruptions tend to indirectly impact on supply chain performance via supply chain disruptions. The impacts however are complex and convoluted. Political disruptions, regardless of its size and scale, tend to cause large scale supply chains disruptions with long-term impacts. This might suggest the impact similar to 'bull-whip effect', which cascades down from initial ginning stage though to final stage garments/apparel manufacturing and distribution of textile to end customers. The complexity of this relationships is illustrated through a vicious circle of supply chain disruptions. This indicates that political disruption causes ripple effects the supply chain whereby supply chain coordination and collaboration such as longer lead-time, production delay, re-scheduling, transportation delays, production facility shutdown are affected. In this paper, we study the effects of political disruptions on supply chain performance by using conceptual framework. Political disruptions has serious effects on supply chain performance directly or linking with supply chain disruptions in Pakistan.

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ESTABLISHING A FRAMEWORK FOR THE EFFECTIVE DESIGN OF RESILIENT SUPPLY CHAINS WITH INHERENT NON-LINEARITIES

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Abstract

Purpose of this paper: Previous control theory research on supply chain dynamics has predominantly taken a linear perspective of the real world, whereas nonlinearities have usually been studied via a simulation approach. Nonlinearities can naturally occur in supply chains through the existence of physical and economic constraints, for example, capacity limitations. Since the ability to flex capacity is an important aspect of supply chain resilience, there is a need to rigorously study such nonlinearities. Hence, the purpose of this paper is to propose a framework for the dynamic design of supply chains so that they are resilient to nonlinear system structures.

Design/methodology/approach: Building on an existing framework to design supply chains (Naim and Towill, 1993) from a real world situation through data capture, modelling, analysis and onto redesign recommendations, we synthesize current research on supply chain resilience and recent developments in nonlinear control theory techniques. We then apply the knowledge gained to develop a new framework and demonstrate its application via a real world case study.

Findings: An updated framework is provided for the synthesis and design of nonlinear supply chain dynamics models and a future research agenda is developed. The framework improves the understanding of the system's behaviour and the impact of nonlinearities on system response. Consequently, supply chain resilience can be enhanced.

Value: The real world is nonlinear and the existence of such nonlinearities makes the understanding of system dynamics difficult. This paper has an academic value since the proposed framework aids system dynamics researchers to gain better insights into complex nonlinear model structures and acts as a precursor to simulation based approaches.

Practical implications (if applicable): The proposed framework may be applied in an industrial context for analysing nonlinearities in a real-world system. The framework provides a process by which supply chain designers gain more insights into nonlinear system dynamics behaviour without going totally relying on time-consuming simulation activity on its own.

INTRODUCTION

Modern supply chains are becoming more and more complex. With the supply chain leaning and lengthening as a result of globalisation, supply chains are becoming more vulnerable to disruptions (Christopher and Peck, 2004). Managers have optimised supply chains by reducing holding inventory, outsourcing noncore activities, cutting the number of suppliers and sourcing globally, on the assumption that the world market is a relatively stable and predictable place (Kearney, 2003). This uncertain and complex business environment has increased the importance of handling risks that can emerge from the customers' or demand side, the suppliers' side, manufacturing processes and control systems (Mason-Jones, 1998). Hence, the ability of a supply chain to be resilient became vital to sustain competitiveness (Pettit et al., 2010).

When investigating the dynamics of supply chain systems, previous analytically based research has predominantly taken a linear perspective of the real world, whereas nonlinearities have usually been studied via a simulation approach. Nonlinearities can naturally occur in supply chains through the existence of physical and economic constraints, for example, capacity limitations. Since the ability to flex capacity is an important aspect of supply chain resilience, there is a need to rigorously study such nonlinearities. Hence, the purpose of this paper is to propose a framework for the dynamic design of supply chains so that they are resilient to nonlinear system structures.

In 1994, Naim and Towill, based on a paper presented at the inaugural International Symposium of Logistics in 1993, developed a framework that used system dynamics modelling, analysis and simulation aids in the decision making process to design supply chain systems according to their management objectives. "This methodology is a direct offshoot of the pioneering works of Jay Forrester" (Bechtel and Jayaram, 1997) and it has been advocated, utilised and adapted by other authors (e.g. Kumar and Nigmatullin, 2011; Bhatti et al., 2012) to design efficient supply chains, re-engineer processes and analyse supply chains' dynamic behaviour.

Building on Naim and Towill (1994)'s work, we synthesize recent developments in nonlinear control theory techniques and current research on supply chain resilience. Our aim to apply the knowledge gained to develop a new framework and demonstrate its application via a 'real world' empirical case study.

NONLINEAR CONTROL THEORY

Nonlinear control theory is the area of control theory that deals with systems that are nonlinear and/or time-variant. Control theory is an interdisciplinary branch of engineering and mathematics that is concerned with the behaviour of dynamical systems and it has seen limited use in the study of supply chain dynamics.

While system dynamics simulation is often used in the analysis and redesign of supply chain models that exhibit nonlinearities, quantitative analytical approaches are more often restricted to linear representations of supply chains. Hence, much of the research on supply chain dynamics either takes a 'trial and error', experimental, simulation approach to redesign (Forrester (1958), Sterman (1989), Larsen et al. (1999); Laugesen and Mosekilde (2006); Hamdouch (2011)) or develops exact solutions of models that are already linearised approximations to the real-world situation (Disney and Towill, 2005; Gaalman and Disney, 2009; Zhou et al., 2010). In reviewing the control theory we found a number of methods for analysing nonlinear system dynamics including those used in supply chain dynamics research (Table 1).

Insights gained from nonlinear control theory literature

This research conducted an extensive literature search and review on the specific topic of nonlinear control theory. To date, simulation techniques have mainly been used to deal with complex, nonlinear supply chain systems. However, our research presents a more rigorous approach that permits mathematical analysis of nonlinearities (Figure 2) as a precursor to simulation experiments.

Firstly, simplification methods should be used to eliminate unnecessary complexities in the model and reveal the underlying relationship between the variables. Then, some of the linearisation methods presented in Table 1 were used to analytically investigate common nonlinearities present in a 'real world' supply chain system.

General approach	**Method of analysis**	**Supply chain application**
Linearisation methods	Small Perturbation Theory with Taylor series expansion	Jeong et al. (2000): Limited application for analysis in SC context Saleh et al. (2010): recommends for SC design but does not apply it.
	Describing Function	None identified
	Small Perturbation Theory with Volterra/Wiener series expansion	None identified
	Averaging and best-fit line approximations	Wikner et al. (1992): testing SC re-engineering strategies Naim et al. (2012): identifying analogies between seemingly different decision rules
Graphical and simple methods	Phase Plane and Graphical Solutions	None identified
	Point transformation method	Wang et al. (2014): Exploring nonlinear behaviour of inventory systems
Exact Answer	Direct solution	None identified
Complex method	Lyapunov-based stability analysis for piecewise-linear systems	Wang and Disney (2012): Stability of inventory systems
Simulation	Numerical and Simulation solution	Sterman (1989): Mis-perceptions of time delays and feedback loops Larsen et al. (1999); Laugesen and Mosekilde (2006): Shaping stability regions of discontinuous systems Shukla et al. (2009): Bullwhip and backlash analysis Hamdouch (2011): Effect of capacity and batching

Table 1. Summary of methods used to analyse nonlinear systems

While the use of this approach potentially yields insights to bear on the understanding of supply chain dynamics behaviour our empirical study is limited to consideration of discontinuities.

ASSESSING SUPPLY CHAIN RESILIENCE

The concept of resilience is multidisciplinary, arousing interest from scientists in various disciplines. In physics and engineering, resilience is the ability of a material to return to its original form after being bent, compressed, or stretched. In other words, it is the ability to behave elastically (Pytel and Kiusalaas 2003). In the supply chain literature, the idea of resilience has only recently emerged, and is essentially defined as ''the ability of a system to return to its original state or move to a new, more desirable state after being disturbed'' (Christopher and Peck 2004).

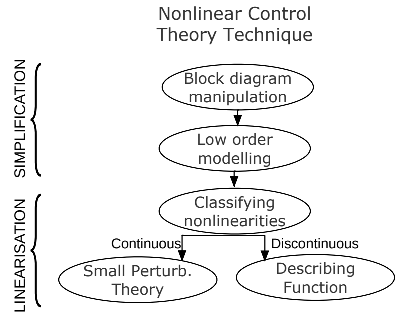


Figure 2: Application of nonlinear control theory

When reviewing the supply chain literature on resilience, we found a number of contradictions and a domination of qualitative aspects that are difficult to measure. In addition to this, several metrics have been used by quantitative researchers to assess resilience. It is important to develop a single measure of resilience to ensure consistency and repeatability of results. In order to achieve this, a clearer and exact concept is needed.

Using theory building, Ponomarov and Holcomb (2009) developed a holistic conceptual framework for supply chain resilience which was defined as: ''the adaptive capability of the supply chain to prepare for unexpected events, respond to disruptions, and recover from them by maintaining continuity of operations at desired levels of connectedness and control over structure and function''. This definition implies achieving the following.

(1) Readiness: being prepared or available for service. The implication of this definition is whether the supply chain can continue providing goods/services at reasonable costs according to the end customer requirements.
(2) Sensing: minimising the lag between the event occurring and the supply chain's recognition of the event. It ensures the number of options available to the supply chain manager is maximized.
(3) Response: reaction to a specific stimulus. A quick response implies minimising the time to react to disruptions and beginning the recovery stage.
(4) Recovery: a return to, or finding an alternative 'normal' stable or steady-state condition.

Sheffi and Rice (2005) established how disruptions would affect companies' performance, which can be measured by sales, production levels, profits and customer service. Their findings demonstrate different phases of the system's performance response: after a disruption the performance decreases but as actions are taken the system's performance will gradually be restored. Similarly, Tierney and Bruneau (2007) also highlight the relation between a disruptive event and business indicators. They call this loss of functionality from disruption followed by a gradual recovery the 'resilient triangle'. According to them, this triangle should be minimised.

FRAMEWORK TO DESIGN RESILIENT SCs AND A REAL WORD APPLICATION

Based on Naim and Towill (1994), a framework to design resilient supply chains is presented in Figure 3. The main difference between Naim and Towill's (1994) framework and the one presented in Figure 3 is the replacement of linear control theory with a nonlinear approach. Hence, this research has addressed the gap in Naim and Towill's (1994) framework which considered only linear control theory techniques to investigate 'presumably linear' models. Moreover, we have addressed a gap in the supply chain literature by examining a particular business objective: to be resilient to nonlinear system dynamics. This qualitative performance objective was converted into quantitative measures in order to use the proposed framework in Figure 3. In this method, there are two distinct, but overlapping, phases of analyses. In the qualitative phase, both the objective of the study and the key drivers are identified through an intuitive and conceptual modelling process. Then, the relationships among key drivers are represented in a block diagram. The second phase is the quantitative analysis, which is associated with the development of mathematical and simulation models. Figure 3 also highlights the steps taken in the empirical research and the main contributions to the framework.

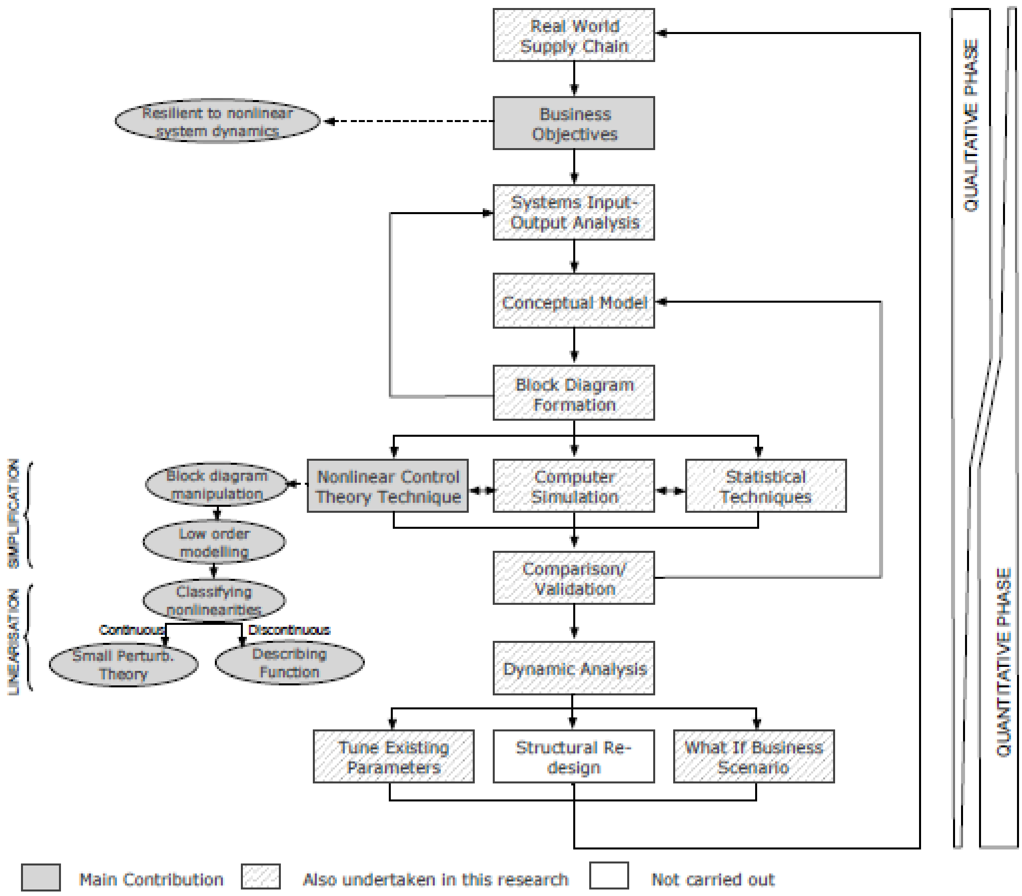


Figure 3: Proposed framework to design resilient supply chains
Extended from: Naim and Towill (1994)

Qualitative phase

This phase started by exploring a particular supply chain system: a major UK grocery retailer with the purpose to suggest improvements to the system, although the underlying structure could not be adjusted. For that, knowing the business and/or research objectives was very important. Forrester (1958) also indicated that in designing a model of an organisation the elements that must be included arise directly from the questions that are to be answered or objectives that are to be achieved. Moreover, since there is no all-inclusive model, different models should be created to address different questions about the same system and models can be extended or altered so that new objectives are achieved. Our research aimed at examining the resilience of their distribution centre (DC) stock ordering systems of the grocery retailer.

Naim and Towill (1994) suggested that four main business objectives could be evaluated using their framework. These are: inventory reduction target, controlled service levels, minimum variance in material flow and minimum total cost of operations and procurement. In this research, a fifth objective has been included: increased supply chain resilience. Moreover, organisations should be aware that there are trade-offs between these objectives and different weighting may be given to each of them.

The resilience term, which has mainly been described in qualitative aspects, was converted into a measurable form by exploring the literature of natural and social sciences. Then, supply chain metrics were chosen to represent this qualitative performance and an index, based on the Integral of Time Absolute Error criterion, was found to epitomise the resilience attributes (refer to Spiegler et al, (2012) for more detail). It was important that, before implementing this newly proposed resilience performance index, tests were made to verify whether this index could provide results consistent with the descriptions in the literature.

The next step was to describe how the material and information flows occur and how production control is managed. This input-output analysis (Figure 4) informs material and information delays, production and logistics constraints, how information is processed and how planning and scheduling operations are carried out. The information obtained from this step then supported the development of a suitable conceptual model.

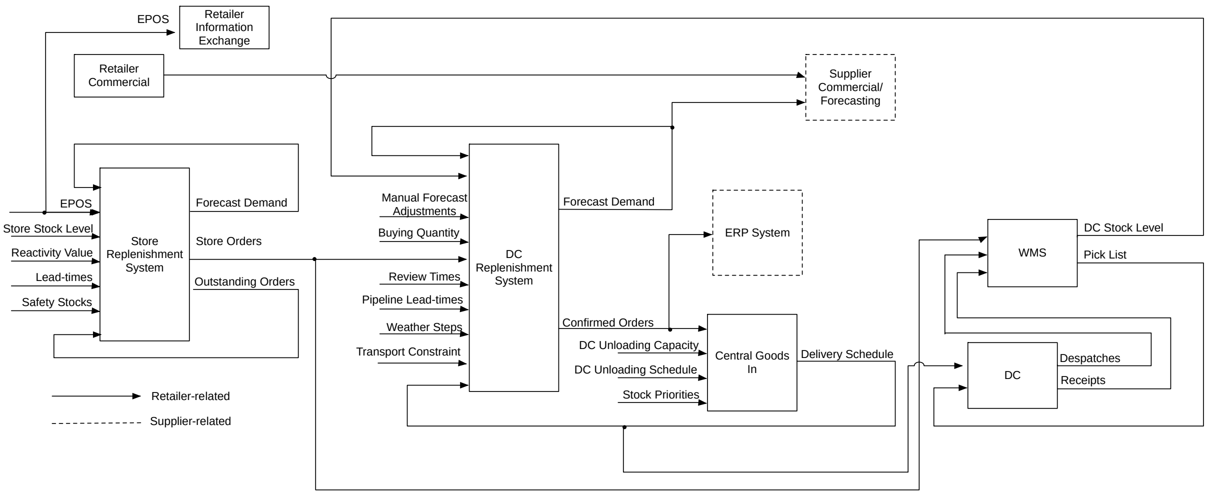


Figure 4. Input-Output diagram of replenishment information flows within the retailer

Finally, as the operations and control procedures become known, the soft system diagram was converted into control engineering block diagram form (Figure 5). This contains mathematical descriptions of the relationships between the various interacting variables in the conceptual model. Each block in the block diagram establishes a relationship by including a mathematical expression that, for example, may represent delays. At this stage, considerable insights into how supply chains work were attained.

Quantitative phase

According to Naim and Towill (1994), the first step of the quantitative phase is choosing one or more of three possible techniques for analysing the supply chain: control theory, computer simulation and statistical analysis. The choice of each method depends on the degree of complexity involved in the setting up of a mathematical model, the volume of data available for analysis and the analytical skills of the supply chain designer.

<u>Nonlinear control theory</u>: We firstly recommend the use of nonlinear control theory techniques before undertaking simulation analysis. This is due to the fundamental insights and understanding that this technique provides, as discussed previously.

The first step for the analysis of complex, high-order models was to undertake simplification. If the system can be simplified that is when underlying control mechanisms are revealed (Wikner et al., 1992). Moreover, because the simplification process provides a clearer view of the model it also aids in the analysis and synthesis of any nonlinear elements. The block diagram in Figure 5 is already in its simplified form and two nonlinearities are clearly identified: ROUNDING and CLIP functions.

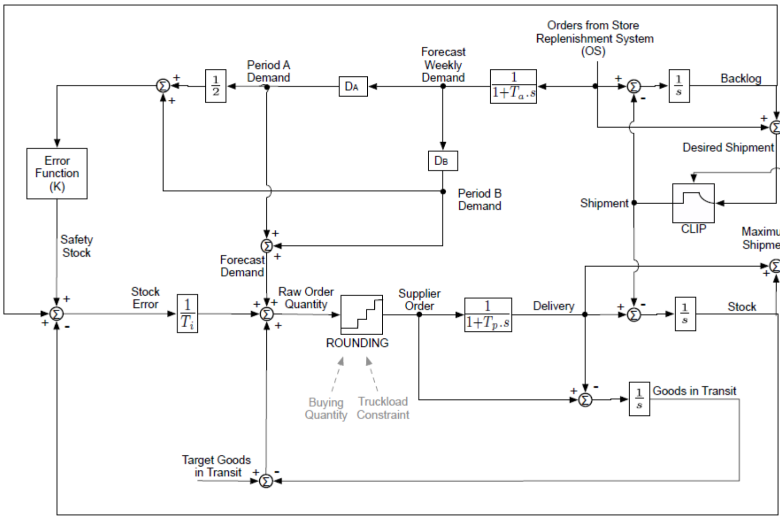
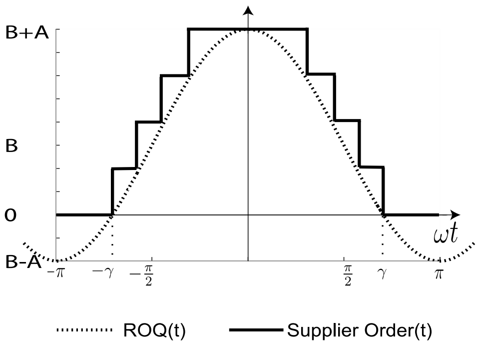
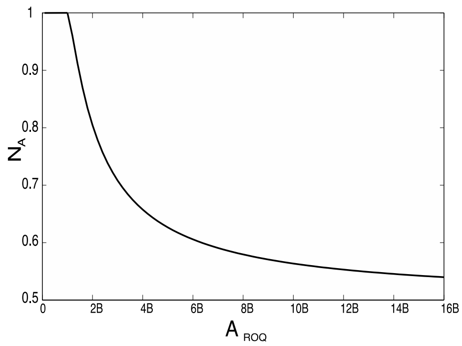


Figure 5. Block diagram of the DC replenishment system

The second step was to analyse the effects of the nonlinearities present in the system. In Table 1, several methods for the analysis of nonlinear models have been presented. In particular, the linearisation methods are recommended whenever a solution can be obtained in this way because there are a variety of techniques available in linear systems theory. We applied describing function techniques for the analysis of both discontinuous nonlinearities. For instance, in Figure 5 if a sinusoidal signal of $ROQ(t) = A.\cos(\omega t) + B$, where ω is the angular frequency, A is the amplitude and B the mean, inputs to the ROUNDING nonlinearity, an output (Supplier Order) of same frequency and phase but different amplitude and mean will be produced as shown in Figure 6a. Although the Supplier Order is nonlinear, it can be represented by piecewise linear equations:

$$Supplier\ Order(t) = \begin{cases} ROQ(t), & if\ ROQ > 0\ (-\gamma < \omega t < \gamma) \\ 0, & if\ ROQ < 0\ (-\pi < \omega t < -\gamma\ and\ \gamma < \omega t < \pi) \end{cases} \quad (1)$$





a) Time series for Supplier Orders *b) Amplitude gain of Supplier Order*

Figure 6. Application of describing function on the ROUNDING nonlinearity

The basic idea of the describing function is to represent a nonlinear element by a type of transfer function, or gain, derived from its effects on a sinusoidal input signal. Given ROQ as a sinusoidal input, the output Supplier Order can be approximated to:

$$Supplier\ Order(t) \approx N_A.A\cos(\omega t + \emptyset) + N_B.B \quad (2)$$

where $\emptyset$ is the phase angle and N_A and N_B are the amplitude and mean gains of the describing function, respectively. For describing function analysis on N_A is needed and this gain can be determined as a function of the input amplitude (A_{ROQ}) by expanding the series and estimating the first harmonic coefficients (Figure 6b)

Computer simulation: After having a better understanding of the system's behaviour and its underlying structures, single or repeated simulations were carried out to confirm the insights acquired in the previous step and to obtain a more exact result of the system responses. The advantage of simulations is that the original conceptual model can be studied without simplification or linearisation, but from experience gained in this research process it is very hard to gain insights from only simulating complex models. Moreover, previous researchers stated that simulation approach might overlook underlying mechanisms and dynamic behaviour (Karafyllis and Jiang, 2011).

Table 2 summarises the insights gained from conducting nonlinear control theory analysis prior to simulation experiments.

Analytical Insights	**Resulting simulation experiments**	**If not carried out**
• Possibility to find system's transfer functions	• Simulation process focused on important parameters for achieving supply chain resilience	• A lack of understanding of the effect of each control parameter on resilience.
• Possibility to find an inventory drift problem in the DC replenishment system	• Simulations were undertaken to visualise the problem and to test solutions	• Possibly gone unnoticed. Although step input simulation revealed the same result, this drift effect is only perceived if plotting both safety and current stocks together.
• Understanding the impact of the different nonlinearities and input amplitudes on system's damping ratio and natural frequency.	• Simulations were undertaken to check whether the analysis gave correct insights and more effort has been given to check unexpected results.	• The understanding of nonlinearities would be very difficult and some results would have been missed when using only simulation techniques.
• Understanding the impact of different input frequencies on system's behaviour	• Simulations were undertaken only to confirm analytical insights.	• Several simulation experiments would have been necessary to gain the same insights

Table 2. Summary of insights gained from the quantitative phase

Statistical techniques: Finally, statistical techniques can be used to analyse real data if sufficient volume of data is available for the purpose of analysis. Such techniques may involve de-trending, smoothing, range analysis, auto- and cross-correlations to identify features in the data, such as degree of scatter, short/long term trends, cyclical variation and exogenous events. In this research, this technique is used only for the initial validation process.

Comparison and validation of the model involved consultation with the interested parties in the supply chain by talking to the system manager through the equations entered into a spreadsheet. Spreadsheet system dynamics simulation was chosen so that the model could be easily understood by the staff at the retailer. This feedback of information ensured that there was no misinterpretation of the results. Then, tests using extreme input and parameter values and eliminating assumptions were undertaken. Finally, actual data from the real system has been used. The information on three different products, obtained on electronic point of sale (EPOS) and DC replenishment orders, has been used.

Following the validation process, the model was subjected to extensive dynamic analysis. The objective of this stage is to determine the dynamic performance of the supply chain by subjecting the model to severe test inputs. In this research the supply chain resilience performance was investigated by making a sharp, step change in the customer demand. Moreover, changes in damping ratios and natural frequencies have also been used as an estimation of the resilience performance.

Finally, the supply chain models were inspected by changing the control parameters, creating various scenarios and undertaking sensitivity analysis to reveal how vulnerable the supply chain is. Naim and Towill (1994) suggest a structured approach to exploit supply chain models:

- Tuning existing parameters: supply chains can be redesigned by varying the control parameters to improve performance, without changing the original structure. This research made use of this technique to find the resilience regions of the different parameter settings.
- Structural redesign: this involves altering the model's structure, such as removing an echelon or including a feedback information into the control system. The purpose of this research was to suggest improvements to the system without changing the underlying structure of the system.
- 'What if?' business scenarios: this involved testing how the supply chain performs for alternative business propositions or unexpected changes in the business scenario. This research tested the impact of expected changes in physical parameters, such as lead-times.

CONCLUSION

An updated framework has been provided for the synthesis and design of nonlinear supply chain dynamics models. The framework improves the understanding of the system's behaviour and the impact of nonlinearities on system response. Consequently, supply chain resilience can be enhanced.

More importantly, this research has contributed in providing a systematic procedure for the analysis of the impact of nonlinear control structures on systems behaviour. The previous framework developed by Naim and Towill (1994) suggested that nonlinearities could be only analysed by undertaking simulation experiments. By adopting nonlinear control theory, this research has found more accurate linear approximations for reproducing nonlinear models, enhancing the understanding of the system dynamics and actual transient responses. Moreover, the analytical phase was found to be an important precursor for undertaking simulations.

Furthermore, we have shown how the proposed framework can be applied in an industrial context for analysing nonlinearities in a real-world system. The framework provided a process by which supply chain designers gain more insights into nonlinear system dynamics behaviour without only relying on time-consuming simulation.

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Section 2: Supply chains and networks

DEMAND-DRIVEN INNOVATION IN MATERIAL PLANNING AND CONTROL: A REVIEW OF EARLY IMPLEMENTATIONS

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Abstract

Purpose of this paper

The paper reports on research into decision-adoption process experienced by companies as they consider implementing Demand-driven, as an alternative to traditional ERP-based approaches planning and control.

Design/methodology/approach

A focus group with three experienced consultants was undertaken to gain expert opinion of the Demand-driven adoption process, and a broad appreciation of the innovation. An in depth investigation into the adoption process was undertaken through participant observation in the adoption-decision and implementation process.

Findings

The research suggests that Demand-driven is a significant innovation that is well grounded in established principles of Operations Management/Supply Chain Management, and that it will continue to diffuse due to low entry costs and ease of trialability.

Research limitations/implications (if applicable)

The qualitative research presented here is based on a modest data set, and further research will be required to develop/challenge the findings and improve validity. Interviews with users, site visits and analysis of published case studies will be particularly important to triangulate the findings.

Practical implications (if applicable)

The research suggests that the barriers to adoption are relatively low. Demand-driven represents a significant challenge to the orthodox MRP/DRP approaches that are embedded in today's ERP systems.

What is original/value of paper

Demand-driven is a significant development which, so far, seems to have escaped the attention of the academic community.

Keywords

Demand-driven, ERP, adoption-decision

Category of the paper

Research paper.

INTRODUCTION

Demand-driven materials planning and control represents a significant and well-developed alternative to the traditional approach to MRP/DRP that is embedded within today's leading ERP systems. The term 'Demand-driven' emerged from the ERP company PeopleSoft in 2002 (Ptak and Smith, 2011). It has been developed upon principles to be found in other supply chain approaches, including Lean/JIT, the Theory of Constraints (TOC) and Factory Physics, and is now promoted by the Demand Driven Institute (DDI). The rationale and principles of Demand-driven have been thoroughly articulated by Ptak and Smith (2011) in a book which positions the approach in the context of MRP evolution, drawing heavily on the concepts established by the American Production and Inventory Control Society (APICS). The approach is rapidly gaining ground as a result of dissemination via professional bodies, including the UK's Institute of Operations Management (see Harding and Ptak, 2012), and via the qualification 'Certified Demand-driven Planner', accredited by the International Supply Chain Educational Alliance (ISCEA).

Although the concept of the 'demand driven supply chain' has been explored by academics (see for example Mendes, 2011), the DDI's approach has not, so far, been covered within the academic literature. There are currently around 50 implementations of Demand-driven worldwide (that can be identified from public domain sources), and that number is rapidly growing. In order to understand the likely trajectory of Demand-driven and, to help inform practitioners of its potential benefits and likely implementation challenges, this paper will report on qualitative research into Demand-driven adoption and implementation.

DEMAND-DRIVEN VERSUS TRADITIONAL MATERIAL PLANNING AND CONTROL

To understand the difference between Demand-driven and mainstream MRP/DRP, it is necessary to consider the *planning, execution* and *control* functions of MRP/DRP. Whereas mainstream MRP communicates detailed planning and execution information via a mixture of 'planned' and 'released' orders across a dependent demand network, Demand-driven dispenses with planned orders (and the associated order maintenance) in favour of kanban-like inter-work centre/inter-echelon replenishment signals; combined with a system of graduated buffer status alerts to help control day-to-day operations. This approach is underpinned by careful positioning, sizing and maintenance of buffers: typically inventory in the case of make-to-stock, but also including the novel innovation of 'time buffers' for make-to-order and non-stocked SKUs.

THE DIFFUSION OF INNOVATIONS

The Operations Management that underpins Demand-driven has already been clearly explained by its main proponents Ptak and Smith (2011). This research therefore focuses on the factors affecting its diffusion. The initial motivation for Rogers' (2003) innovation research was to understand the pattern of adoption of new farming methods in America's mid-West in the post-World War II period. Rogers was trying to understand why some farmers would rapidly adopt new methods, like pesticides and seed drills, while others would 'stick' with tried and tested approaches, despite the seemingly obvious benefits of the new techniques. Rogers developed a general model to explain the innovation-decision process, considering factors including: prior conditions, innovativeness of the host company, and the complexity, observability and trialability of the innovation, as shown in Figure 1.

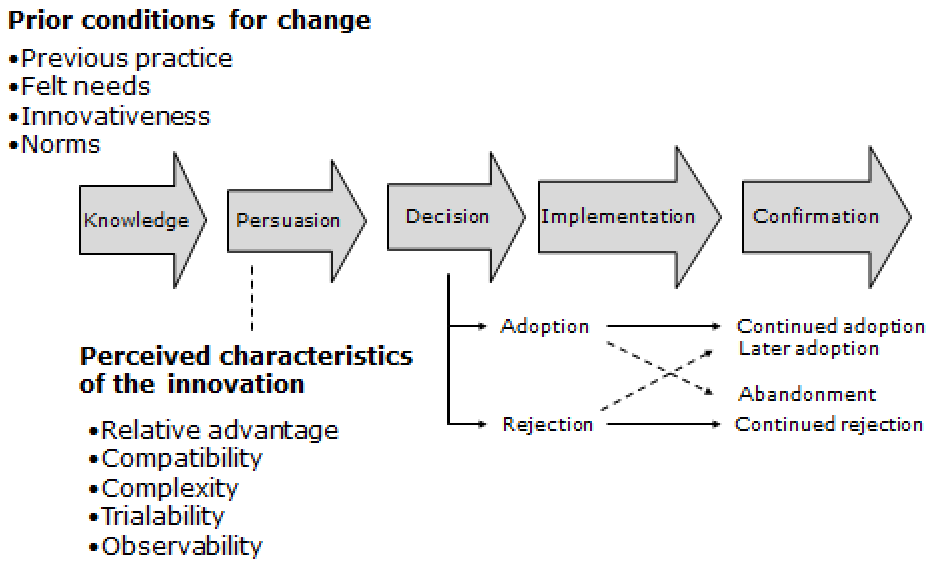

Figure 1. The innovation-decision process, adapted from Rogers (2003)

The great strength of this model is that it allows the researcher to consider contextual factors alongside the technological characteristics, business requirements, and organisational implications of the innovation. In this way, it is possible to explain the factors affecting the adoption of a new technology and potential for its further diffusion.

RESEARCH METHODOLOGY

The current population of Demand-driven implementations has been estimated by searching for customer lists and testimonials on the web pages of the Demand-driven software providers that are currently accredited by the Demand Driven Institute (DDIa, 2015). Other sources include case studies provided by the DDI, and case studies from their 2015 conference (DDIb, 2015). These sources accounted for 51 implementations, and a further 10 were known to one of the authors through his network of consulting colleagues.

In order to achieve a broad understanding of factors affecting the adoption of Demand-driven, the authors attended an IOM course on Demand-driven held at the Chartered Institute of Logistics and Transportation's (CILT) headquarters in Corby, UK. Research has focused initially on the experiences of experts: consultants who have delivered courses on Demand-driven to supply chain professionals, and, who have worked with clients to implement Demand-driven across a range of organisations globally. A more in-depth understanding of the adoption and implementation issues has been obtained through a case study (Yin, 2003) based on the experience of one of the authors who, in consultant role, has participated in the adoption and implementation of Demand-driven within a European pharmaceutical supply chain.

The focus group was undertaken immediately after a 2 day Demand-driven course (CDDP) with three experienced consultants in April 2015. The researcher employed a series of open-ended questions developed from Rogers' (2004) framework, to stimulate a discussion on the factors affecting adoption. The focus group was recorded and transcribed. Some initial qualitative analysis is presented here, structured around stages in the diffusion of innovations (Rogers, 2004). The same framework has been employed to structure the case study data.

ESTIMATED POPULATION OF DEMAND DRIVEN IMPLEMENTATIONS

The population of Demand-driven implementations has been estimated, as shown in Table 1, but this only serves as a rough indication as it is biased towards the more longstanding users.

Sector	Number
Apparel	12
Food	10
Industrial	9
Engineering	9
Household products	5
Pharmaceuticals	3
Electronics	2
Business Services	2
Cosmetics	1
Automotive	1
Aerospace	1
Packaging	1
Other	5
Total	61

Table 1. Estimated population of Demand-driven implementations by sector

Demand-driven is generally supported by proprietary software which interfaces with an ERP system. The DDI exert close control over the terminology and algorithms employed within Demand-driven applications, and publish a list of 'compliant software'. The packages that currently carry DDI approval are Replenishment+, Flowsoft and Orchestr8. The current distribution of software applications is shown in Table 2.

Software	Number of implementations	DDI compliant?
Replenishment+	11	Yes
Flowsoft	31	Yes
Orchestr8	13	Yes
Other	3	No
Spread sheet	3	No
Total	61	

Table 2. Estimated population of Demand-driven by software application

The largest proportion of our estimated implementations are in South America (31), using Flowsoft, and predominantly in Columbia, a country with a history of TOC drum-buffer-rope applications. There are 12 applications in North America and 1 in Canada, mainly using Replenishment+. There are 14 implementations in the UK, mainly using Orchestr8, with 2 in France and 1 in Germany. However, these mainland Europe figures seem understated.

FINDINGS FROM FOCUS GROUP

Characteristics of adopting companies

The facilitator asked whether many companies used Demand-driven across echelons, as in retail. Consultant 1 replied "a lot, it makes distribution easier.

Considering the operating characteristics of adopting companies, Consultant 1, said that it worked for make-to-stock (MTS) and engineer-to-order (MTO), but that "MTS companies tend to think it's for MTO, and the MTO companies tend to think it's for MTS.. MTO uses control points with capacity buffers whereas MTS uses control points with inventory buffers." Consultant 1 recounted the case of an MTO electronics company in Canada that had seen their supply chain as a competitive weapon and had adopted Demand-driven with remarkable results; cutting their backlog and lead times, and reducing inventory turns. Demand-driven allowed them to achieve market leading responsiveness, for which they charged premium prices, leading to quite remarkable growth in sales revenue and profitability. Consultant 1 reflected that "customer value comes from product features, or, delivery", and recounted the case of a US Forgings manufacturer, situated in the upstream end of engineering supply chains, "they are the buffer in their supply chain, that was their strategy". Demand-driven had enabled them to provide that buffer cost effectively, and without excessive inventory holdings. In response, Consultant 3 recounted the cautionary tale of a company that had, after implementing Demand-driven, offered too much to the market. The marketing department had seen the benefits of Demand-driven and offered 2 week lead times to customers, which was less than half the market norm, while promising 100% on-time-in-full. The company quickly became inundated with orders and overwhelmed, leading to customer service failures and a cash flow crisis. Consultant 1 reflected that they should have segmented the market and understood the [price] elasticity, employing demand shaping to harvest the benefits of Demand-driven. Consultant 2 commented that there is "an equilibrium of forces in the supply chain between Sales and Supply Chain, normally Sales have the power". Consultant 1 reflected that "DDMRP (the term preferred by the DDI) is all about: 'How do I strategically leverage my supply chain to provide value to my customer and profit to myself?'.. it's not an inventory reduction platform."

Prior conditions for change and acquisition of knowledge

The facilitator sought to discover which *previous practices* for planning and control would typically be in place prior to adoption of Demand-driven? Consultant 1 explained that many would be disappointed users of SAP's Advanced Planning and Optimisation (APO) package. She outlined a typical trajectory involving Class A [APICS definition] but legacy MRP, followed by a costly ERP implementation with disappointing results, leading to APO, also with disappointing results. Companies would go on to implement "some fancy forecasting software in the belief: 'If only I could do a better forecast, then my life would be complete'. And, what they are finding, is that none of it works".

In relation to the *felt needs*, Consultant 1 reflected on the corporate environment inhabited by Materials Managers. "Companies have the wrong inventory, they've got too much of the wrong stuff..[and] too little of the right stuff. Overall we've got too much stuff, and senior management are looking at this inventory number and saying: 'Why can't we deliver products? Why do we have shortages? What is the matter with you people?' Look at your Materials Managers, they have breakdowns because the stress is incredible. Consultant 2 commented: "And that is why there will be a massive wave of implementation, because the [Demand-driven] pioneers have done all that [implemented ERP, APO and forecasting software], and they fail. You can tell the story 'skip all that.. just go to the right answer.'"

The group's reflection on the influence of firm size and ownership helped to explain the *innovativeness* of the early adopters. Consultant 1 explained that Large companies have 'process owners', the 'brightest and the finest' who are on the lookout for new ideas, and who have time to attend conferences etc. Consultant 1 reflected that she would initially meet someone from corporate, and later see the supply chain team booked onto a course. "These are the typical early adopters.. they will try anything." Consultant 2 commented "but also for mid-market, APO is prohibitive". Consultant 1 added: "the privately held mid-market company is the other one that we tend to get". These companies, it emerged, have the same issues with customer service and inventory as the larger companies, less resources to invest in planning and control systems, but more freedom to act. Consultant 3 identified another innovation-driver which he called the "burning platform". He recounted the case of a pharmaceutical company facing an unwanted takeover that decided to quickly implement Demand-driven in order to achieve a step-change in performance. The Supply Chain Manager's rationale was that he would have to improve performance either before or after the possible takeover, so he may as well take the plunge and "do it now." Consultant 1 added that there is also the lean group that had [misunderstood] what Ohno said, and believe that all inventory is evil. Those supply chains have now been extended globally and are incredibly fragile with all the inventory driven out.. and supply chains are breaking.

In order to explore the *norms* that increase the propensity to adopt, the facilitator asked the consultants to identify any existing practices that made a company more likely to consider Demand-driven. Consultant 1 identified two groups, those that had "done lean" and the Theory of Constraints (TOC) people who had implemented drum-buffer-rope. Companies using lean were "still tripping over the fact that they are short of material, and are so frustrated with those MRP people [in their own organisations] because they were constantly in their way." For the TOC people "the problem is, as in any pull system, that you can only pull if there is material there. But the raw material is ordered by a two level process via a forecast driven Master Production Schedule (MPS) and MRP." These companies are already familiar with the principles of flow, and want to make it work better.

Perceived characteristics of Demand-driven and persuasion

To explore the *relative advantage* of Demand-driven, the facilitator asked what specific problems motivated companies to consider Demand-driven. Consultant 1 replied that it was: "One, cash flow. Two, customer service is terrible, even with high inventories. And Three, revenues are declining. Consultant 3 added that "you sometimes get people in the business who just want to do things better." Reflecting on the motivation of the Retail Vice President who had sent three people on the course, Consultant 1 commented: "He sees the pain that his planners are going through, and the company he came from did things differently".

Concerning *compatibility*, Consultant 1 was very clear that ERP cannot deliver Demand-driven by itself. "I don't care how good you are at flipping switches.. it does not work. One, because the planning equation is different. Two, management of the stock buffers is different. Three, replenishment of the stock buffers is different. Four, we do not use a master schedule, we do not forward-do a planning calculation. Five, everything is based on our available inventory today." The facilitator noted some similarities between MRP and Demand-driven, in the need for accurate bills of materials (BOM) and an inventory management and accounting system. Consultant 3 added that: "You need to have a transaction management system [in Demand-driven]" Consultant 3 agreed: "It hasn't changed. Item master hasn't changed. BOM hasn't changed. What you do with it has changed."

Regarding *complexity and trialability*, the consultants agreed that Demand-driven can be piloted for a small number of SKUs using spread sheets. Consultant 1 said that she encouraged clients to run a pilot with their six worst items. It became clear that extending this approach across the range of SKUs would become unfeasibly complex. In response to a question about trials, Consultant 1 explained that "a lot of simulation work is done, especially in big companies." It is possible to "look at what [inventory] we had. To run the transaction file against

Demand-driven buffers [appropriately sized according to variability and lead time etc.], and to find: 'What would my customer service level and inventory have been [with Demand-driven]?'" The facilitator commented that these findings could be used to make the business case for Demand-driven, and the other consultants agreed. In response to a question concerning the number of companies implementing Demand-driven, Consultant 1 replied that she "had no idea how many" and drew an analogy with Goldratt's influential book *The Goal*, "it made sense to people and they just did it.. like in this class, we have a pilot running". Consultant 1 was referring to three participants in the IOM/CDDP course from a high fashion retail organisation who were already piloting Demand-driven using spreadsheets for a small range of Stock Keeping Units (SKUs).
Concerning *observability*, the consultants reflected on the prime mover's need to see results before committing to 'roll out', and that people tended to trust what they knew from their own experience, and this tended to underline the requirement to run a pilot, and/or the importance of previous experience with flow-oriented approaches.

Decision and adoption
Concerning the decision to *adopt*, the facilitator asked whether people decided to adopt because of the success of their own trials, or because they have seen Demand-driven working somewhere else. Consultant 1 replied that "Usually it's their own pain. 'Is it going to solve my problem?'" She also reflected on a barrier affecting APO users, because to adopt Demand-driven after implementing APO may be to admit that millions [of dollars] has been wasted. The facilitator went on to ask whether any companies had adopted and then abandoned Demand-driven. The consultants could identify a small number of cases, but these were all associated with buy-outs, where the acquiring company had insisted on implementing their own systems and approaches. The facilitator also asked whether any companies had rejected Demand-driven and later adopted it. Consultant 3 recounted the experience of a senior manager who had been intellectually interested in Demand-driven, and then promoted. Once in a position to go ahead, he sensed a lack of support from IT, who preferred to use more famous proprietary software. He decided to 'wait and see' how the standard approach would work. Five years later, in the light of disappointing results, he is now feeling more empowered to adopt Demand-driven.

FINDINGS FROM A EUROPEAN LIFE SCIENCE CASE STUDY
Company A is a large life science company with a factory in Europe and global distribution. The factory handles a wide variety of products in make-to-stock batch mode supplying a warehouse in Europe, which operates as a hub supplying markets in Europe, Russia and the Middle East, and trunking directly to regional distribution centres in the USA and AsiaPacific. Company A's Supply Chain Manager had met the consultant at a conference and had been impressed by the Demand-driven rationale and reported results achieved by example companies. The company faced the possibility of an unwanted takeover (mentioned above by Consultant 3) and, in this business environment, he was able to persuade the Marketing and Operations VP to authorise a trial of Demand-driven.

Prior conditions for change and acquisition of knowledge
Company A had previously implemented Sales and Operations Planning and its planning and control system was pure 'forecast push', using proprietary software for forecasting and DRP/MRP. Its planning and control system could not be described as 'best in class', and it had no particularly strong track record of adopting innovative approaches (e.g. lean or TOC) to improve material flow. However, its Supply Chain Director had previously worked in the automotive industry, and had experience of running Just in Time (JIT) and was aware of more advanced ways of working. She had a good understanding of queuing

theory and Hopp and Spearman's (2000) approach to improving material flow and was very supportive. Company A's existing customer service levels was in the early 90s (line-fill percentage)

Perceived characteristics of Demand-driven and persuasion

To improve its competitive position, the company needed to improve is customer service levels and increase its inventory turn. Company A also recognised the negative impact of schedule instability on factory capacity and costs. It needed to get more output from the factory, and schedule stability was therefore an important objective.

In order to understand the potential contribution of Demand-driven, the company engaged a TSP to simulate the potential impact of Demand-driven for a representative group of products, looking at the DC and hub echelons. Using six months of actual demand history, the simulation used lead-times, batch sizes (equal to shipping quantity), supply constraints and Demand-driven control points and buffer sizes to estimate service levels and requisite inventory levels. The simulation showed that service levels could be raised to 99% with an accompanying 35% reduction in inventory. This stage of the project took 3 weeks to complete.

Decision and adoption

Company A understood that Demand-driven would be a completely different way of working and recognised the need for additional software. The company undertook a pilot (trial) of Demand-driven for a range of SKUs, using proprietary cloud-based Demand-driven software. The company retained its ERP system for transaction management purposes only, with requirements planning functions 'switched off'. The proprietary Software as a Service (SAAS) package employed FTP file transfers for functions including inventory status capture, and, to input Demand-driven orders into the system. MRP was retained within the factory. Distribution Planners used the Demand-driven software planner screens to monitor the inventory buffer status at control points in the warehouses and, to manage order release. The pilot, affecting a small range of SKUs was run for 3 months and evaluated. As a result of its success, the pilot was extended to cover all SKUs handled in the European market, and is expected to last for six months.

Learning from the pilot

Demand-driven has improved the general level of predictability within the supply chain. As a result of 'right-sizing' the distribution inventories, the supply chain is de-stocking, which is causing anxiety in the factory and requests for more orders. The existing management accounting system indicates that the factory is failing to recover overheads. What these difficulties suggest are incompatibilities between the Key Performance Indicators (KPIs) and the Demand-driven approach. The existing performance management system encourages Operations Managers to make product that is not actually needed. Company A's manufacturing operation therefore needs to change mode from 'can and will build' to 'can build and sell'. There are clearly significant change management implications involved in Demand-driven implementation.

The nature of the company's S and OP process has changed from one pre-occupied with shortages, to a more measured focus on reviewing buffer inventory targets in relation to underlying changes in demand. The unexpected reduction in factory output also points to a need for new approaches to managing capacity. Overall, the unnecessary variability, and system induced bullwhip, has been taken out of supply chain operations, leading to a sense of greater control and the opportunity to make more deliberate choices.

The role of the planner has completely changed and the European planner 'loves it'. With far fewer shortages and schedule changes to manage, it would be possible to have global planning done by one person, instead of splitting it amongst 3 in regional locations, thereby enabling a more efficient 1:1 relationship with the factory. Territory forecasts by SKU are still needed to review buffer inventory targets and to forecast capacity.

CONCLUSIONS

The trialability of Demand-driven through low cost simulations and pilots will aid diffusion, as will the low cost 'pay as you go' SAAS model (i.e. with no high cost capital expenditure barrier). Adoption seems likely to proceed through a standard diffusion process, with the defining characteristics being urgency (burning platform) and supply chain education at high seniority levels. It seems likely that there will be a tipping point as the performance of the innovators begins to significantly outstrip that of others, who may later have to play 'catch up'. The approach of the five leading consultancy organisations (thought leaders) and ERP providers, that do not currently support Demand-driven, is bound to significantly affect the rate of diffusion. In the meantime, the rate of diffusion will depend upon the ability of pioneering change agents to network and publicise the process to gain opinion leader support.

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GLOBAL SUPPLY CHAIN OPTIMISATION: CASE STUDY FROM THE INSULATION INDUSTRY

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ABSTRACT

The insulation industry is characterized by the need for a leveled production output, varied demand, a high degree of product substitution, quick delivery expectations, and products of large physical volume but low density. Supply chain optimization is therefore of key importance to this industry. However, it is an industry which has been largely unexplored in literature. The purpose of this paper is to describe and quantify cost effective improvements in a supply chain, derived from a case study in the Insulation industry.

INTRODUCTION

Increased competition and cost pressures as well as new markets have challenged traditional approaches to supply chain management. Supply chains have become larger, spanning several countries and often even continents global and therefore also more complex. Today competition is not on a corporate level but between supply chains Christopher (2011). Having an agile, cost effective supply chain which can quickly adapt to customer needs are therefore essential.
This paper investigates supply chain optimization for the insulation industry as this is a huge and important sector with unique supply chain challenges for which little supply chain research has been carried out. The insulation industry deals with products of large physical volume but low density, making transport costs high. Furthermore, there is a high degree of product substitution and quick delivery expectations from clients. This has resulted in a supply chain which often has an overwhelmingly large amount of storage facilities due to a very high customer service level. Therefore, a key focus area for this industry in terms of supply chain optimization is to investigate the use of storage facilities.

This paper explores the current supply chain for a large Danish company in the insulation industry with a focus on storage facilities.

LITERATURE REVIEW

A supply chain is "*A network of connected and interdependent organisations mutually and co-operatively working together to control, manage and improve the flow of materials and information from suppliers to end users*" Christopher (2011). The activities in a supply chain transform raw materials into final goods that are delivered to the consumer. In figure 1 the role of inventory is depicted throughout a general supply chain. As can be seen from the figure inventory management is a crucial part of managing supply chains since inventory is present between all stages of the supply chain to give the required service level to the customer and provide product availability at an acceptable cost.

Generally, inventory management is challenging because it affects both cost and service when managing the supply chain. Felea (2008) identified inventory, together with transport and the location of the production spaces and the storage as the main factors that influence the performance of the supply chain. Changes to inventory policies can lead to an important alteration of the efficiency and responsiveness of the supply chains. Inventory is a fundamental measure of the overall efficiency of supply chains since it is used in many companies as an indicator tool to detect supply chain inefficiencies (Waller & Esper, 2014).

Figure 1: Supply chain steps and the role of inventory

Inventory management is defined as "*The group of activities employed in maintaining the optimum number of amount of each inventory item to provide uninterrupted production, sales, and/or customer-service levels at the minimum cost*." (The Business Dictionary, 2015). The term inventory considers the raw materials, the work in progress and the finished products of a supply chain. Emmet & Graville (2007), summarize the reasons why it is often necessary for companies to hold inventory:

- To better balancing supply and demand.
- As safety/protections against demand volatility and forecast errors.
- To improve forecasting in anticipation of demand, especially when there is seasonality.
- To provide service to customers.
- To reduce waiting time and material flow time.

If the time of supply is a known factor and demand is stable without unforeseen fluctuations, no need for protection against stock-outs exist, neither anticipation of the demand is required, and the time of reorder initiation can be categorized as the point where the level of inventory can satisfy the given demand until the ordered quantity arrives on stock (Waller & Esper, 2014). However, global competition, rapid product development, flexible manufacturing systems and an unmatched diversity in products increases the severity of predicting demand and planning the corresponding production and inventory levels (Fisher *et al*., 1994). Thus, supply chain managers need to identify the main strategies for inventory and design their parameters and the way they can be dimensioned as an essential element of supply chain optimization (Gattorna, 2010).

METHODOLOGY

This research focuses on the understanding of the key supply chain optimisation challenges for insulation manufacturers with global operations and customer base, identified as inventory management decisions. Due to the complex nature of the investigation, this research uses a qualitative approach, as well as a quantitative approach, providing rich and in-depth data on the research area. The explorative nature of the study allows for detailed understanding of the field of Supply Chain Management within the process industry. Therefore the case-study approach is the most appropriate research methodology (Yin, 1989; Oakley, 1999). The case organization was selected based on key parameters including, (i) an insulation manufacturer with a global supply chain, (ii) large inventories around the world, (iii) the company expressing a need for supply chain optimisation, (iv) storage management was viewed as a key obstacle to supply chain optimisation and (v) access to a substantial amount of quantitative data from the business warehouse and direct access to interview partners in appropriate as well as leading roles within the business.

The research had three phases: First, an extensive literature review was carried out. Second, data was gathered from the case study. Third, qualitative data was coded and analysed while the quantitative data was modelled and analysed using state of the art simulation software and statistical methods to detail theoretical and practical implications of the new knowledge.

Data from the company focuses on 2014. Data was gathered through observations, company documents and interviews. The researcher team was working in the company's headquarters on a daily basis and visited several production and storage facilities across Europe. Furthermore, quantitative data was gathered from the company's ERP system like for example financial information as well as data relating to customer orders, inventory expenses and a general overview of current costs and profit margins.

This method ensured accurate representation and enabled triangulation of the findings between different sources of information, thereby improving validity. In this manner the project ensured a high level of industry relevance and involvement while focusing on utilizing key theories within this research area.

FINDINGS

The case study focused on one of the largest suppliers of innovative products and systems based on stone wool in the world, called Insulation Inc. for the sake of anonymity. The company services the insulation industry with products and solutions for all major application areas for buildings. Insulation Inc. has a large and complex supply chain with a large number of outsourcing partners as well as production and sales facilities in Europe, Russia, North America, India and other Asian countries.

In 2014, the level of stock in Insulation Inc. had increased (Figure 2) due to low sales in the last weeks of December and extra inventory which was needed to fulfill customer demand. The main reason for this excess inventory is the tight capacity situation the company is dealing with. Furthermore the increased sales in 2014 required more products on stock in order to meet demand. This situation is predicted to become even more difficult for the coming years. The sales forecast for 2015 predict that production lines will be utilized close to 100%. The financial burden of inventory is therefore predicted to increase.

The company operates with very high customer service levels for all customers on all products in order to avoid loss of sales. Insulation Inc. therefore deals with two types of inventory. On one side, the seasonal stock is the additional stock of inventories build up to meet demand that is variable throughout the year (Figure 2). The insulation industry is characterized by seasonality and Insulation Inc. has followed a level production strategy to address this, meaning producing items when demand is low to meet high seasonal demand for which their production capacity is insufficient. The company follows stock build for seasonal stock closely to ensure there is no risk of losing sales in the high season. On the other side, due to demand variability and capacity problems, the company is working with operational stock. In general terms, the operational stock consists of a minimum operational stock, below which delivery service and efficiency of production would become a problem, and a small volume of safety stock. Of the two types of stock, this paper investigates the latest as the safety stock only account for a very small amount of the financial burden of inventory the company deals with.

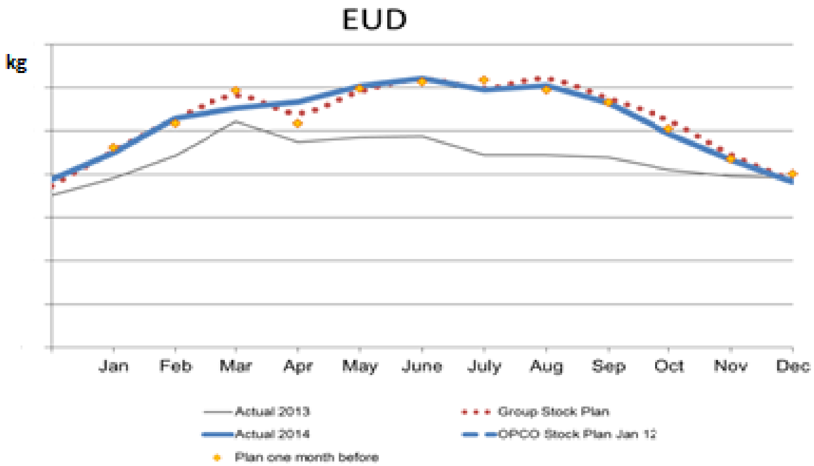

Figure 2: Total stock values of inventories

To get an overview of the current profitability of the product portfolio it was investigated on a Stock Keeping Unit (SKU) level. To do so several ABC analyses were constructed in order to get an overview of the product sales, the volumes on stock, the production costs as well as the contribution margin for every single SKU. Sales data, volume data and production data were extracted by the use of predefined queries for Insulation Inc.'s business warehouse and analysed in Excel.

Table 1 shows the results obtained during this study. A majority of the portfolio, the C products which account for 79 % of the portfolio, contributes with 5 % of the total sales for one annum, whereas 6 % of the top earning products, the A products, account for 80 % of the total sales for one annum.

Categorization	*Count of*	*% of totals SKU´s*	*Net Sales pr. Category*	*% of total*
A	121	6%	EUR 787.759,02	80%
B	295	15%	EUR 149.179,92	15%
C	1568	79%	EUR 49.394,20	5%

Table 1: ABC Analysis on sales carried out during this study

Table 2 shows the ABC analysis carried out and maintained by Insulation Inc. Several SKUs are not included in this analysis compared to the one carried out in this study, particularly C-products. In this analysis 41% of total SKUs are C products and these account for 15% of the total sales for one annum.

Categorization	*Count of*	*% of totals SKU´s*	*Net Sales pr. Category*	*% of total*
A	163	8%	EUR 655.868,39	70%
B	275	14%	EUR 135.857,66	15%
C	818	41%	EUR 139.917,77	15%

Table 2: ABC Analysis on sales currently used in Insulation Inc.

Comparing the results obtained in the two different analyses it can be seen that both the amounts of A, B and C products differ, as well as the overall count of product numbers. The first can be explained by the practical approach taken by Insulation Inc. where A, B and C products are not calculated, but representing pricelist products and non-pricelist products. For the differing amount of products overall, it is likely because the products that are not found in the ABC analysis carried out by Insulation Inc. have only been produced, thus they have not been taken into consideration as potential portfolio products yet and have not gotten a classification.

Figure 3 show the different SKU's net sales on the horizontal axis and the corresponding contribution margin on the vertical axis. The graphical representation show the A products, represented by the green dots, the B products, represented by the blue dots and the C products, represented by the red dots. The black line represents the general contribution margin ratio, which a product should surpass in order to be economically profitable for Insulation Inc. It can be seen that a large amount of the portfolio is not profitable. To be precise merely 57% of the portfolio lies above the required contribution margin ratio.

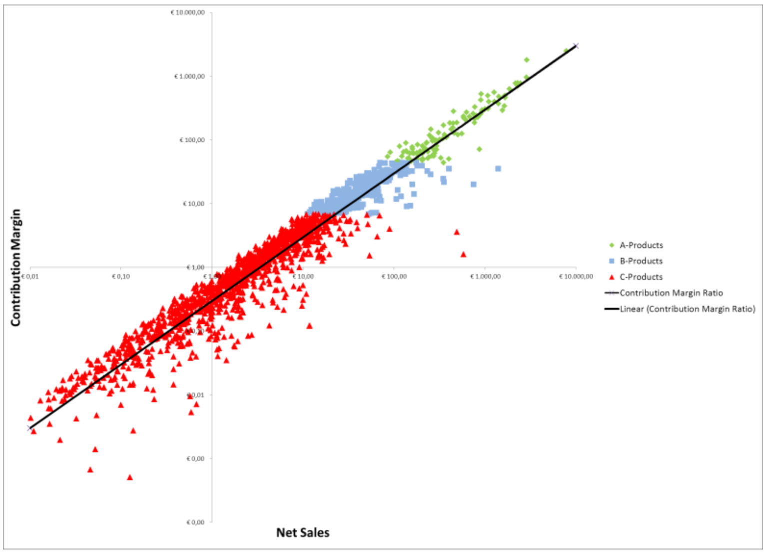

Figure 3: Graphical representation of ABC analysis

The stock balance development throughout 2014 has been analysed based on monthly data on SKU's levels. SKU's are classified as A, B or C depending on the volumes on stock through all the year. The results are shown in table 3.

Category	*Count of*	*% of total SKU's*	*m3 of stock pr. category*	*% of total volume*
A	114	10%	1.897.480,7	80%
B	128	11%	360.265,135	15%
C	928	79%	119.397,765	5%

Table 3: ABC analysis on stock balance development

As with the previous ABC analysis the data follows Pareto's rule, though in this analysis 10% of the products on stock correspond to the 80% of the total volume of inventory through the year, 11% of the SKU´s account for 15% of the volume and 79% correspond to the remaining 5%.

Insulation Inc. has its own ABC classification for its products. In this classification only sales are taken as the criterion for classifying products. In order to examine the real ABC classification of the company, data for material stock movements for each SKU is analysed. By subtracting the total amount delivered from the stock to the total amount received on stock at the end of the year 2014, the surplus the company is producing, which goes directly to stock, is calculated (see table 4).

Categorization	*Count of*	*% of totals SKU´s*	*Surplus (kg)*
A	528	11%	1.646.828,5
B	532	11%	311.439
C	3810	78%	558.378

Table 4: Surplus of products

Table 4 shows that the company has high levels of product surplus, which means large stock levels. A and B products are made to stock so high levels of stocks are expected, however, a large amount of surplus is found on products considered by Insulation Inc. as C products. C products are made to order, so no surplus is expected to be produced for these SKU's.

The findings show that the company has a high percentage of C products, many of which are only produced once throughout the entire year and often these orders are very small, including very few products (m^3).

ANALYSIS

The findings showed that C products constituted close to 80% of the product portfolio and that 43% of the portfolio is economically non-beneficial for Insulation Inc. Wilson & Perumal (2010) suggest that a company can increase the profitability of its portfolio by radically cutting the long tail of C products. In Insulation Inc. the cost of having a SKU on inventory is estimated to be EUR500. If the company deleted all the C-Products found in the ABC analysis on sales, this would lead to a cost reduction of EUR784.000 in inventory reduction alone. Including the cost of maintaining the SKU's in the portfolio, the cost savings would be much higher. However, cutting products should be considered with great care (Wilson & Perumal, 2010; Fisher & Vaidyanathan, 2012). Some products that seem to be C products can be essential for the sales of highly profitable products (door openers) and cutting these from the product portfolio could result in significant losses. It is therefore essential to understand the attributes of a product that attracts the customers in order to make sure that the company has a product that can substitute a door opening C product if the company decides to delete this.

The company could potentially optimise their supply chain through creating a rationalized product portfolio which could lead to, i.e. ERP SKU maintenance cost reduction and inventory cost reduction.

Firstly, the company can carry out a qualitative analysis to identify which attributes of a product matter most to the customer (Fisher & Vaidyanathan, 2012). This should be investigated through a thoroughly conducted survey among product managers as well as customers. The next step is to identify what the customers would do, if their favoured product is not available any longer. Again this is optimally determined through a thoroughly conducted survey among customers.

Secondly, a quantitative analysis can be carried out (Fisher & Vaidyanathan, 2012):

1. Analyse actual and anticipated sales by the attributes found in the qualitative part of the analysis. This includes the collection of sales data and the development of a forecast for the SKU's that could replace the ones that should be removed from the portfolio.
2. Optimize the portfolio
    a. Decide if revenues or profits should be maximized
    b. Determine a price for the SKU's that could replace the ones removed from the portfolio
    c. Delete the SKU's found throughout the analysis and replace them by the new ones.

A main contributing factor to the high supply chain costs in terms of inventory is the high customer service level. Insulation Inc. is producing next to all products required by the client. As a consequence, the assortment of products is increasing (especially C products). A part of the high service levels are also short transport times which the company shortened even further in 2014 for all customers and all orders. The power of the customers and the demands they put on the company has therefore increased in recent years.

It could therefore be relevant for Insulation Inc. to investigate whether they are over-serving some or all of their customers. An idea could be differentiated service levels. The company could divide its clients into categories and offer the highest service level to its most profitable customers and a lower level of service to less profitable customers. Furthermore, the company could try and move demand. For example the company could offer a discount if a less profitable client requests products not in stock, in particular C products, if they are willing to wait till these are produced. In this manner some orders previously serviced through made-to-stock could be serviced through made-to-order. The inventory savings from such an action could be set up to ensure it far outweighed the discount offered to the client.

These findings show that the company need to conduct a more in-depth investigation of their current approach to their customers and their product portfolio development. Understanding these aspects will help the company understand inventory issues and thus enable them to optimise their supply chain. Key considerations the company should do include:

- Service levels should be investigated to understand the balance between different customer needs and profitability.
- Customers should be classified so it can be investigated whether it is necessary to offer the same type of service level to all clients.
- Consideration of missed opportunities (lost sales) and costs per units of stock-outs should, as far as possible, be calculated to ensure the best solution is selected.
- The company should try to more actively predict customer needs through knowledge and information sharing between retailer and manufacturer. Such sharing should be routine and take place at specific intervals as well as at certain milestones, specially replenishment policies and inventory levels.
- The product portfolio should be thoroughly investigated to see if any of the many products which are not profitable could be cut from the product portfolio.
- Products for which demand is predictable should be separated from those characterized by unpredictable demand in order to implement a different policy for each group. The idea is to avoid unpredictable products made-to-stock.
- ABC analysis should be conducted for all products and include all parameters which affect profitability, including storage space and cost.

The analysis should also routinely be shown at sales and operations meetings in a graphical format to make it clear which products are profitable and which are not so informed decisions on this information can be taken.

CONCLUSIONS AND NOTES FOR FURTHER RESEARCH

This paper investigated how a company in the insulation business could optimise their supply chain. Due to the large physical volume of products in this industry, high substitution and high customer power an essential aspect of this is inventory management as inventory is a huge expense for companies in this sector. The research was carried out through a case study of a large Danish insulation company. The findings showed that the company had a huge expense when it came to inventory and had a very large product portfolio they offered their clients. Furthermore, their customer levels were very high and the same for all customers. Furthermore, the company had many C products that were not profitable.

To address the issues with inventory the company would need to carry out an analysis to identify which C products could be eliminated without jeopardizing customers demand. Furthermore, it could be relevant to look into the possibility to differentiate customer service level. This could lead to cost savings and a more optimized supply chain.

This paper contributes with empirical research within supply chain management in a sector that has not been well-researched. Further studies will focus on developing a detailed optimized inventory strategy and connect this to the company's supply chain. Hereafter, the aim is to test the results in other companies in the industry.

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ECO-FRIENDLY RISK-AWARE SUPPLY CHAIN NETWORK DESIGN USING A LOCATION ROUTING PROBLEM; THE CASE OF THE LPG INDUSTRY

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ABSTRACT

Liquefied Petroleum Gas (LPG) has become one of the major fuels in developed countries. The final price of LPG is hugely dependent on logistics costs. There are several studies on facility location and routing planning in fuel distribution systems; however, these are interdependent and the overall cost of the chain may be unjustified if they are considered separately. This paper sought to propose a new multi-objective multi-period location-routing problem (LRP) for the design of a two-echelon LPG supply chain network, and solve it using NSGA-II. The main contribution of this study is to highlight the significance of risk and green factors, by simultaneous incorporation of externalities including CO2 emission, congestion, wear and tear, and noise pollution, and risk factors containing transportation risk and site risk. The proposed mathematical model is tested on the LPG supply chain of a major South Korean LPG company. Results indicate an improvement in the risk and externalities of the network as compared to current network norms.

KEYWORDS: Location Routing problem, network design, risk, cost of externalities

INTRODUCTION

The supply chain network of Liquefied Petroleum Gas (LPG) consists of globally dispersed entities. At the primary stages of supply, natural gas must be transferred to the refinery plants to be refined and then shipped to export terminals. The logistics costs up to this point of the LPG supply chain are inevitable. The supply network in importing countries is more complicated and includes a variety of uses across residential/commercial, industrial, transportation and agricultural sectors. The design of the LPG supply chain network at this point is an important issue, since it can considerably affect the final price of LPG in the market and have side effects on the environment and the people around. Consequently, the optimization of the related decision variables contributes greatly to the operational aspects of this sector. The strategic decisions in supply chain network design directly affect the decision making process at the tactical (including inventory and transportation policies) and operational (such as pricing and service level) [1] levels. Although the facility location and routing decisions basically originate in different stages of the decision making process in a supply chain, they are interdependent and the overall cost of the chain may be unwarranted if they are considered separately. The location-routing problem (LRP) was devised to settle this issue. The classic LRP consists of locating the distribution centres (DC) in a chain, assigning customers to each DC, and determining vehicle routes for the flow of materials, the overall aim being to minimise the cost of construction and operation in the supply chain network.

Nowadays, consideration of multiple objectives in optimization models is a common approach in academia. LRP, as the most recently proposed mathematical model, is no exception to this trend. Some of the major measures studied in this way include social and humanitarian issues, responsiveness, and risk. The risk-related LRP papers have tended to focus on hazardous waste. In the study by Alumur and Kara [2], the authors aimed to determine the location of treatment and disposal centres, and the best routing schedule for different types of hazardous waste in a way that would minimise transportation risks. Boyer and colleagues [3] worked on the same case to minimize the risk of population exposure within a bandwidth along particular routes. The green issue is another interesting measure which has not been sufficiently studied in the LRP literature. The first published research in which greenness was addressed, albeit indirectly, was an LRP model detailing a "carbon-capped supply chain network problem" [4]. In this paper, authors incorporated environmental management decisions into the supply chain design using a constraint for carbon emissions. The first multi-objective optimization model in green studies was proposed by Reza and colleagues[5]. They developed a new model for stochastic green hub LRP with simultaneous pick-up and deliveries which reflected the minimisation of transportation costs and the environmental effect of emissions. In another related article, S. Validi et al. [6] recently proposed an extension to LRP in which two green objectives were incorporated into the model. They also added a green constraint based on the Analytic Hierarchy Process. The few listed articles available in this area have focused on carbon emission as the only negative effect. Although C. Sterle [7] incorporated traffic issues into LRP models to address a city logistics problem, there is no research considering externalities as a whole.

Due to the flammability of LPG and the polluting nature of its supply chain, the main contribution of this study will be the incorporation into the LRP model of externalities including air and noise pollution, wear and tear, and congestion as the primary objectives, along with the population at risk as the secondary objective. The remainder of this article is organized as follows. In Section 2, the mathematical formulation is described. Section 3 introduces the case study and formally discusses the problem. Section 4 details the numerical analysis and experiment in detail. Finally, section 5 concludes the paper.

MODEL DEVELOPMENT

This research sought to propose a multi-objective multi-period location-routing problem to address the strategic and tactical/operational decisions in the design of a two-echelon supply chain network. In the proposed model, the location and capacity of the intermediate storage tanks and two different sets of assignment decisions in the first and second echelon will be determined. In addition to the mentioned decisions at the strategic level, operational level decisions relating to the routing schedule and shipment size for each delivery will also be specified. The objectives which will be optimized are the externalities, including congestion, wear and tear, CO2 emission and noise pollution, and the risk of transporting and storing LPG in stations and the storage tanks.

Let S be a set of n stations with a deterministic but randomly generated demand in a planning horizon of P, associated with a population exposure within a specific bandwidth from the station node denoted by $\mathrm{PESN_i}$. The variable $\mathrm{I_{j0}}$ is also associated with each station node to show the LPG primary inventory at station j at the beginning of the period. Let CST be the set of m Candidate Storage Tanks to fulfil the station's needs. Each CST is associated with a population exposure denoted by $\mathrm{PEST_j}$. Each of the nodes, including stations and storage tanks has a specific storage capacity, which demonstrates the maximum LPG that can be stored in that node (denoted by CapST-Caps). In the first level of the two-echelon model, IT indicates the set of LPG import terminals. The problem will be defined on a complete, weighted graph $\mathrm{G = (V, A, D)}$ in which $\mathrm{V = (S \cup CST \cup IT)}$. Each arc is associated with a weight in distance ($\mathrm{d_{ij}}$ is an element of the distance matrix-D) and a weight in population exposure ($\mathrm{PEV_{ij}}$ is the matrix of average population exposure along each route). An unlimited fleet of heterogeneous vehicles (set fl) will be considered for the transportation part. Each of the vehicles in this set will be associated with a capacity indicated by $\mathrm{Capv_k}$, wear and tear, and noise factor indicated by $\mathrm{WT_k}$ and $\mathrm{N_k}$, and emission parameters which are functions of the transportation mode. The input data for the mentioned parameters will be in the form of a vector, each cell addressing a specific mode of transportation. The following decision variables have been defined to formulate the mathematical model.

$Y_i = 1$ If storage tank $\mathrm{i \in CST}$ is opened

$F_{ij} = 1$ If station $j \in S$ is assigned to storage tank $i \in CST$

$E_{hi} = 1$ If storage tank $i \in CST$ is assigned to import terminal $h \in IT$

$X_{ijkt} = 1$ If there is a route from i to j with vehicle mode $k \in Fl$ in period $t \in P$

$CapST_i$ The decided capacity for the storage tank $i \in CST$

LPG_{ijkt} LPG volume delivered to station j from ST $i \in CST$ in period t via mode k

The other parameters and variables are defined as follows;

e_{ijk} Emission rate to traverse from $i \in CST$ to $j \in S$ using vehicle mode $k \in Fl$

The emission rate will be calculated based on the equation (S1), and will form the matrix of CO2 emission. CO2 emission is calculated as a function of the transportation mode and the weight of the maximum capacity of the vehicle. As shown in the following equation, the emission factor can be calculated by multiplying the amount of emission for each mode per unit of traverse by the distance and weight of the vehicle at full capacity.

$$e_{ijk} = Capv_k * dist_{ij} * \text{emission parameter}_k \tag{S1}$$

$Cong_{ij}$ The congestion (traffic) factor

The congestion factor for each transportation link is estimated using ArcGIS software based on a press release report from the South Korean Ministry of Land, Infrastructure and Transport which measures the probability of drivers' perceived congestion on the roads.

$Capv_k$ The maximum capacity of the vehicle mode $k \in Fl$

$Caps_j$ The maximum capacity of the station $j \in S$

TF_{hi} Trip frequency in first echelon from import terminal $h \in IT$ to ST $i \in CST$

Since routing in the first echelon is with a full truck load, the trip frequency equation will be defined to simply ensure the demand fulfilment in the second echelon. Therefore, the trip frequency will be calculated based on the total demand in the second echelon as follows:

$$TF_{hit} = \frac{\sum_{j \in S} F_{ij} d_{tj}}{Capv_k} \quad \forall i \in CST, \forall t \in T \tag{S2}$$

Dem_j Total demand of station $j \in S$ in whole a period ($D_j = \sum_t d_{jt}, \forall j \in S$)

d_{jt} Demand of station $j \in S$ in period $t \in P$

$fixc_i$ Fixed cost of constructing the storage tank $i \in CST$; It should be a function of the decided capacity for that storage tank.

Max_{st} The maximum number of storage tanks, as a function of the total budget the company is willing to invest in development plan equal to ($Budget/fixc$)

I_{jt} Inventory in station $j \in S$ at period $t \in P$

The parameter I_{jt} is subject to upgrade on a daily basis/after receiving each shipment. It will be recorded in a matrix of n stations and t periods. Considering a randomly generated demand and Ij0 for the first day, each cell will be calculated using equation (S3). The model assumptions are summarised as follows:

$$I_{jt} = I_{j(t-1)} + LPG_{ijkt} - d_{jt} \tag{S3}$$

The model assumptions are summarized as follows;

(1) The stations' daily demand is assumed to be randomly produced (at a predefined interval) and must be fulfilled within the time period by at least one shipment;

(2) The total supply in the first echelon to each storage tank in each day of the period will be equal to the total daily demand of the assigned stations to that storage tank. Since the shipment in the first echelon is a full truck load, there will be no decision variable for the sequence of visits, and a single mode of vehicle will be considered;

(3) In calculation of the site risk, the full capacity of the storage tanks will be considered as the inventory. In terms of the transportation risk, a constant value equal to the vehicles' capacity will be used;

(4) The maximum number of intermediate storage tanks to be established will be calculated based on the company's budget for the development plan, while the fixed cost of constructing the storage tanks will be assumed to be the same.

The proposed mathematical model aims to find the location and capacity of the storage tanks, the size of each delivery, and the most efficient routing schedule to minimise the total externalities and risk. The first objective set involves externalities such as CO2 emission, congestion, wear and tear, and noise. Due to the TL shipment in the first echelon, total emissions will be calculated based on the total traversed distance for the shipment of LPG to each of the storage tanks.

$$\mathrm{Min}\left(\sum_{t\in T}\sum_{k\in fl}\sum_{j\in S}\sum_{i\in CST} e_{ijk}X_{ijkt} + \sum_{t\in T}\sum_{h\in IT}\sum_{i\in CST} TF_{hit}\, e_{hi}E_{hi} + \sum_{i\in CST}\sum_{j\in S}\sum_{k\in fl}\sum_{t\in T}(Cong_{ij})\,X_{ijkt} + \sum_{t\in T}\sum_{k\in fl}\sum_{j\in S}\sum_{i\in CST}(WT_k)\,X_{ijkt} + \sum_{t\in T}\sum_{k\in fl}\sum_{j\in S}\sum_{i\in CST}(N_k)\,X_{ijkt}\right) \tag{1.1}$$

Different parts of this objective will be measured based on relative values. In the second set of objectives, the risk of population exposure along the transportation routes, as well as around the network nodes will be minimised.

$$\mathrm{Min}\left(\sum_{k\in fl}\sum_{j\in S}\sum_{i\in CST} PEV_{ij} * Capv_k * X_{ijkt} + \sum_{i\in CST} PEST_i * CapST_i * Y_i + \sum_{j\in S}\sum_{t\in T} PESN_j * I_{jt}\right) \tag{1.2}$$

The objective function will be subject to the following constraints, including the common constraints from the literature [8] which have been adopted, and several exclusive constraints:

$$\sum_{k\in fl}\sum_{i\in CST} LPG_{ijkt} + I_{jt-1} \le Caps_j \qquad \forall j \in S, \forall t \in T \tag{2}$$

$$\sum_{h\in IT} E_{hi} = 1 \qquad \forall i \in CST \tag{3}$$

$$E_{hi} \le Y_{ic} \qquad \forall i \in CST, h \in IT \tag{4}$$

$$\sum_{i\in CST} F_{ij} = 1 \qquad \forall j \in S \tag{5}$$

$$F_{ij} \le Y_i \qquad \forall i \in CST, \forall j \in S \tag{6}$$

$$\sum_{i\in CST}\sum_{j\in S} X_{ijkt} * LPG_{ijkt} \leq Capv_k \quad \forall k \in fl, \forall t \in T \tag{7}$$

$$CapST_i \geq \sum_{j\in S} F_{ij} * d_{jt} \quad \forall i \in CST, \forall t \in T \tag{8}$$

$$\sum_{k\in fl}\sum_{i\in CST} (X_{ijkt-1} * LPG_{ijkt-1}) + I_{j(t-1)} \geq d_{jt} \quad \forall j \in S, \forall t \in T \tag{9}$$

$$\sum_{k\in fl}\sum_{i\in CST} X_{ijkt} \leq F_{ij} \quad \forall j \in S, \forall t \in T \tag{10}$$

$$\sum_{i\in V} X_{ipkt} - \sum_{j\in V} X_{pjkt} = 0 \quad \forall t \in T \tag{11}$$

$$\sum_{k\in fl} X_{ijkt} \leq Y_i \quad \forall i \in CST, \forall j \in S, \forall t \in T \tag{12}$$

$$\sum_{i\in tour}\sum_{j\in tour} X_{ijkt} \leq |tour| - 1 \quad \forall t \in T, \quad tour \subseteq S \tag{13}$$

$$\sum_{i\in CST} Y_i \leq Max_{st} \tag{14}$$

$$\sum_{t\in T}\sum_{i\in CST} X_{ijt} \geq 1 \quad \forall j \in S \tag{15}$$

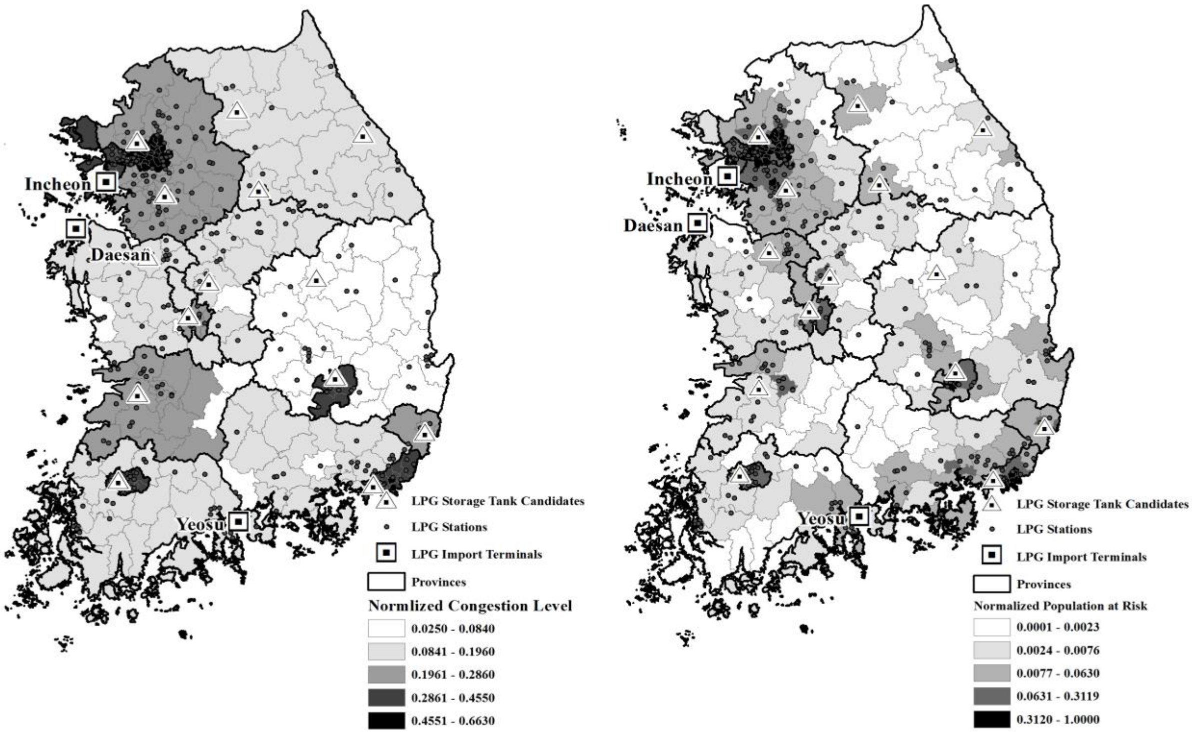
$$X, Y, E, F \in \{0,1\}, \quad LPG^2_{ijkt}, CapST_i \in N \tag{16}$$

The stations and the vehicles' capacity have been respectively guaranteed in constraint (2) and (7). The assignment constraints in the first and second echelon are separately mentioned in the equations (3) and (5). According to this set of constraints, each station will be assigned to one and only one opened storage tank, and each open storage tank will be assigned to only one import terminal. Constraints (4) and (6) assure assignments in the first and second echelon to an open storage tank. The constraint set (8) guarantees that the decided capacity to construct a new storage tank will exceed the daily demand of the assigned stations to the corresponding storage tank. According to constraint (9), the total LPG inventory in a station at period t-1 must be more than the demand in the next day, to avoid a potential shortage. Each station will receive at most one shipment in a day (10); it also ensures that there is a link between $i \in CST$ and station $j \in S$, if and only if that station is assigned to the corresponding ST. Constraints (11) are the flow continuity constraints which ensure that the arrival at a node is equal to the departure from the same node in the same period. Routing from the open storage tanks by just one mode of vehicles will be guaranteed in constraints set (12). Equation (13) is the set of sub-tour elimination constraints. The maximum number of storage tanks is restricted in equation (14). Finally, constraints set (15) guarantees that each station will receive at least one shipment in the entire period.

CASE DESCRIPTION

In order to examine the applicability of the proposed model, a case study has been conducted. Since network design is the main application area for LRP, the supply chain network of a Korean company in the fuel sector was selected. E1 has specialized in providing LPG in Korea, covering about 50% of the LPG import demand nationwide. The company imports LPG from oil-producing countries through three terminals (Incheon, Daesan, and Yeosu). They supply LPG to auto gas stations, bottling stations, and gas retailers. In the current supply network, there are no intermediate storage tanks, the

LPG being stored in big depots at two of the import terminals. All the raw numeric data used in this study was collected from the headquarters of E1. The collected data includes a database of the location and capacity of the company's facilities, and the fleet of vehicles they use. The supply network map, including the 3 import terminals, 359 local gas stations, and 14 storage tank candidates, is shown in Fig.1. The candidates for the inland storage tanks were chosen by running the location-allocation application in the ArcGIS software which considered all the local gas stations while avoiding the high population density areas.



(a) (b)

Figure 1: LPG Supply Chain Network/South Korea; (a) Road congestion, (b) Population at risk

The LRP model in this study will simultaneously determine the number, location, and capacity of the storage tanks, the assignment of stations to storage tanks, and the assignment of storage tanks to the import terminals, as well as the best routing schedule, so that the total externalities and risk are minimised. A fundamental assumption in applying the problem is that tankers in the second echelon must deliver LPG to more than one station per route. Inventory management decisions in this model are considered in a supply chain system with intermediate storage tanks over a discrete time period. Apparently, sound decisions on the mentioned matters can considerably optimise both objectives. Nevertheless, there will be a conflict among the objectives; whereas the first objective may demand congested routes, places near the cities, and the least pollutant transportation modes, the secondary objective necessitates an opposite strategy aimed at the least possible amount of transportation risk and site risk.

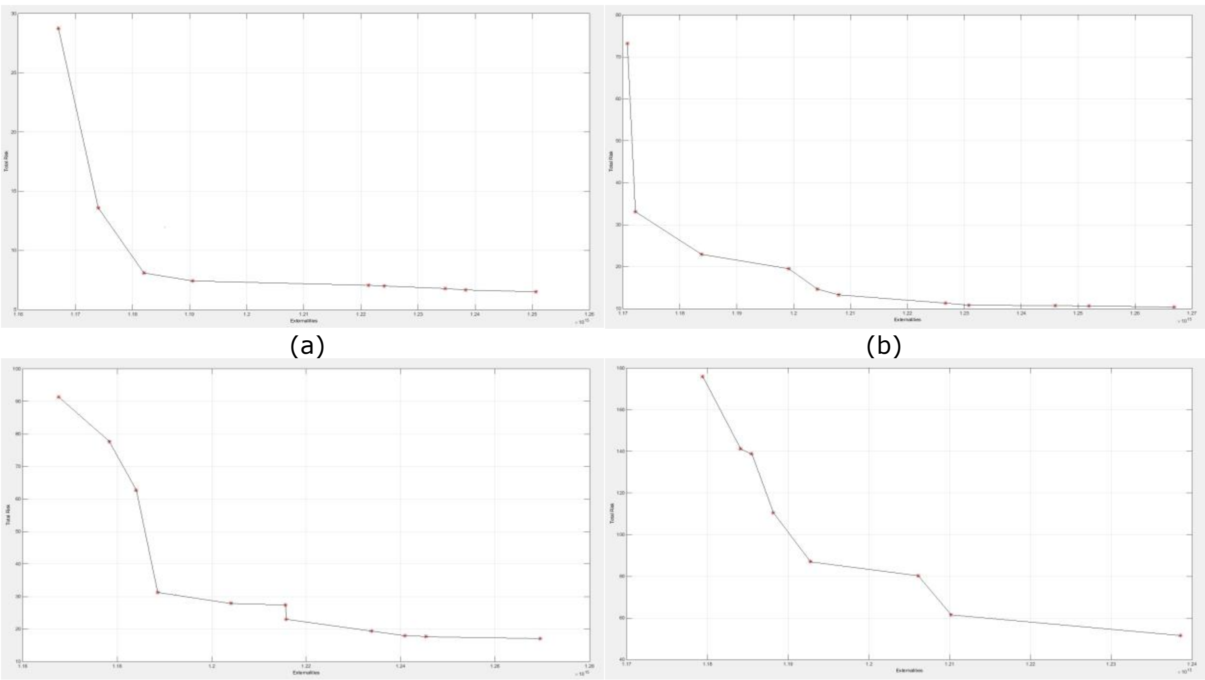
NUMERICAL ANALYSIS

LRP arises from the combination of two NP-hard problems, facility location and vehicle routing. It can therefore be considered an NP-hard problem [9]. According to the review of the literature, the majority of the LRP models have been solved using Genetic Algorithm, Simulated Annealing or Tabu Search methods. Due to the nature of multi-objective problems, a population-based algorithm was considered to be the best option, and as a result, NSGA-II, one of the best global search approaches for multi-objective cases, was selected to solve the proposed model. The pseudo-code of the algorithm is presented in Table 1.

```
1.  generate INPUTS
2.  Specification of the algorithm parameters
3.      for q=1:NumberOfIndividuals
4.          Initialization of the chromosomes (Function)
5.          Verification of the initialized population and Adoption of the random
    solutions to the constraints
6.      end for
7.   Non-Dominated Sorting for the random population (Function);
8.   Calculation of Crowding Distance (Function);
9.   Sorting the population based on rows 4 and 5;
10.     for  it = 1:Generation
11.         for counterc=1:ncrossover
12.             Crossover Function
13.         end for
14.         for counterm=1:nmutation
15.             Mutation Function
16.         End for
17.             Merge;
18.             Non-Dominated sorting and Crowding distance calculation;
19.             Sort Population;
20.             Truncate;
21.             Store he Pareto Front;
22.         Plot the first frontier
23.     end for
24. return OUTPUTS;
```

Table 1. The pseudo-code of the NSGA-II

The encoded model was first tested on a small data set. According to the pilot test outcomes, the algorithm was set to run in 100 iterations based on a population of 50 individuals, a mutation rate of 0.02, and a crossover rate of 0.7. After the mentioned steps, the model was applied to the real data. We ran the algorithm for the different number of intermediate storage tanks. The Pareto front results for each set are shown in Fig.1; an individual point in this plot represents an optimal network configuration for the design of E1's supply chain. However, the choice of one particular solution of the Pareto front depends on how the company prioritises each of the objectives in the objective functions set 1 and 2. Selection of this specific solution will be made by the stakeholders who will provide the budget for the development project. Moreover, in the design of the supply chain network, the decision on the optimum configuration will vary according to the available physical resources such as the vehicle fleet, etc.



(a) (b)

(c) (d)

Figure 2: Pareto Front Solutions (Number of Intermediate Storage Tanks, a:3 b:5 c:8 d:12)

CONCLUSION

Network design as a powerful modelling approach has become a vital component in a firm's supply chain process. As a matter of fact, sound planning in this area, including the proper selection of the facility's location, transportation modes, inventory policies, and the scheduling of deliveries can noticeably minimise risk and environmental problems, as well as reduce logistics costs. This study sought to propose a new LRP model for the eco-friendly risk-aware design of an LPG supply chain network, while maintaining fixed costs at an acceptable level. The proposed model suggests constructing intermediate storage tanks in the supply chain network of the case study, making it possible to store LPG in small quantities and in places which are not congested. Furthermore, the total traversed distance, and in turn total emissions, in outbound logistics will be considerably reduced. To sum up, the proposed model can noticeably improve the total risk and externalities when compared to current networks.

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CUSTOMER VALUE CREATION THROUGH SUPPLY NETWORK AND RELATIONSHIP MANAGEMENT—PARTICIPATORY RESEARCH METHODS IN THE CREATION OF A PRACTICAL APPROACH

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ABSTRACT
To be successful, organisations must focus their efforts on what adds value to the customer, and real customer value requires close customer relationships. Customer value is created throughout the supply chain, such that each phase increases or decreases value and individual actors play important roles in customer value creation. Knowing what customers currently value is not sufficient; instead, gaining competitive advantage requires exploring what customers will value in the future. Anticipating future customer values plays an essential role in developing business processes and building optimal network relationships to develop the core capabilities needed to deliver superior value to customers. The main purpose of this paper is to introduce the participatory future research methods as a tool for helping companies identify the most relevant future trends and how they will affect future customer value, network decisions and relationships in the business-to-business context.

KEYWORDS: customer value, trend, network relationships, futures workshop

INTRODUCTION
The creation of unique and individualized sources of customer value is one of the primary targets of solutions involving supply chain members (e.g., Langley and Holcomb, 1992; Mentzer et al., 2001). Suppliers must have an understanding of what their customers value, especially when customers are increasingly looking at purchasing as a way to increase profits—and, thus, are pressuring suppliers to reduce prices (e.g., Anderson and Narus, 1998). All functional, economic, emotional and symbolic value determinants are essential for understanding total customer value creation (Leek and Christodoulides, 2012; Rintamäki et al. 2007). Managers should understand and be aware of the specific value determinants in their business contexts. This will enable companies to effectively develop supply chain processes, make the best business choices, add value to customers and serve customers in the best way. Customer value is created throughout the supply chain, such that each phase increases or decreases value and individual actors play important roles in customer value creation. Knowing what customers currently value is not sufficient for success; instead, gaining competitive advantage requires exploring what customers will value in the future. To be able to respond to near-future market requirements, suppliers need to be a step ahead in planning future solutions (Sarshar and Pitt, 2009). Therefore, the anticipation of future customer values plays an essential role in the development of business processes, as well as in the building of optimal network relationships to develop the core capabilities necessary to deliver superior value to customers. The main purpose of this paper is to introduce the participatory future research method as a tool for helping companies identify the most relevant upcoming trends and how they will affect customer value creation in the business-to-business (B2B) context. The aim is to investigate the effects of trends and megatrends on

customer value—and, subsequently, how these trends influence company network relationships and decisions related to supply networks. The second aim of this paper is to explore the meanings of network relationships and the roles of individual actors in creating total value for the customer. This paper increases our understanding of the meaning of anticipating customer value determinants in the future, thereby allowing companies to respond to customers' changing demands and requirements.

METHODOLOGY

This paper is based on a portion of a larger two-year project: "Determinants of value and vulnerability in a customer-oriented service network (Custor)". The paper aims to identify and analyse the effects of trends on future customer value creation, as well as on future supply network decisions and relationships, in order to achieve superior customer value. The following questions are answered: (1) How can the effects of trends on customer value creation be identified? and (2) What are the roles of individual actors and network relationships in customer value creation?

The paper is based on a literature review and a case study in the form of an expert group futures workshop. The purpose of futures research and methodologies is to explore, create and test both possible and desirable futures to improve decisions (Glenn, 2009b). Futures workshops are a type of participatory research method used to facilitate group processes to deal with actual problems concerning the group (CIPAST, 2012; Vidal, 2006). Since participatory methods are more likely to produce normative results than analytic ones, they can be used to produce general strategies rather than detailed plans (Glenn, 2009b; Vidal, 2006). A participatory approach advocates actively involving experts in decision-making processes (Slocum, 2003). The expert group workshop described in this paper followed the basic principles and phases of futures workshops (Vidal, 2006), as follows:

- preparation (invitations, facilities, timetable, facilitators, orientation)
- critique (critical and open discussion of the current situation)
- fantasy (brainstorming, free visioning of the future and ideas for achieving the future)
- implementation (critical evaluation of ideas and development of strategy, action-plan elaboration)
- follow-up (reporting and dissemination of results)

In the expert group futures workshop, the aim was to consider trends and megatrends in the current business environment, as well as their effects on customer value creation. A detailed, three-phase process was carried out and practically tested by expert group members. The expert group consisted of seven top managers and experts from five case companies in different industries. One essential method used in the workshop to explore the future was the futures wheel. The futures wheel is a kind of structured brainstorming. It is a simple, but also highly effective method for exploring the future. The futures wheel is a method for identifying primary, secondary and tertiary consequences of trends, events, emerging issues and future possible decisions. It begins with the writing of the name of the explored phenomenon in the middle of a piece of paper. Then, the primary impacts are written in a circle around the phenomenon name. Next, the secondary impacts of each primary impact form a second ring of the wheel. This ripple effect continues until a useful picture of the implications of the explored phenomenon becomes clear. The futures wheel helps to identify potential problems and opportunities, as well as new markets, products and services. It also assists in the assessment of alternative tactics and strategies within companies. It is used, for example, to examine the possible impacts of current trends or potential future events, to engage workshop participants in thinking together about the future and to show complex interrelationships. (Glenn, 2009a).

IDENTIFYING FUTURE CUSTOMER VALUE

The nature of customer value is dynamic, and it changes over time. Therefore, knowing what customers currently value is insufficient for success (Flint, Woodruff and Gardial, 2002, in Flint et al., 2010). In our ISL 2014 conference paper, we presented value creation determinants in a service networks context based on six case studies (Hemilä et al., 2014). The functional, economic, emotional and symbolic value determinants are essential in understanding customer value creation (Rintamäki et al., 2007). In our case, company managers recognized emotional and symbolic values as being particularly vital values; however, the challenge is to not only identify and measure such values, but also point out their direct meaning and their effects on businesses. In order to gain competitive advantage, anticipating future customer value is significant. After identifying today's customer value determinants, the case companies in our research highlighted the importance of foretelling customer value. Specifically, they noted that what customers value at the moment may be different from what they will value in the future. Trends, megatrends; dynamic business environments; and changing world environments, habits and lifestyles all directly impact customers' value determinants. Trends refer to the direction of events: That is, a trend illustrates the long-term general development of the phenomenon under consideration (Finnish National Board of Education, 2014). Examples of some acknowledged consumer micro-trends include: sharing, co-consumption and peer leasing. Macro-trends include, for example: group offers; demand for easy-to-use, not-place-related consumption; a remix culture; and information overload. A megatrend is a coherent entity that is connected to numerous phenomena and that involves a history and a development trend. A megatrend is said to be the "big wave" or line of development. (Finnish National Board of Education, 2014). Some recognized megatrends are: 1) globalization (the world has never been so small), 2) localization (national pride is growing stronger and larger), 3) digitization (people are more confident in technology) and 4) fragmentation (sub-sub-sub-genres) (Consumer Trends, 2006). According to various other sources, identified categories of megatrends include, for example (DNV, 2010; EEA, 2010):

- Population: ageing and urbanization
- Economy: globalization and strong development in Asia
- Energy: growth of demand and an increasing share of renewable energy
- Environment: climate change, emissions and the sufficiency of natural resources
- Technology: everything in the web and accelerating development

Company managers should be aware of leading trends and megatrends in order to make optimal business decisions, and they should also be ready to change their supply chains and follow customers' demands in the future. Staying a step ahead will give managers time to respond to upcoming changes before they happen, as well as enable them to succeed in both B2B and business-to-consumer (B2C) markets.

CREATING CUSTOMER VALUE—NETWORK RELATIONSHIPS

From supply chain network and value network definitions, we can clearly see that the relationships and people in such networks are eventually the ones who create value for customers. Supply chain networks involve inter-organizational structures designed to achieve certain purposes; however, they also involve interconnected business relationships with social aspects. (Gadde et al. 2003; Choi et al. 2002; Paulraj et al. 2008; Harland et al. 2001). Value networks, on the other hand, can be defined as complex and interconnected webs of direct and indirect ties among a group of actors, which create value for customers through the products and services produced (e.g., Li and Whalley, 2002; Lusch et al., 2010). Single actors in such networks create value and influence the experience that customers receive. All portions of the value network need to be linked the adaptability of customer value, and individual portions of the network must be measured in terms of their contribution to customer agility.

According to the model developed by Kothandaraman and Wilson (2001), the objective of a value-creating network is to create superior customer value. In their model, three building blocks—superior customer value, core capabilities and relationships—enable value creation. The extent or degree of value creation is influenced by the core capabilities of the participating firms; that is, the capabilities create value together. The value that the customer of a network wants to consume determines the nature of the participating firms' core capabilities and how the other members of the network value them. Moreover, the way to create value is influenced by the nature of the relationships among the firms. Therefore, the types of relationships that exist among network participants, as well as related relationship changes, affect value creation. Thus, the three building blocks of the model are highly interconnected. For example, the core capabilities needed by the network members are determined by the type of superior customer value that the network seeks to create; however, at the same time, the core capabilities are used to create the desired superior value. Relationships among network members, on the other hand, maintain the use and configuration of the core capabilities, while also facilitating value co-creation in the network. The final value desired by customers of value-creating networks determines the nature of the member actors' core capabilities, which will be valued by the other network members. (Figure 1).

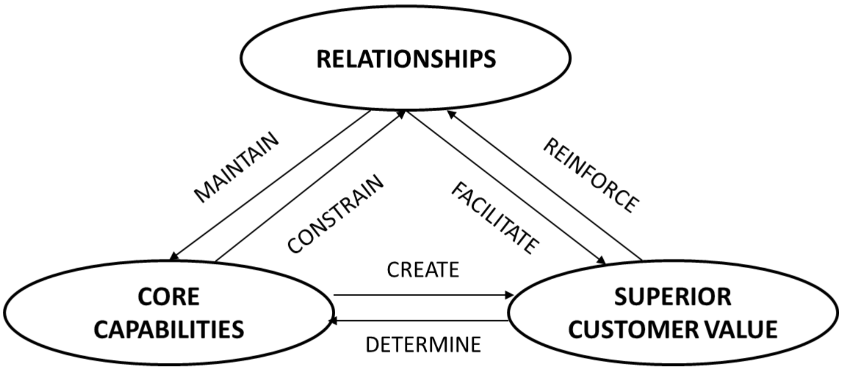

Figure 1. A model of value-creating networks (Kothandaraman and Wilson, 2001).

Since companies aim to create superior customer value in both the present and the future, future customer values need to be identified so that the core capabilities and relationships needed to facilitate customer value can to be determined. Future research methods offer effective tools for identifying future customer value and its effects on business.

EXPERT GROUP FUTURES WORKSHOP

The expert group futures workshop consisted of three phases. The aim was to explore future customer value, identify the effects of trends on customer value and test the introduced process model in a practical setting. First the effects of megatrends on business and customer value creation were discussed. Next, the five most relevant trends for future business development were listed. The last phase considered the primary and secondary effects of specific trends. This process model is illustrated in Figure 2. Seven experts participated in the workshop, including top managers and experts from five case companies from different industries. The expert group future workshop was supplemented by project researchers, who facilitated the workshop and participated in the debate when necessary. The main results of the workshop are presented in this study.

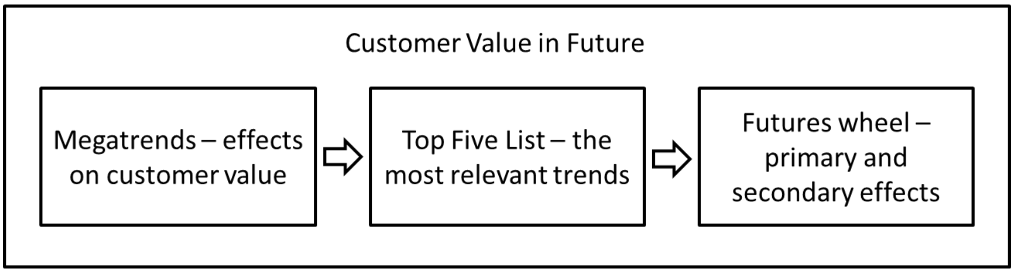

Figure 2. Process of identifying the effects of trends on customer value

The megatrends discussed with the expert group were globalization, localization, digitization and fragmentation. The experts were divided in two groups to facilitate a more productive discussion. Thoughts based on the discussions of each megatrend were gathered on sticky notes. The effects customer value creation was determined to have on business are presented in Figure 3. The idea was to find as many effects as possible. In the discussion, the megatrend of digitization was seen to be particularly strengthening for the future.

Megatrend	**Effects on customer value creation in business**
Globalization	Global competition, Need of logistics increases, Alienation from the customer, size/volume conclusive in procurement, different rules in different countries e.g. effects on energy, networking, concentration of actors
Localization	Opposite reaction to the globalization, increased appreciation of domestic products and services, local food and face to face service, increased national proud and self-interest, utilization of the local production in a wider perspective
Digitization	World is getting smaller, enables globalization, the need for labor is reduced, due to compartmentalisation the flexibility decreases, automation of various supply chains
Fragmentation	Enables a success of customized small demand products, the products along with its variations increases, increased of customization, increased need of customer specific solutions, increased of customized experiences, extreme phenomenons and groups increase

Figure 3. Megatrend effects on customer value creation in business

After determining and generally discussing the effects of megatrends on customer value creation, the experts were asked to list the five most important trends affecting their future business. This method is a variation of the so-called "Top Ten method", which is a method for examining the ten most important factors that affect the future of a focal phenomenon (Finnish National Board of Education, 2015). The experts were divided in two groups. After several minutes of discussion, the following two "Top Five" lists were created: 1) energy efficiency, peer to peer (P2P), welfare, ease of use, and seniors; and 2) digitalization, sustainable development, location independence, ease of use, and individuality. In the futures wheel exercise, the aim was to describe the first- and second-order impacts of specific chosen trends on business. The purpose of this exercise was to consider the future and answer the following question: What are the effects of the chosen trends on customer value creation in business? The experts were divided into two working groups. Each group was asked to choose one trend from the Top Five list; this trend was the starting point of the group's futures wheel. By chance, both groups chose similar trends: demand of ease of use and easiness. For the purposes of giving an example here, the other futures wheel for easiness is presented in Figure 4. The first-order impacts recognized in this futures wheel were: reliability, speed, quality, impatience, non-alignment and reliability. Second-order impacts were: response time, feedback, price, timelines, automatic operations, risk of continuity, open alternatives, customised solutions, audited processes and notice of deviations.

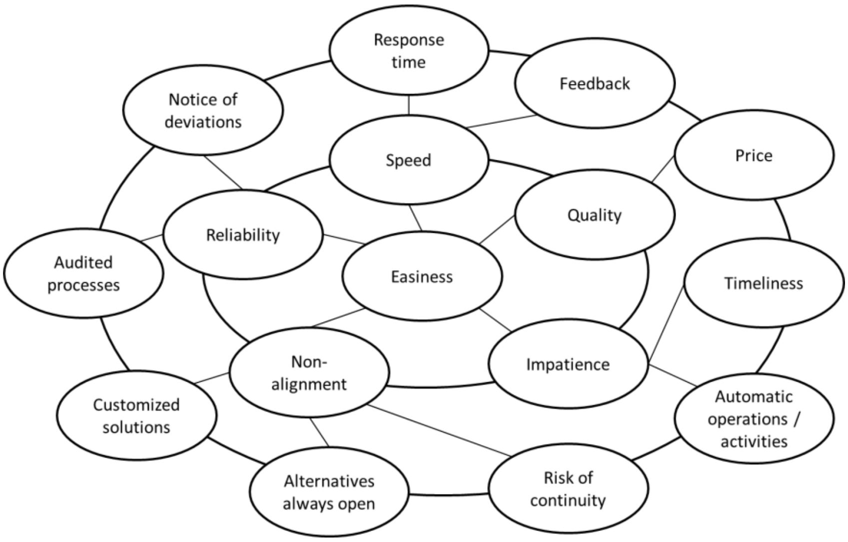

Figure 4. Futures wheel of easiness.

RESULTS AND DISCUSSION

Since futures research methodologies aim to explore, create, and test possible and desirable futures, they are also suitable for company managers as tools for making strategic decisions and visualizing future scenarios. The process model for future research methods presented in this paper was considered to be well suited for identifying the effects of trends on customer value in the future. The three-phase model using future research methods was tested in a practical setting, with an expert group representing five case companies in different industries. Experts participating in the future workshop mentioned that the model helped them understand the big picture of the future business environment. The model enables the recognition of future trends and their effects on customer value: that is, what customers will value and what is needed to create customer value in future. This is essential for companies to be ready for changes before they happen.

Based on the discussion with the case companies' experts, we came to the conclusion that knowing and being aware of future trends, megatrends and their effects on customer value are essential for making optimal, future-oriented strategic business decisions. Future customer value determinants have an influence on the relationships within a network, since future customer value determines the core capabilities needed and valued by the partners. The final value that customers desire determines the nature of the member actors' core capabilities, which will be valued by the other network members. Core capabilities constrain the relationships, and relationships facilitate superior customer value, as presented in the model of a value-creating network proposed by Kothandaraman and Wilson (2001). If a customer will value, for example, the ease of use determinant in the future, the company seeks partners who are able to meet this customer requirement and create value for the customer. The core capabilities in the supply chains are, therefore, the ones creating superior customer value, which then reinforces the network relationships. The creation of customer value depends heavily on individual actors in a network. Company strategic guidelines are created by individuals through their viewpoints and opinions. Network relationships are also formed by individuals. Therefore, trends affecting individuals are meaningful.

This paper opens up several avenues for future research. First, the effects of trends on customer value can be explored at a company level through in-depth case studies. This may increase a company's understanding of its business environment and its customers' future values. Furthermore, the model presented in the paper requires further testing and evaluation in different contexts and different case companies. The paper also raises the issues of future supply chain management, network management and value network management models.

CONCLUSIONS

The world is changing: Trends and megatrends are shaping future business models, but also providing the guidelines for companies to develop business processes for future business environments. Customer value, which is also affected by trends, is both individual and dynamic. It changes over time and all the time. In the future, symbolic and emotional values are likely to be highlighted. Customers will increasingly base solutions and decisions on symbolic and emotional values. The need to recognise customer value determinants in the future is essential for companies to achieve competitive advantage. Trends and megatrends influence what customers will value in future. Therefore, it is critical to identify their effects on customer value. Identifying future customer value will enable companies to choose the best partners with the right core capabilities, thereby enabling superior customer value to be reached. Participatory future research methodologies offer valuable tools to identify these issues, to serve customers as best as possible in the future and to develop business processes in the right direction.

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DEVELOPING MASS CUSTOMIZATION AND SUPPLY CHAIN MANAGEMENT IN HIGH TECHNOLOGY INDUSTRY COMPANIES

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INTRODUCTION

Global procurement, global production structures, increasing visibility over the markets, increasing dynamics of business operations and customer-driven supply chains set challenges, demands and opportunities to supply chain development. Businesses emphasize end-user focus, which leads to increasing consumer-centricity and consumer-driven supply chains. The challenge is to combine the economies of scale in volume based mass-production products tailored to customers. Mass customization is one approach to execute this business challenge to combine high quality customer service with high profitability. In other words, the goal of mass customization is to enable mass production with a high variety of products customized to the individual customer's needs (Ahoniemi et al., 2007; Chandra and Kamrani, 2004; Pine, 1993; Tseng and Piller, 2003).

The purpose of this paper is to introduce a new method to develop mass customization capabilities in supply chain management in high technology industry companies. The paper comprises synthesis of a theoretical discussion based on a literature review and case study in the form of training workshop for experts. Through theory and empirical data from the training workshop the paper seeks answers to the following research questions: (1) How to develop mass customization in supply chain management in high technology industry companies and (2) What are the key issues in developing mass customization in supply chain processes.

MASS CUSTOMIZATION IN SUPPLY CHAIN MANAGEMENT

The goal of mass customization is to enable mass production with a high variety of products customized to the customer's needs. (Ahoniemi et al., 2007) Mass customization can be defined as developing, producing, marketing and delivering affordable goods and services with enough variety and customization that nearly everyone finds exactly what they want (Pine, 1993; Tseng and Piller, 2003). Mass customization recognizes individual customer needs while achieving maximum reusability in order to maintain low production costs (Chandra and Kamrani, 2004).

In order to benefit from mass customization the managers must tailor the process to an existing business. Managers should think of mass customization as a process in which a company moves away from mass production toward mass customization. The three following capabilities are required: solution space development, robust process design and choice navigation. Solution space development means identifying the product attributes along with customer needs diverge, robust process design is reusing or recombining existing resources and choice navigation is to help customers determine or build their own solutions. A company might decide to improve all these three capabilities simultaneously or, rather, to prioritize one or two of them. (Salvador et al., 2009) Efficient logistics and supply chain management is one of the key preconditions for adopting mass customization strategies. Mass customization requires an agile supply chain to function optimally. Key factors for a success of a mass customization system are customer sensitivity, process amenability, competitive environment and organization readiness. (Chandra and Kamrani, 2004)

Challenges in mass customization

The challenge in supply chain management is simultaneously to minimize the costs and maintain the level of service in the entire chain. (Simchi-Levi et al., 2008) According to Mäkipää et al. (2009) the main challenges in mass customization utilization are variations management, product change management, communication, sales configuration and modularization of product structure. Companies who are implementing mass customization usually have very ambitious targets and they want to offer customers everything they want. This can lead ever-new product variants and challenges in variations management. The implementation of mass customization had made it easy to make small customer-specific changes in order engineering, but sometimes even the small changes in product qualities cause major changes in production processes.

Implementation of mass customization requires information of the demand for customized products. Challenging is to know how much customers are willing to pay for individuality, how much does it cost to produce a customized product and how much will it cost to the customers. Different targets of customers, designers and producers can cause challenges. Efficient, deep and complete interaction with the customer is very important. A successful mass customization strategy depends on an appropriately designed configurator. Setting possibilities and limits for customization is one of the challenges; mass customization grants certain possibilities while excluding others.

Tseng and Piller (2003) highlight the five challenges when addressing diverse customer needs individually. These are speed, lead time, customer's need, economies of scale, value and complexity. Speed and lead time relates to customers' expectations to have same order of magnitude in short lead time by extrapolating the expectation from standard items onto the custom goods. The gap between customer's expectation and real time needed for the customized production is significant. Customization to individual customers' needs intuitively can lead to higher varieties, which means difficulties to reach the necessary scale of economy. Offering choices does not always mean value to customers. Synchronizing choice between product attributes and options with customer appreciation is a major challenge in the customization. Managing the complexity with high variety and small lot sizes requires good scheduling, co-operation and IT solutions.

New operation models require change management and effective processes to follow through it the whole organization. Main challenge is to handle increasing complexity however without oversimplifying the solutions. Mass customization is not only utilizing techniques and supporting systems, instead it is more change project affecting to organization, target-setting, operations models and processes of the company or department or business unit. The changes do not have to be remarkable, even small improvements can lead to substantial benefits. Lean management as a customer-driven approach is one disposable approach to manage change management processes and increasing mass customization capabilities to supply chains of a company. Lean organizes the operations according to targeted customer segment targeting to maximize the customer value in relation to costs (Harrison et al., 2011).

A Comprehensive model of mass customization development

Comprehensive mass customization can be seen as a high mountain situated on flat surroundings. By climbing up to the hilltop, you can see much further, but on your way up, you have to make a full circle around mountain and even to find your paths on more unfamiliar hillsides. (Ahoniemi et al., 2007; Mäkipää et al., 2009) This way the comprehensive mass customization can be reached. This is so called mass customization mountain model (McMountain). McMountain model consist of six categories, which are production development, network cooperation, development of management tools, organizational and other factors, customer intimacy and product development. Customer intimacy means closer attention to customer needs and customization of products. Moving to mass customization requires multi-faced development and better management of information processes related to all operations. Product development and modularity is considered to be a key enabler of mass customization. Modularity allows production of modules and components in volume while offering a greater range of end products. Product designing requires time and a natural way to introduce modular products could be in the same cycle as new product development and new product family launches. (Ahoniemi et al., 2007; Mäkipää et al., 2009)

Mass customization generally calls for the postponement principle in production that is to delay some of the value-adding activities until a customer order arrives. In order to achieve both efficiency and effectiveness of production, as required in mass customization, companies need to combine lean and agile approaches. That way production development is an important part in achieving comprehensive mass customization. Same way the deep supplier cooperation is needed to ensure a fluid supply of customer-specific components. Network cooperation is about the management of sourcing, taking care of logistics networks and collaborative process development. (Ahoniemi et al., 2007; Mäkipää et al., 2009)

One of the hillsides in McMountain model is development of management tools. Mass customization requires well-defined information management, especially from the product information perspective and for management of complexity of mass customization. Organizational and other factors in the model relates to the management of change, commitment, creativity and learning. The management of the change process to mass customization requires commitment, complexity management and education of employees. (Ahoniemi et al., 2007; Mäkipää et al., 2009)

WORKSHOP AS A METHOD TO DEVELOP COMPANY'S MASS CUSTOMIZATION IN SUPPLY CHAIN MANAGEMENT

The new method to develop high technology industry company's mass customization in supply chain management is based on both the findings of the literature review and the workshop, which was held in global high technology industry case company. The workshops are among the participatory research methods used to facilitate group processes to deal with actual problems concerning the group (Vidal, 2006). The participatory methods are more likely to produce normative than analytic results, i.e. they can be used to produce general strategies rather than specific plans (Glenn, 2009b). The process of the three days' workshop was systematic structured and scheduled beforehand. The workshop was hold two times, which ensures the development and the quality of the created method. Workshops mainly consisted of short lectures, group discussions and group works carried out with different methods. After each group discussions and small group works the results and key outcomes were shared to the whole group. The aim of the workshop was to give inputs, tools and ideas to the participants how they could develop their work. The aim was to develop mass customization capabilities in supply chain management in participants' company in a strategic, tactical as well as an operational level. The participants in the workshop were mixed group of experts in high technology industry company. In this paper the results of second training workshop is handled. In the second training, there were together 17 experts from different levels of the organization, e.g. from different product management and customization entities.

Structure of the workshop

The workshop consisted of three days face to face module. Beforehand the participants were asked to do a pre-study material in order to explore topic. Four articles and some short case studies as a pre-study material dealt generally with the mass customization issues, challenges in mass customization, services and supply chain management. Based on the pre-study material the participants were asked to reflect the questions in a short questionnaire. Expectations for the workshop were also asked to ensure the quality of workshop and being aware of the starting point of the participants' knowledge about the theme.

The first part of the workshop was dealing the issue why to do mass customization. The workshop was started with introduction part, as determining objectives for the company. After introduction part and getting to know each other the program continued with

introducing the changes in business environment, drivers for these changes and trends in supply chain management. Supply chain's role in company success was also highlighted and some key features to develop customer driven supply chain were discussed. This was followed by determining the future consumer trends and their affects in order to give perspectives about the coming perquisites for developing the products and services. In the next part of the workshop some case examples of mass customization was presented and discussed among participants. The discussion was followed by examining the company strategy, product and service strategy, and supply chain and customization strategy.
The second part of the workshop concentrated on the question: what is to mass customize? The session started with introducing theories of mass customization, following the discussion what is customized and how, and what is the customization process currently in the company. Also the developments of effective lean operations were discussed. The next thing to do was to examine challenges in supply chains and mass customization. This part was wrapped up with change management theory and discussion.
The third part of the workshop was about how to mass customise? In this part one mass customization tool McMountain was introduced and used for developing mass customization from the company perspective. Approaches followed during the workshop were cost efficiency, product profitability and company profitability, chosen beforehand together with the case company.

Table 1. Structure of the training workshop

Part 1 - why mass customize	Part 2 - what is to mass customize	Part 3 - how to mass customize
Introduction - Changes in the business environment - Developing customer driven supply chain	*Mass customization* - Background and theories - Starting point - What is customized and how in the company?	*Mass customization I* - Tools and methods - Case studies
Drivers of change - Analysing trends and their affects, Futures wheel	*Lean operations* - Developing effective lean operations - Where and how can waste of resources be reduced?	*Mass customization II* - Tools and methods - Case studies
Mass customization - Why adopted mass customization - Examples of mass customization in the consumer markets	*Key challenges and development targets in mass customization* - Recognising the challenges for the company	How to do mass customization?
Company strategy - Product and service strategy - Supply chain and customization strategy	*Management of change* - What kind of management of change is needed?	Presentations of group work and reflections to company strategy

Description of method

The method to develop company's mass customization in supply chain management combines both theory and practice (Figure 3.1). It provides comprehensive approach and the holistic understanding about the development of mass customization. The systematic process starts with consideration of changes in business environment and trends and ends with the discussion of development possibilities of mass customization and supply chain processes. As a result the development targets, lists of measures and new ideas are achieved.

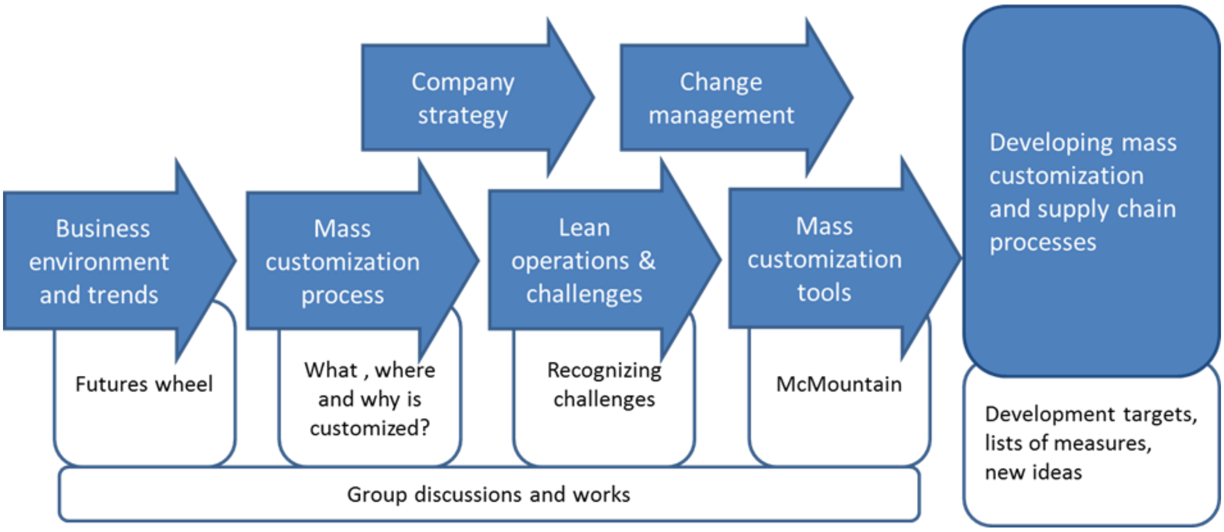

Figure 1. Method to develop mass customization in supply chain management

The method has been evaluated twice as the workshop has been organized two times in high technology industry company. Based on the experiences and feedback from the workshops the few changes were made in order to improve the developed method. As a result the introduced method was built. In following sections we will present some outcomes from the second organized training workshop.

Consumer trends and futures wheel

Trend can be defined as a long term general development of the phenomenon under consideration. Trend is a direction of events. (Finnish National Board of Education, 2014) The futures wheel is a method for identifying and packaging primary, secondary, and tertiary consequences of trends, events, emerging issues, and future possible decisions. (Glenn, 2009a) With the help of a futures wheel drawn on a paper, the first, second and third-order impacts of some trend, event, decision or emerging issue on the functioning and values of society or particular organisation are traced. The different ideas and possible future consequences of a certain phenomenon can be organised, understood and specified.

The futures wheel exercise was done with pairs. The aim was to describe the first and second-order impacts of some specific consumer trend, which pairs were free to choose from given list. The aim was to think the effects for high technology industry company business. The chosen consumer trend was the starting point of this futures wheel exercise. The consumer trends are the ones which companies should be aware of, when designing products and implementing mass customization strategies. The pairs were asked to share their futures wheel to whole group by presenting which trend they worked on, what were the most important primary and secondary effects and what was the most surprising or did they come up with something they did not have thought of before.

As an example, some outcomes from the second organized workshop considering the following consumer trends: simplicity, mix'n match, and learning is fun. Trend of simplicity was seen to effect on capability to react and on capability to be proactive. These mean both empowerment of teams and individual and improvement of speed of technology. Simplicity also means clarity towards stakeholders, minimalistic design, clearer processes and more focus towards customers. Second effects are therefore focus on communication, clear roles, understanding customer needs and business, transparency and technology which are easy to use. Primary effects of mix'n match trend are customer and competitor understanding, collaboration possibilities, product strategy and modularity. Second effects were found related to modularity, like way of working, operations and product structure. Learning is fun –trend impacts on digital learning material, learning mobility, entertainment industry and global access. Digital learning material means digital license and reduced paper backs. Learning mobility on the other hand can mean new device concepts and place independency. Entertainment industry consists of games and movies based on learning. Global access can result with new business models, localized offering for example weather forecasts and cloud sharing.

What is customized in case company?

The participants were asked to write down key words and thoughts and discuss in the smaller groups what is customized in their company. The aim was to challenge the participants to think what they actually customize and how in their company. The participants found quite many customized products and services and also the process were seen similar. Customized products include entire products, sales boxes, settings, accessories, stickers, print materials etc. The sales box and its content can be very different depending for example on the market. From the services the customized delivery method includes for example variation of pallet sizes. One group also divided customized products into the pure customized products and products that are tailored customized strategy products. The customization process is done with the help of customization guideline, which defines the offering. Offering is modelled to configuration tools and variants are created and produced against to the customer order. Process ends with delivery and shipment.

Mass customization challenges in case company

The participants were asked to think, what the challenges in developing mass customization are. All the findings were documented on the flip charts and some of those key findings will be introduced here. One of the challenges was that the participants were not completely sure what is actually their company's vision for customization, and should there be more customization or even less. The main question was that if the mass customization is adding value and what kind of value it is adding. Isolated and complex tools and lack of information sharing between organizations were also considered challenging. Target setting and visibility are challenges related to process and information technology site. The concern in visibility was that in research and development teams there is not always information about what actually goes to the market; tracking and fixing afterwards is difficult. How the ownership of customization is organized was also unclear for the participants. Modular structure and design for configurability were missing. Pricing, price setting and also the lack of cost consequences in variant creation was seen challenging. Demand planning, commitment from the company site and prioritizing certain customers were also problematic. Moreover lack of big market pull from consumer site was also seen as a challenge. Long lead times in variant creation and testing process is not helping flexible and responsive supply chain operations. There was also worry about, if focusing only on profitability; maybe it is preventing the innovation.

The exercise was very good and brought out many concrete development targets and improvement proposals for the managers for operational, tactical and strategy level. In a group discussion the visibility and information sharing, price setting and need for simplifying the processes were highlighted the most important things to develop in near future.

Mass customization mountain in high technology industry company

In the concluding exercise the aim was to examine the six categories in McMountain framework from the company perspective. The participants were divided into smaller groups and they were asked to write down the ideas from each category on different coloured post-it notes. All the post-it notes were then collected and put it in together in one framework. As a result the coherent mass customization model for the company was created. Together 49 development ideas were found: 9 ideas in management tools, 13 in organization, 6 in customer, 10 in product development, 5 in production development and 6 in network cooperation. Management tools, organization and product development were clearly the categories with more development needs and ideas compared to other categories.

In management tools category the most recognised development target was the visibility. Other development targets were to improve the demand and supply predictions tools and configuration management tools. In network cooperation category the same need for visibility improvement was mentioned. For good network cooperation the flexible and better demand forecasting is needed. Product deliveries also need attention. In organization the experts highlighted the need for clear vision and target scale throughout the whole company. Clear visibility to existing development projects was also seen important. Other development targets were integration of processes and tools, commitment plan for change management, information sharing, priority commitments, target communication etc. In the product development category good cooperation and communication with the partners were mentioned. The need for improvements of demand and supply predictions tools and configuration management tools was also main issues in this category. In production development category especially the affection on product testing in factories was seen remarkable issue. Other things mentioned here were postponement, direct distribution and clear targets. Customer category the main things were offering, services, knowing the demand and good communication.

RESULTS

The main and first research question in this paper was to find out (1) how high technology industry companies can develop mass customization in supply chain management. As a mass customization development method this paper introduces three days training workshop module, which was carried out in a same high technology industry company two times. As a result of these workshops the company was able to develop their supply chain processes as well as mass customization strategies and target settings. Training workshop consisted of theory discussion, group discussions and group works related to mass customization and supply chain processes. Consumer trends, mass customization present state and mass customization and supply chain management challenges in company were recognised by the experts. One introduced tool for developing mass customization in this paper was mass customization mountain (Mäkipää et al., 2009), including six categories to be developed: production development, network cooperation, development of management tools, organizational and other factors, customer intimacy and product development. With the help of this tool company can achieve the comprehensive mass customization. The tool gave to the company the lists of needed measures to be taken into account and to develop mass customization.

Customer centric supply chain is one of the key issues in developing mass customization strategies successfully. This is the starting point for the answer of research question (2): what are the key issues in developing mass customization and supply chain processes? Recognizing customer specific needs and serving customers in the best way ensure the company success especially in high technology industry field. Existing consumer trends effect on the developing of mass customization in supply chain processes. Demand for increasing mass customization capabilities relates to existing trends. Trends like global procurement, global production structures, increasing visibility and dynamics of operations and customer-driven supply chains set challenges, demands and opportunities to supply chain development. Recognizing challenges in mass customization strategies and processes help the company not only to focus on the most relevant development targets, but also to reduce possible wastes in the existing processes. Key issues are e.g. agile manufacturing, customer driven design, advanced technologies, information technology and change management. According the training workshops especially sharing the information and visibility was seen one of the most important things in developing process and development targets. Lack of information was seen as a big challenge. Good demand and supply predictions tools and configuration management tools are needed. Three introduced capabilities: solution space development, robust process design and choice navigation were also recognized in workshops.

As a practical implications the key objectives of the workshop was to increase the mass customization and supply chain management competencies in the companies' customization teams, increase awareness for mass customization theories, provide information for the best practices in different industries, drive the need for customer centricity and supply chain service deployment, provide participants with the holistic knowledge about the product customization positioning in the company´s strategy, provide ideas for improving existing processes and networking with colleagues. According the feedback from the workshop, this developed method deepened the participants' understanding about the mass customization and gave some good tools and new thoughts from theory parts. The method also gives a vision how the customization work should developed in order to better match with the customer needs with low cost effect. The workshop gave new ideas and perspectives to assess ways of working and current processes. It was also highlighted that meeting colleagues of different functions were refreshing and it was possible to do critical evaluation of the company's processes.

Mass customization can be seen one of the strategies used in supply chain management to achieve competitive advantage. The workshop method gives the basic understanding about the different concepts and areas that needs to be taken into consideration when planning and executing customization in supply chain activities. Trend meanings, financial perspectives, agile supply chain, the whole current customization chain in the company and group members roles in that chain were the issues the experts wished to be discussed more during the training workshops.

CONCLUSIONS

In this paper we have contributed to the understanding of developing mass customization in supply chain processes for high technology industry case company. The main contribution of this study to theory is the development of the new methodological approach for developing efficient mass customization in supply chain management. The main finding is that the developed method suits well for developing mass customization in supply chain processes in high technology industry company. The method was tested twice in form of three days' training workshop in one high technology industry case company. The outcomes of the workshops show that with this method the participants were able to develop their own work and increase their understanding of mass customization practices and supply chain management. The development targets and lists of needed measures in the form of mass customization mountain tool can be constructed as a concluding part of the workshop, even when the participants are not familiar with the mass customization concepts. With the developed new method the company can start developing comprehensive mass customization as a part of supply chain processes.

This study opens up several avenues for future research. Most importantly, the training workshop method developed during the study needs further testing and evaluation. Such further evaluation could be done in several high technology industry case companies or other case companies from different industry fields. Nevertheless, in order to verify the theoretical and practical contribution of the method developed, further empirical studies need to be carried out. The challenge is to implement the discussed ideas right away inside the ever-changing case company.

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ANALYSIS OF THE ISL COMMUNITY – A SOCIAL NETWORK PERSPECTIVE

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ABSTRACT

Purpose of this paper:
The community surrounding the International Symposium on Logistics (ISL) has been developing for more than two decades. Organizationally, it has relied on the participation of few key persons during this time, while the larger scientific community has been more dynamic. Over the years it has evolved and developed into an interactive and dynamic community where the participants are able to share, network and develop their ideas and concepts into more meaningful short and long-term collaborative research projects. Therefore, the purpose of this paper is to investigate the development of this particular scientific community utilizing social network analysis. This is valuable not only for the ISL conference stakeholders as such, but also to larger logistics and supply chain research community.

Design / methodology / approach:
The study is based on the social network analysis of the co-authorship data from the ISL conferences between 1993 and 2014. Co-authorship is used as an indicator for realized collaboration, and several different measures are used to assess the impact of key authors and collaborators.

Findings: This study provides an important, yet sparsely addressed viewpoint to the dynamics of scientific communities by examining the structural development of the ISL conference. In particular, as we have a rarely available longitudinal data, spanning over 20 years, we can observe how the co-authorship patterns have developed over last two decades.

What is original/of value in paper: The value of the study lies in the knowledge it provides about the development of scientific communities, firstly by illustrating which factors have influenced the structural development of the community and secondly, by increasing the understanding about the key individuals in the community and their role in the network.

Practical impact: The presented study offers a broad viewpoint to be considered in managing the ISL community. By better understanding the structure of the network the organizers can better utilize the potential that lies in it, and the authors are able to identify interesting potential collaboration opportunities.

Keywords: ISL; scientific community; co-authorship; social network analysis.

INTRODUCTION

Academic progress and development of science is fundamentally a social phenomenon. Science builds cumulatively through different approaches, disciplines, paradigms and discourses (Kuhn, 1962). These, in turn, are formed and developed in various fora, such as universities, conferences, academic journals. In this study we examine the development of logistics research community through a particular forum – the ISL (International Symposium of Logistics) events over the period of 1993 – 2014.

Literature streams examining scientific collaboration have utilized various approaches, and one very concrete approach is the co-authorship analysis (e.g. Newman, 2001, 2004; Morlacchi et al., 2005). The particular benefit of this approach is that it allows for understanding the actual, realized result of scientific collaboration, with concrete measures (co-authorship in publications) to assess it (Vidgen et al., 2007). Co-authorship analysis is often coupled with social network analysis (Wasserman & Faust, 1994) which allows for understanding both role of individual actors as well as the overall co-authorship structure (e.g. Morlacchi et al., 2005; Santonen & Ritala, 2014).

In this study we focus on the authorship and co-authorship patterns of ISL events between years 1993 – 2014. Such longitudinal dataset, spanning over 20 years, is extremely rare and allows for examining issues on co-authorship not typically available. Thus, our research aim is to understand the *longitudinal* evolution of authorship and co-authorship within a specific scientific community. In our study, one academic event, ISL, is adopted as a case study since it allows for unambiguous sampling frame to study the topic within well-defined field and context.

THEORETICAL BACKGROUND: ACADEMIC COLLABORATION AS SOCIAL NETWORKS

There are several studies conducted on how academic communities are structured through co-authorship with social network analysis. These include for instance ECIS conference in information systems (Vidgen et al., 2007), industrial marketing and purchasing (IMP) conferences (Morlacchi et al., 2005), as well as innovation management conference ISPIM (Santonen & Ritala, 2014). Such studies provide more understanding of the structure and dynamics of specific academic contexts and communities, and to the authors' knowledge, no such research exists on the co-authorship patterns among logistics researchers.

Research in the field has shown overall that typically there are few key or hub actors, around which larger networks of other actors are clustered (e.g. Santonen & Ritala, 2014). This clustering also has been noted to be connected to the similarity in the collaboration authors' geographical location and institutional affiliations (Su & Lee, 2012; Santonen & Ritala, 2014). Further, it is also suggested that collaboration structures and patters could vary between different disciplines (Abt, 2007). In this study we expect to see key actors emerging from the data, and it is also interesting to investigate whether some actors emerge as important nodes over time, or in particular periods.

Furthermore, we view scientific events and forums (typically these are called conferences, symposia, workshops) as arenas for collaboration, interaction, and social construction. From this perspective, we expect that social capital between the researchers participating to the same specific events will grow over time. This might lead to different collaboration patterns over time, such as increase in co-authorship, cross-disciplinarity, or from other perspective, division to more defined streams or schools of thought.

RESEARCH DESIGN

Data collection and measures

The data was acquired from the archive records of ISL (International Symposium of Logistics). The data included the year of the conference, and the name of the published authors in a standardized format. In addition, the data included the information about co-authorship ties. For instance, for 2-author paper there were one linkage between the authors. For 3-author papers, there were a total of three linkages between pairs of authors, for 4-author papers, there was a total of six linkages, etc. This type of data format allowed us to construct the data matrix needed to analyse the actor positions, as well as the overall network structure.

In this study, we focus on two actor-level measures: degree centrality and betweenness centrality. Degree centrality refers to the total number of direct linkages a specific actor has (Freeman, 1979; Wasserman & Faust, 1994). For instance, if an author has co-authored a paper with another author, he/she will have the degree centrality of 1. If the same author would also authored another paper within an author team of three persons, 2 degrees are added to this measure, totalling to degree centrality of 3. Betweenness centrality provides a score for a particular actor based on its position as a gatekeeper between two or several different independent components of other actors (Freeman, 1979; Wasserman & Faust, 1994). This means that these actors are structurally between various networks, and can thus potentially utilize such gatekeeper role for various purposes such as connecting different types of specialized knowledge together, or but helping resources to flow together from different parts of the network (see e.g. Granovetter, 2005).

Case context – ISL and logistics research community

The International Symposium on Logistics (ISL) was formed at a time when various regional trading blocks in Europe, the Pacific Rim, Continental America were being established to take advantage of emerging trends in globalisation as well as the opening up of Eastern Europe and the break-up of Soviet Union. It was argued that the increased global economic uncertainty was also creating new challenges and opportunities for enhancing logistical operations. During this period many organisations are keen to focus their resources and attention on improving logistics capability and efficiency. In parallel, there was a growing realisation that a common forum in the area logistics and supply chain to bring together and stimulate the exchange of ideas between academic research and industrial practice did not exist. Previous similar events tended to be rather focused in the area operations, materials or inventory management and there was a need to bridge this gap. In early 1992, a proposal was made to the United Kingdom's Operations Management Association (OMA), which subsequently expanded as the European Operations Management Association (EurOMA), to provide support for the launch of the inaugural International Symposium on Logistics (ISL) in Nottingham, UK in July 1993. The aim of this first event was to stimulate the exchange of ideas between academic research community and industrial practitioners. After the success of 1993 which attracted delegates from over dozen countries, subsequent ISL events were held in Nottingham, 1995, Padua, 1997 and Florence in 1999. There was a huge interest from the Japanese academic community to organise ISL 2000 in Iwate which proved to be an even bigger success. This also led to the concept of alternating ISL between Europe and outside Europe on an annual basis. To date this event has been held in Salzburg, 2001, Melbourne, 2002, Seville, 2003, Bangalore, 2004, Lisbon, 2005, Beijing, 2006, Budapest, 2007, Bangkok, 2008, Istanbul, 2009, Kuala Lumpur, 2010, Berlin, 2011, Cape Town, 2012, Vienna, 2013 and Ho Chi Minh City, 2014, with the 20th ISL held in Bologna in July 2015. In this paper we reflect back on the last 19 years and analyse the type and nature of networks and collaboration which has formed as a result of participating in ISL events over the last two decades or so.

RESULTS AND ANALYSIS

The analysis of the SNA results is discussed from two perspectives, namely from the ISL's co-authorships evolution perspective, and from the most relevant authors perspective in terms of their centrality, both overall and in four different time clusters.

Co-authorship evolution over time

In the beginning of the ISL, the number of papers attending rose quite rapidly from around 50 to around 100. Since then the number of authors contributing has had small variation but still remaining quite steady except for the years 2004 (see table below).

Table 1. Co-authorship evolution

Year of ISL	Number of authors							Total	Dev. from average
	1	**2**	**3**	**4**	**5**	**6**	**7**		
1993	26	12	13	3	0	0	0	54	-37 %
1995	20	18	10	2	0	0	0	50	-41 %
1997	30	44	21	4	1	1	0	101	18 %
1999	41	42	17	7	0	0	0	107	25 %
2000	19	32	29	10	2	1	0	93	9 %
2001	21	26	17	6	2	0	0	72	-16 %
2002	20	26	27	9	1	1	0	84	-2 %
2003	13	40	24	15	2	0	0	94	10 %
2004	9	16	16	9	0	0	0	50	-41 %
2005	9	37	23	11	2	0	1	83	-3 %
2006	19	41	30	5	2	1	0	98	15 %
2007	11	34	33	8	2	1	0	89	4 %
2008	14	29	27	12	2	1	0	85	0 %
2009	10	32	24	15	6	1	1	89	4 %
2010	7	24	33	8	3	2	0	77	-10 %
2011	7	33	38	18	7		0	103	21 %
2012	11	29	23	15	3	2	1	84	-2 %
2013	17	44	31	18	3	2	0	115	35 %
2014	11	20	30	21	9	2	1	94	10 %
Aver.	16,6	30,5	24,5	10,3	2,5	0,8	0,2	85,4	0 %
Total	**315**	**579**	**466**	**196**	**47**	**15**	**4**	**1622**	

When considering the evolution of the co-authorship in ISL over time it can be seen what kind of impact the event has had. One of the major changes in the community's contribution has been the increased collaboration indicated by the lower number of single authored papers and on the other hand the increasing number of papers with four or more authors.

Table 2. ISL Co-authorship evolution, in percentages

Year of ISL	Number of authors 1	2	3	4	5	6	7	Total
1993	48,15 %	22,22 %	24,07 %	5,56 %	0,00 %	0,00 %	0,00 %	100,00 %
1995	40,00 %	36,00 %	20,00 %	4,00 %	0,00 %	0,00 %	0,00 %	100,00 %
1997	29,70 %	43,56 %	20,79 %	3,96 %	0,99 %	0,99 %	0,00 %	100,00 %
1999	38,32 %	39,25 %	15,89 %	6,54 %	0,00 %	0,00 %	0,00 %	100,00 %
2000	20,43 %	34,41 %	31,18 %	10,75 %	2,15 %	1,08 %	0,00 %	100,00 %
2001	29,17 %	36,11 %	23,61 %	8,33 %	2,78 %	0,00 %	0,00 %	100,00 %
2002	23,81 %	30,95 %	32,14 %	10,71 %	1,19 %	1,19 %	0,00 %	100,00 %
2003	13,83 %	42,55 %	25,53 %	15,96 %	2,13 %	0,00 %	0,00 %	100,00 %
2004	18,00 %	32,00 %	32,00 %	18,00 %	0,00 %	0,00 %	0,00 %	100,00 %
2005	10,84 %	44,58 %	27,71 %	13,25 %	2,41 %	0,00 %	1,20 %	100,00 %
2006	19,39 %	41,84 %	30,61 %	5,10 %	2,04 %	1,02 %	0,00 %	100,00 %
2007	12,36 %	38,20 %	37,08 %	8,99 %	2,25 %	1,12 %	0,00 %	100,00 %
2008	16,47 %	34,12 %	31,76 %	14,12 %	2,35 %	1,18 %	0,00 %	100,00 %
2009	11,24 %	35,96 %	26,97 %	16,85 %	6,74 %	1,12 %	1,12 %	100,00 %
2010	9,09 %	31,17 %	42,86 %	10,39 %	3,90 %	2,60 %	0,00 %	100,00 %
2011	6,80 %	32,04 %	36,89 %	17,48 %	6,80 %	0,00 %	0,00 %	100,00 %
2012	13,10 %	34,52 %	27,38 %	17,86 %	3,57 %	2,38 %	1,19 %	100,00 %
2013	14,78 %	38,26 %	26,96 %	15,65 %	2,61 %	1,74 %	0,00 %	100,00 %
2014	11,70 %	21,28 %	31,91 %	22,34 %	9,57 %	2,13 %	1,06 %	100,00 %

Centrality analysis

In order to analyse the significance and role of different actors in ISL we utilized centrality measures, namely the degree centrality and betweennes centrality. The analysis is carried out from five different time periods: from the whole time span and with four selected time periods (1993-1999, 2000-2004, 2005-2009, 2010-2014).

The degree of centrality indicates the actors connectivity in the network. According to our analysis, during ISL's existence Mohammad Naim is the most connected actor, having most connections in his network. When considering the betweennes centrality, Chandra Lalwani is, the one who has mediated the most information in the network. Overall the results would seem to suggest that while some of the actors have had many co-authors (degree centrality), they have not necessarily been with actors that have long term presence in ISL community. Actors with both high degree centrality and betweennes centrality can be considered most significant actor in the ISL.

Table 3. Actor centrality measures for 1993-2014 (cumulative)

#	Degree centrality		#	Betweenness centrality	
1	NaimM	44	1	LalwaniC	138 935
2	LalwaniC	38	2	PawarK	128 658
3	GohM	34	3	BourlakisM	88 014
4	PawarK	32	4	GallearD	85 540
5	OhbaM	27	5	GhobadianA	84 594
	TowillD		6	LiuJ	83 557
7	RahmanS	26	7	ZhangW	80 730
8	ChangY	24	8	KarasawaY	79 359
	PettitS		9	SuzukiK	62 171
	PotterA		10	YoshifujiT	49 494

When considering the different time periods of ISL evolution, the dynamics of the co-authorship can be noticed. Both the degree centrality and betweenness centrality measures have improved over time which indicates increased collaboration in the network.

Table 2. Actor centrality measures for 1993-1999

#	Degree centrality		#	Betweenness centrality	
1	NaimM	9	1	KatayamaH	59
2	KatayamaH	8	2	HinesP	33
	KayJ		3	BennettD	32
4	HinesP	7	4	NaimM	32
	NakamuraN		5	JamesR	28
	TsuboneH		6	TsuboneH	24
7	TowillD	6	7	KayJ	23
	UetakeT		8	HollierR	22
9	15 authors	5	9	SohalA	17
			10	UetakeT	16

Table 3. Actor centrality measures for 2000-2004

#	Degree centrality		#	Betweenness centrality	
1	MiyazakiM	18	1	DisneyS	324
2	KarasawaY	16	2	NaimM	250
3	TsuboneH	15	3	TowillD	223
4	DisneyS	9	4	MiyazakiM	162
	KatayamaH		5	KarasawaY	150
	NorrmanA		6	McCullenP	123
	SugawaraM		7	HolmstromJ	112
8	6 authors	8	8	HolwegM	95
			9	TsuboneH	86
			10	LalwaniC	65

Table 4. Actor centrality measures for 2005-2009

#	Degree centrality		#	Betweenness centrality	
1	LalwaniC	19	1	LalwaniC	8 304
2	ChangY	16	2	PotterA	6 069
3	ChilderhouseP	14	3	ChilderhouseP	5 154
	MasuiT		4	MasonR	4 257
5	BanomyongR	13	5	PawarK	4 106
	GohM		6	BanomyongR	4 023
	OhC		7	LinC	3 528
	PawarK		8	WuY	3 527
	PotterA		9	ThobenK	3 465
	WuY		10	FoundP	3 085

Table 5. Actor centrality measures for 2010-2014

#	Degree centrality		#	Betweenness centrality	
1	GohM	24	1	KamB	8 534
2	RahmanS	21	2	RahmanS	7 753
3	LalwaniC	19	3	LalwaniC	7 435
	NaimM		4	PawarK	6 500
	PawarK		5	LirnT	5 425
6	PettitS	17	6	WuY	5 195
7	DarkowI	16	7	AbareshiA	3 993
8	KamB	15	8	ChanC	3 473
	OhbaM		9	GohM	3 186
10	MasonR	14	10	LiuC	2 718

CONCLUSION

Academic communities can have strong influence on the professional and personal relationships between scholars. Since the beginning of ISL 1993 it has had a strong influence on the logistics and supply chain management related academic networks.

Our study contributes to the understanding of scientific communities both in general, as well as in the specific context of ISL (International Symposium of Logistics) community. The unique data set spanning from 1993 (establishment of ISL events) until 2014 gives us the opportunity to not only examine the network structure and measures as such, but also to pick out longitudinal developments. This provides us several contributions that are related to scientific community evolution, as well as network evolution; both themes that have been pointed as important research gaps (e.g. Santonen & Ritala, 2014). While supply management and logistics researchers have been using social network analysis in their substance-focused studies (e.g. Carter et al., 2007; Borgatti & Xun, 2009), our study is the first broad-based attempt to utilize social network analysis to logistics *researchers* themselves. There are several interesting results that emerge from our study.

First, a notable trend over the years is that the number of single-authored papers have declined. In the first year of the conference 1993, about half (48.15%) of the papers were single authored. Over the course of the analysed data, the number of single-authored papers has dropped to just over 10% and has been in that region between 2009-2014. Thus, there seems to be a major shift from single-authored writing teams to collaborative authorship of typically two, three or four authors (five or more author-papers are more rare). This can be a result of many things. First, it could be that the broad patters of co-authoring have changed in the academia to favour more co-authorship (see e.g. Cronin et al., 2003). Second, this can also be an indicator of the community-building effects of ISL events. Over time, as the researchers get to know each other, they will develop linkages between each other, which will result in more dense co-authorship patterns over time. All this feeds into progression of scholarly knowledge due to better transfer of knowledge from author to author, and sometimes between disciplines and approaches.

Second, the results show that over the course of the conference, some of the key actors have been able to achieve quite central positions in the overall collaboration fabric. This indicates that consistent community involvement will create positions through which other actors are connected to (high degree centrality) or that acts as a bridge between the actors (high betweennes centrality.

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CYCLE STOCK OPTIMISATION IN THE FRACTAL SUPPLY NETWORK

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ABSTRACT

The aim of this research paper is to investigate the effect of replenishment frequencies on both transportation and inventory holding costs in the fractal supply network. This enables the practitioners to optimise the cycle stock at different stages of the supply network including inventory and transportation costs. Fractal supply network and mathematical models of cycle stock, inventory and transportation models are developed. The proposed mathematical models and a hypothetical fractal supply network are implemented and validated using Supply Chain GURU Software, in order to optimise cycle stock at different stages of the proposed supply network and in turn minimise both inventory and transportation costs.

INTRODUCTION

Nowadays, fractal supply network attracting many of industrialists because of its capabilities in terms of "self-similarity", "Self-optimization", "self-organization", "goal orientation", and "dynamics nature" (Warnecke 1993). In fractal supply network due to decrease of complexity, system can be understood and managed clearly. Each fractal has own structure while they have same inputs and outputs and has abilities to choose and use appropriate methods to optimise itself and divided large problems to small problems, perform a goal-formation process to generate their own goal by coordinating process with the participating fractals and modifying goals if necessary, and finally each fractal has ability to adapt to the dynamically environment changing. In fractal supply network local optimisation replaced with global optimisation. Therefore, calculation times will be divided. Cumulative decision of local optimisation and reducing of calculations times make the fastest responsiveness in fractal supply network. In terms of fractal concept each members and combination of members can be considered as fractal. Nowadays, to provide value advantages in the supply chains, companies try to minimise cycle stock with higher replenishment frequency to reduce inventory holding cost. However, it may leads to increase in the transportation cost due to more shipments. In addition, inventory holding cost and transportation cost are independent to each other; both of them are function in cycle stock (replenishment frequency) with inverse and direct relationship respectively. Contrast between transportation cost and inventory holding cost has been focused for planning activities. There are some research tried to integrate transportation cost and inventory cost to minimise total logistics cost. Viau et al. (2007) used decision making model (DSS) to integrate inventory control and transportation operation in the spread supply chain by considering delivery frequency and date of delivery to nodes(e.g. Friday and Monday) as variables and mathematical models of inventory holding cost and transportation cost created in order to reduce logistics cost. Qu et al. (1999) developed mathematical model to integrate inventory and transportation policies by considering a central warehouse and several suppliers under stochastic demand during a period time. Hong et al. (2012) presented a model to integrate inventory and transportation in the ubiquitous supply chain management and developed mathematical model which demand of products assumed as linear, convex and concave function of price. Chen et al. (2012) used non-linear programing to minimise both inventory and transportation cost with model of one supplier and several retailers and compared with traditional approach which was based on Economic order quantity (EOQ). Kutanoglu and Lohiya (2008) built inventory model in terms of single-echelon and multi-facility and integrated with both transportation and service responsiveness by using alternate modes including namely, slow, medium and fast in the service parts logistics system. Zhao et al. (2010) developed an algorithm to solve Markov decision process model applied to formulate ordering and delivery problems based on vary transportation modes, costs and inventory issues. Pei et al. (2012) used bi-level programming method to establish mathematics model in order to integrate and optimisation inventory and transportation cost with probable demand and various products. There is some research focused on integration of inventory and transportation in order to minimise logistics costs. However, in terms of fractal supply network, there is very few technical research carried out in this area. The focus of this paper is to optimise the cycle stock in fractal supply network in order to minimise logistics costs.

CYCLE STOCK, INVENTORY HOLDING COST AND TRANSPORTATION COST MATHEMATICS MODELS

Figure 1 displays a framework of a fractal supply network which is used to present mathematical models of cycle stock, inventory holding costs and transportation costs. Whole supply network considered as a fractal with chains as sub-fractals. Each chain divided in to upstream and downstream stage. Upstream consists of suppliers, hubs and manufactures based on raw materials and the downstream stage consists of manufactures, distribution centres and retailers based on finished products. Each node in the supply network also is considered as fractal.

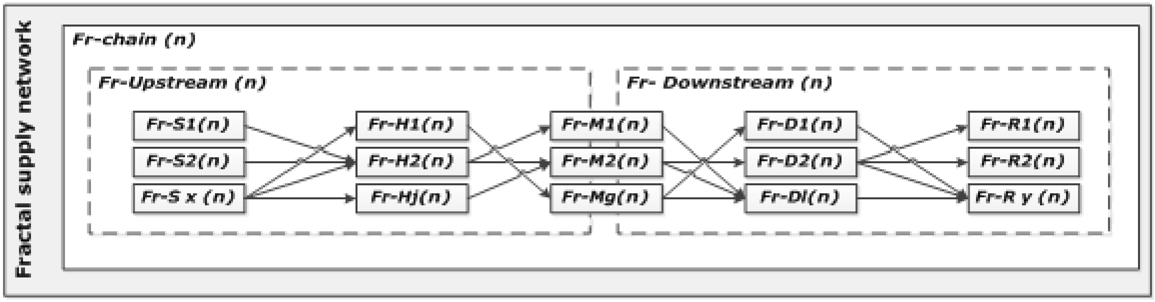

Figure 1: Fractal supply network framework

According to the fractal framework presented and through understanding the mathematical equations governing the problem of cycle stock, inventory holding costs and transportation costs; mathematical models are presented in the following sections briefly due to space limitation, which will be presented in details during the conference.

Cycle stock mathematics model

To calculate the cycle stock (CS) in supply network, two types of cycle stocks considered, namely; production cycle stock (PCS) for production sites and replenishment cycle stock (RCS) for none production sites (see equations 1 and 2). While, in this case both are used in manufacture to calculate raw materials and finished goods cycle stock. To determine(PCS), days between production(DBP), production quantity per period (P_q) and period time (T) are used. While for (RCS) calculations, days between replenishment

(DBR), flow quantity per period from source (i) to destination (r) $\left(q_{i\rightarrow r}\right)$ and period time (T) are considered.

$$PCS=DBP\times\left(\frac{P_q}{2T}\right) \tag{1}$$

$$RCS=DBR\times\left(\frac{q_{i\rightarrow r}}{2T}\right) \tag{2}$$

Cycle stock in the whole fractal supply network is equal to the sum of the cycle stock in the different chains (n). As mentioned before, each chain is divided in to upstream and downstream stages. Cycle stock of chain is equal to the sum of the cycle stock in the upstream stage and downstream stage. Cycle stock in upstream stage consists of the production cycle stock in supplier (S_x), replenishment cycle stock in hub (H_j) and manufacture (M_g) deal with raw materials. Cycle stock in the downstream stage consists of the production cycle stock in manufacture (M_g), replenishment cycle stock in distribution centre (D_l) and retailer (R_y) deal with finished products. Therefore, cycle stock of the whole supply network can be calculated as follows:

$$CS_{network}=\sum_{x=1}^{S}DBP\times\left(\frac{P_{qS_x(n)}}{2T}\right)+\sum_{x=1}^{S}\sum_{j=1}^{H}DBR\times\left(\frac{q_{S_x(n)\rightarrow H_j(n)}}{2T}\right)+\sum_{J=1}^{H}\sum_{g=1}^{M}DBR\times\left(\frac{q_{H_j(n)\rightarrow M_g(n)}}{2T}\right)+$$

$$\sum_{g=1}^{M}DBP\times\left(\frac{P_{qM_g(n)}}{2T}\right)+\sum_{g=1}^{M}\sum_{l=1}^{D}DBR\times\left(\frac{q_{M_g(n)\rightarrow D_l(n)}}{2T}\right)+\sum_{l=1}^{D}\sum_{y=1}^{R}DBR\times\left(\frac{q_{D_l(n)\rightarrow R_y(n)}}{2T}\right) \tag{3}$$

Inventory holding cost mathematics model

Inventory holding cost (IHC) in the whole fractal supply network is equal to the sum of the Inventory holding cost in different chains (n). Inventory holding cost in each chain is equal to the sum of the inventory holding cost in upstream stage and downstream stage. Inventory holding cost in the upstream stage consists of the Inventory holding cost in supplier (S_x), hub (H_j), and manufacture (M_g). Inventory holding cost in each node in upstream stage can be calculated using total raw material $(T_{(r)})$, component value $(C_{(v)})$, period time (T) and inventory carrying cost $(I_{(CC)})$ (see equation 4).

$$IHC=T_{(r)}\times C_{(v)}\times\frac{T}{365}\times I_{(cc)} \tag{4}$$

Inventory holding cost in downstream stage consists of inventory holding cost in manufacture (M_g), distribution centre (D_l), and retailer (R_y). Inventory holding cost in each node in the downstream stage can be calculated using total product $(T_{(p)})$, product value $(P_{(v)})$, period time (T) and inventory carrying cost $(I_{(CC)})$ (see equation 5).

$$IHC=T_{(p)}\times P_{(v)}\times\frac{T}{365}\times I_{(cc)} \tag{5}$$

Therefore, inventory holding cost of the whole supply network can be calculated as follows:

$$IHC_{network}=\sum_{x=1}^{S}\frac{T}{365}\times T_{(r)S_x(n)}\times C_{(v)S_x(n)}\times I_{(cc)S_x(n)}+\sum_{j=1}^{H}\frac{T}{365}\times T_{(r)H_j(n)}\times C_{(v)H_j(n)}\times I_{(cc)H_j(n)}+$$

$$\sum_{g=1}^{M}\frac{T}{365}\times T_{(r)M_g(n)}\times C_{(v)M_g(n)}\times I_{(cc)M_g(n)}+\sum_{g=1}^{M}\frac{T}{365}\times T_{(p)M_g(n)}\times P_{(v)M_g(n)}\times I_{(cc)M_g(n)}+$$

$$\sum_{l=1}^{D}\frac{T}{365}\times T_{(p)D_l(n)}\times P_{(v)D_l(n)}\times I_{(cc)D_l(n)}+\sum_{y=1}^{R}\frac{T}{365}\times T_{(p)R_y(n)}\times P_{(v)R_y(n)}\times I_{(cc)R_y(n)} \quad (6)$$

Transportation cost per mile mathematics model

To calculate direct transportation cost $(T_{(c)})$, average transportation cost per mile $(A_{(c)})$, number of occurrences (O) and travel distance (L) from source (i) in the chain (n) to destination (r) in the chain (n). The product of this should be doubled for the return journey (see equation 7).

$$T_{(c)}=2\times O\times A_{(C)}\times L_{i(n)\rightarrow r(n)} \quad (7)$$

Transportation cost in the whole fractal supply network is equal to the sum of the transportation cost in different chains (n). Transportation costs in upstream stage consists of transportation cost from supplier (S_x) to hub (H_j) and from hub (H_j) to manufacture (M_g). Transportation cost in downstream stage consists of transportation cost from manufacture (M_g) to distribution centre (D_l) and from distribution centre (D_l) to retailer (R_y). Therefore, transportation cost of whole supply network is calculated by the following:

$$T_{(c)network}=\sum_{x=1}^{S}\sum_{j=1}^{H}2\times O\times A_{(C)}\times L_{S_x(n)\rightarrow H_j(n)}+\sum_{j=1}^{H}\sum_{g=1}^{M}2\times O\times A_{(C)}\times L_{H_j(n)\rightarrow M_g(n)}+$$

$$\sum_{g=1}^{M}\sum_{l=1}^{D}2\times O\times A_{(C)}\times L_{M_g(n)\rightarrow D_l(n)}+\sum_{l=1}^{D}\sum_{y=1}^{R}2\times O\times A_{(C)}\times L_{D_l(n)\rightarrow R_y(n)} \quad (8)$$

APPLICATION OF THE PROPOSED MODELS

Baseline model

In this paper, we assumed a fractal supply network located in England with two chains named chain (A) and chain (B). Chain (A) includes two suppliers S_1(A) (Liverpool) and S_2(A) (Chester), one hub (HA) (Bolton), one manufacture (M) (Manchester), one distribution centre D(A) (Leeds), and three retailers R_1(A) (York), R_2(A) (Hull), R_3(A) (Harrogate). Chain (B) including two suppliers S_1(B) (Southport) and S_2(B) (Preston), one hub H(B)(Wigan), and one manufacture (M) (Manchester) which is common with chain (A), one distribution centre D(B) (Sheffield), and two retailers R_1(B) (Derby) and R_2(B) (Lincoln) (see figure 2). Chain (A) deals with product K_1 made from two different components (c_1 and c_2) and each of them made and supplied from one supplier in the chain (A) once during a period of 8 days. Chain (B) deals with product K_2 made from two different components (c_3 and c_4) and each of them made and supplied from one supplier in the chain (B) once during the period of 8 days. The time span between replenishment and production is 8 days. Therefore, shipment occurrences happen just once per period in the base line model. Flow quantity among nodes displayed in Table 1. On the other hand, direct routes applied on the baseline model (see figure 3). Safety stock in all nodes assumed to be zero, inventory carrying cost was 12%, transportation cost was calculated based on cost to ship per mile and there was no limitation for transportation assets in terms of capacity. Average transportation cost per mile was £1. Value for components

c_1,c_2 and c_3,c_4 were £40 and £35 per component and value for products K_1 and K_2 were £80 and £70 per product respectively. We assumed there was stable sale for retailers R_1(A),R_2(A), R_3(A) with 370, 250, and 125 products per day respectively in chain (A) and 125 and 250 products per day for retailers R_1(B), R_2(B) respectively in chain (B).

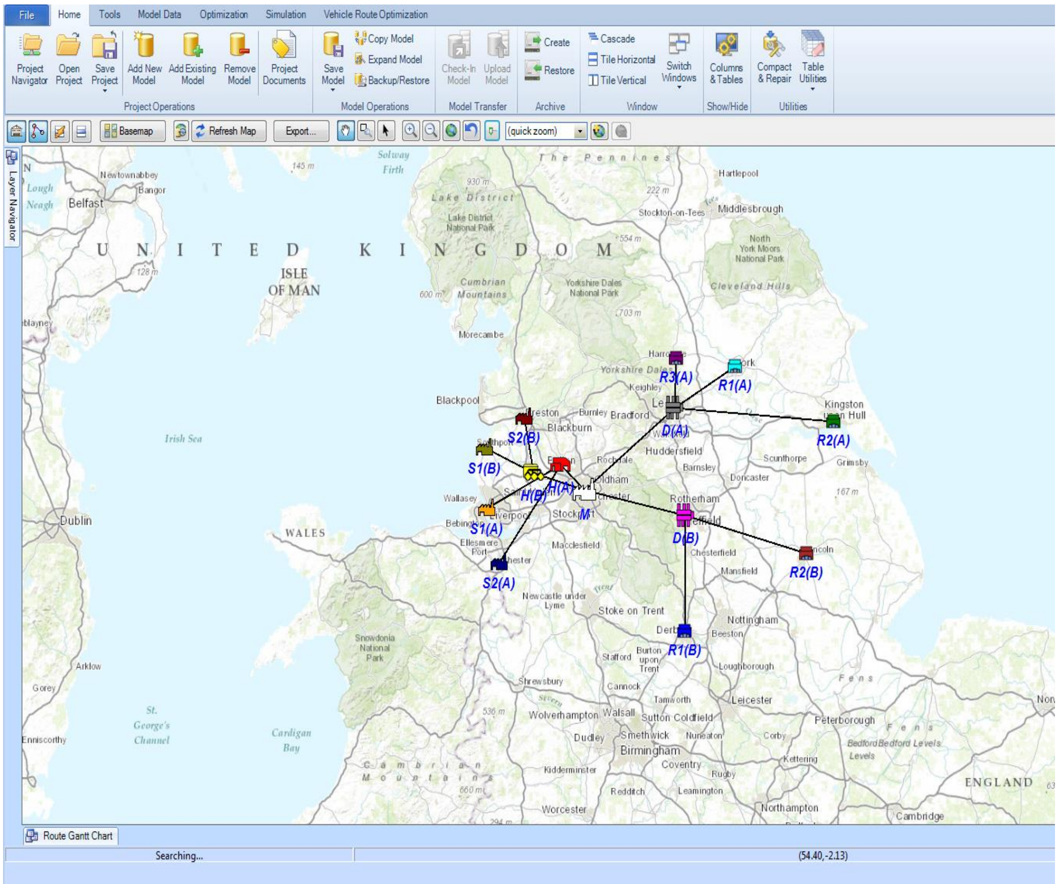

Figure 2: Supply chain Guru Software screen shot of assumed supply network

K_e/c_e	Source Site	Destination Site	Flow Quantity
c_3	S1(B)	H(B)	3000
c_4	S2(B)	H(B)	3000
c_1	S1(A)	H(A)	6000
c_2	S2(A)	H(A)	6000
c_1,c_2	H(A)	M	12000
c_3,c_4	H(B)	M	6000
K_1	M	DC(A)	6000
K_2	M	DC(B)	3000
K_1	DC(A)	R1(A)	3000
K_1	DC(A)	R2(A)	2000
K_1	DC(A)	R3(A)	1000
K_2	DC(B)	R1(B)	1000
K_2	DC(B)	R2(B)	2000

Table 1: Flow quantity among sites during the period time of 8 days

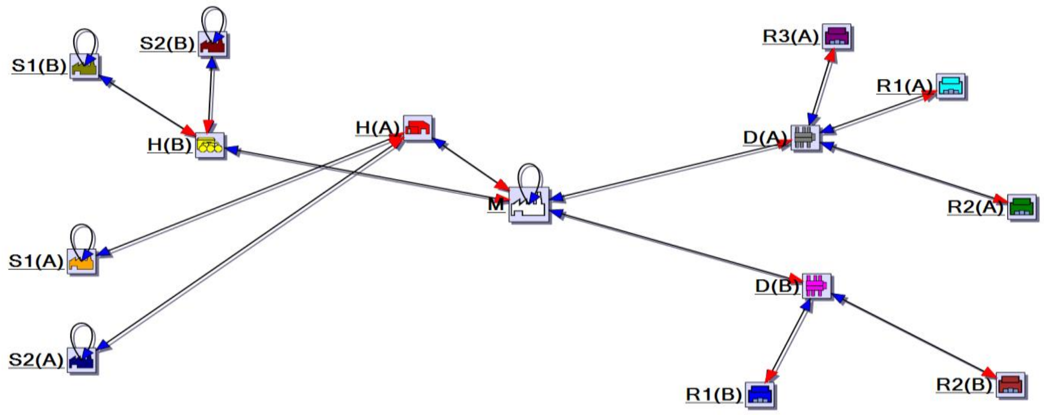

Figure 3: Direct transportation routes in baseline model

According to equations (3), (6) and (8) during the period of 8 days with cycle stock of 40,500 items, the reported inventory holding cost and transportation cost of the baseline model were £16,354.1683 and £801.2 respectively. Therefore, total cost of supply network in the baseline model was £17,155.3683.

Optimised models

To optimise the baseline model, the fractal supply network was reconfigured using multi stop routes approach in order to reduce transportation cost (see figure 4).

The proposed shipments in the multi stop route model were:

- Equipment starts from H (A) , pickup components c_1 and c_2 from suppliers S_2(A) and S_1(A) and delivery to H (A).
- Equipment starts from H (B), pickup components c_3 and c_4 from suppliers S_2(B) and S_1(B) and delivery to H (B).
- Equipment start from (M), pickup components c_1, c_2 , c_3, and c_4 from hubs H (A) and H (B) delivery to manufacture.
- Equipment start picks up products K_1 and K_2 from manufacture, delivery to distribution centres D(A), D (B) and return to manufacture.
- Equipment start picks up products K_1 from D (A), delivery to retailers and return to distribution centre D(A).
- Equipment start picks up products K_2 from D(B), delivery to retailers and return to distribution centre D(B).

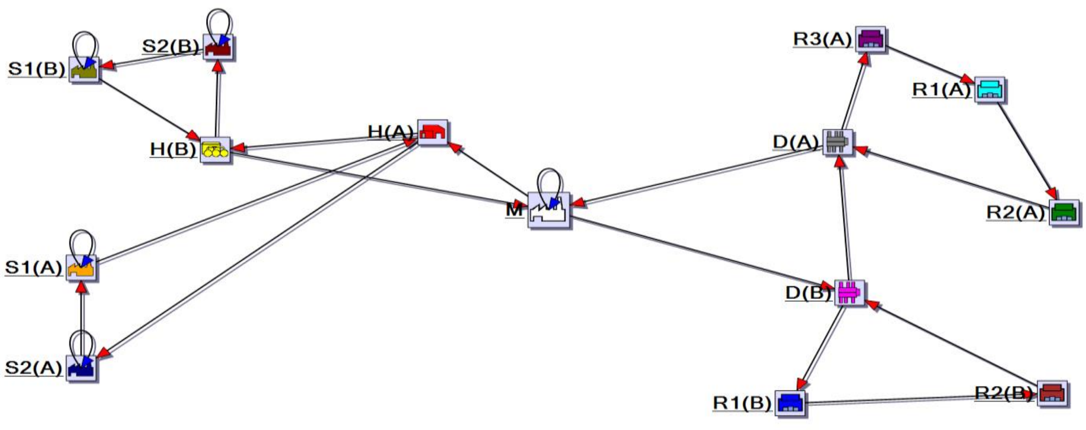

Figure 4: Multi stop transportation routes in the optimised model

To achieve lower total logistics cost among fractals and finally the whole fractal network different number of days between replenishment (from 1 day to 8 days) were investigated between fractals to choose the best match of inventory holding cost and transportation cost. The results proved that best days between replenishment (DBR) were 4 days among fractals, except from hubs to manufacture which were 2 days, see Figure 5.Therefore, days between production in the suppliers and manufacture decreased from 8 days to 4 days. The outcomes from equations (3) and (6) and in the case of the multi stop transportation routes during a period of 8 days, the cycle stock in the optimised model was 18,000 items, transportation cost was £1,184.512, and inventory holding cost was £ 13,405.127 .Therefore, total logistics cost of supply network in the optimised model was £14,583.4756. To validate the results, a period of 16 days and double flow quantities among sites were tested and led to the same trend that is presented in Figure 5.

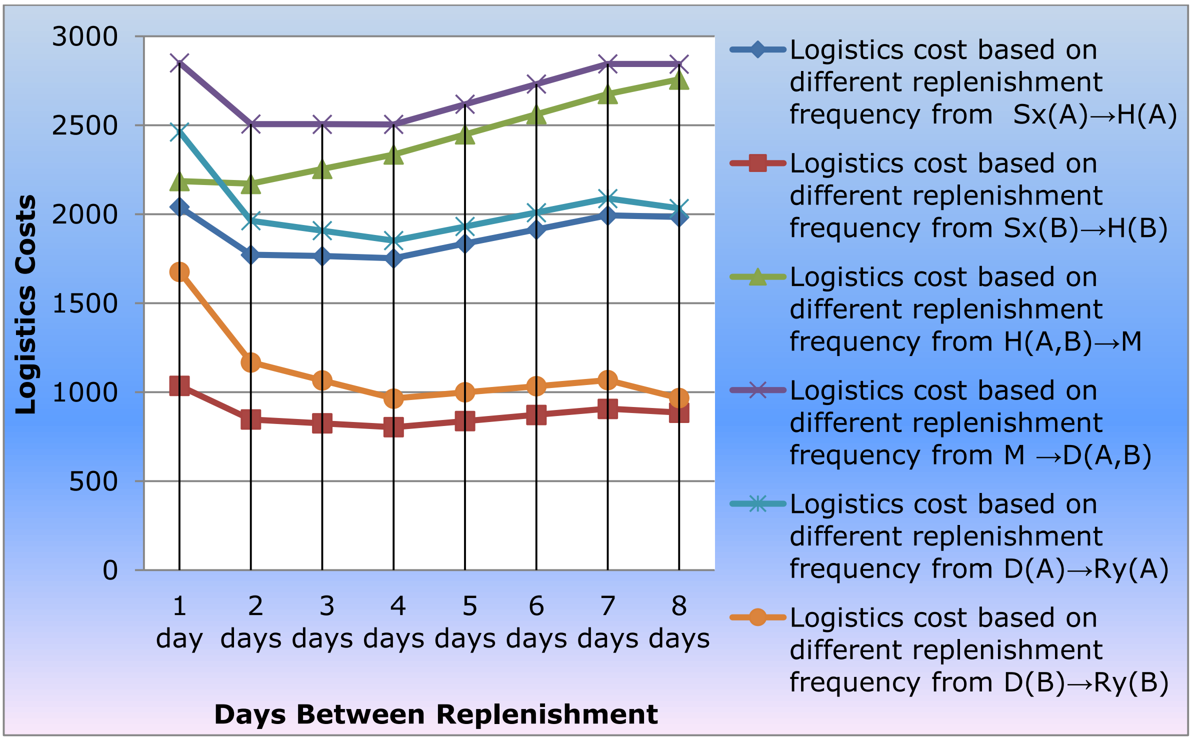

Figure 5: Investigation of different number of days between replenishment among fractals

Discussion

In comparison to the baseline model, cycle stock of the optimised model decreased from 9,000 items in suppliers and hubs to 4,500 items in optimised model, from 13,500 items to 4,500 items in manufacture, from 4,500 items to 2,250 items in distribution centres and retailers. Inventory holding cost decreased from £2,722.1916 to £2,268.493 in suppliers by reducing days between productions from 8 days to 4 days, from £2,727.2936 to £2,273.595 in hubs with the days between replenishment being 4 days, from £5,446.8369 to £4,312.59 in manufacture by decreasing days between production from 8 days to 4 days and the days between replenishment of 2 days, from £2,729.2396 to £2,275.541 in distribution centres with the days between replenishment of 4 days, and from £2,728.6066 to £2,274.908 in retailers with the days between replenishment of 4 days. In terms of the transportation cost, travel distance was reduced from 801.2 mile in the baseline model to 559.987 mile in the optimised model by applying multi stop routing; however, the transportation cost in the optimised model increased because of rising in the number of replenishment frequency. In conclusion, the total cost in the optimised model decreased from £17,155.3683 to £14,583.4756 in comparison to the baseline model which shows 14.99 percent reduction in the total logistics cost.

CONCLUSION AND FURTHER WORK

In this paper, a framework of the fractal supply network and its mathematical models of cycle stock, inventory holding cost and transportation cost were proposed. The hypothetical fractal supply network located in England as the baseline model was implemented and validated using Supply Chain GURU Software. Multi stop transportation routes were used to optimise traveling distance and cycle stock optimised by investigating different days between replenishment (from 1 day to 8 days) among fractals to choose the best match of inventory holding cost and transportation cost; in order to minimise the total logistics costs among nodes, chains and finally the whole fractal supply network. Thus, in comparison to the baseline model, logistics costs in whole the fractal network dropped about 14.99 percent. In addition, it was evident that the proposed models have provided a systematic method through which practitioners should be able to decide upon the cycle stock, frequency of delivery and transportation mode.

For further work, safety stock will be optimised to decrease the risk of stock out and apply zero inventories concept in the fractal supply network.

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PREDICTIVE ANALYTIC MODEL FOR CYCLIC FORECASTING

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ABSTRACT

This project was an applied research effort focused on forecasting models for a market environment where cyclic demand patterns may repeat themselves year after year, however with the possibility of random or prolonged changes in each cycle. The literature search does not provide a robust forecasting model to handle this case. The goal however was to create a model which allows adaptation of the forecasting parameters to the current market conditions as well as incorporating the management judgment. Therefore, based on historical data an automated analytic tool was created to act as a predictive forecasting model for the above requirements and successfully implemented at a client company. This paper explains the details of the process for creating this analytic forecasting model.

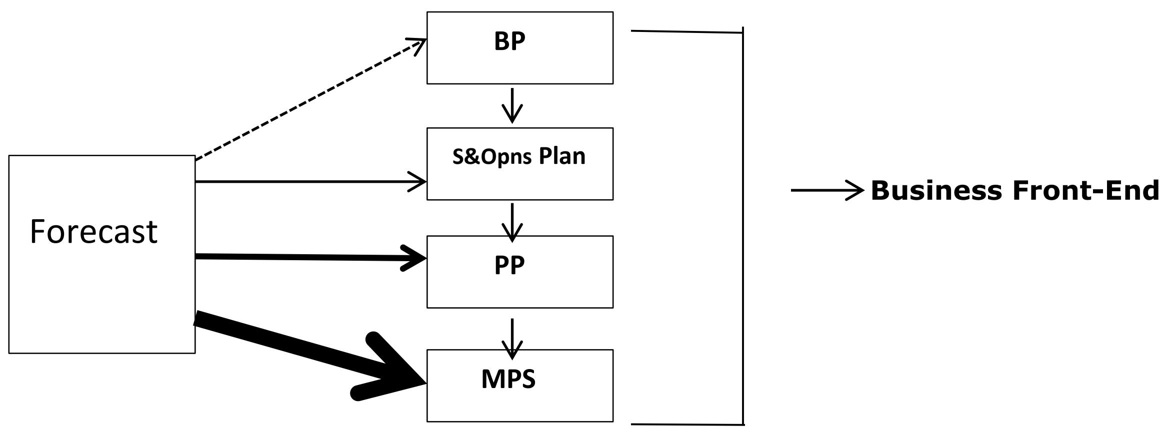
INTRODUCTION

One of the most critical inputs to the front-end of the manufacturing companies is the forecast information. The front-end of the business consists of four integrated and iterative functions or modules. First, the **business plan (BP)** module sets the stage for the coming fiscal year and near distant future. It makes decisions related to launching newly developed products to capture new global market segments, opportunities for supply chain strategies, inventory make/buy decisions for the products' final configurations, requisition and merger potentials and other top level strategic analysis. At the end, the business plan module typically recommends revenue goals for various product lines in the coming year. The business plan output is then used by the **sales & operations plan (S&Opns)** module to set the desired inventory levels, customer service levels and the linkage between the sales goals for different product families and the internal operational requirements, specifically resource requirements, to support and satisfy the sales objectives. At this stage of the business front-end, critical questions on logistics planning must be analyzed to ensure the revenue goals of the business plan can be achieved and therefore both monetized and unitized plans must be created.

In the next module, the **production plan (PP)**, unitized plan for each product family is analyzed and a decision on aggregate production rates per unit time must be decided. Corresponding requirements for manufacturing (machine capacity and human resources, space, critical raw material, and other direct and indirect support system) should be evaluated and an exact resource requirements plan (RRP) must be approved typically by the vice presidents of the manufacturing, human resources, finance, marketing, R&D and IT functions. Finally, the last module of the manufacturing business front-end is the **master production schedule (MPS)**. Here, the aggregate plan of the PP module is disaggregated into a schedule of production for independent demand including the finished goods, service products (replacement parts), or else for the common subassemblies and components in customized manufacturing. Finally, the MPS output acts as the input (driver) to the MRP engine to generate manufacturing and purchase orders.

The forecasting function acts as an input to all the four modules of the manufacturing business front-end. As depicted in Figure 1, the forecast information and accuracy starts from a fuzzy input to gradually more of a concrete set of information as one moves from the BP down to the MPS level. Therefore, most companies must update their forecasts on quarterly and even monthly for the PP and MPS modules to ensure the production goals are linked to the most recent market information.

Figure 1- Forecast input to the business front-end modules

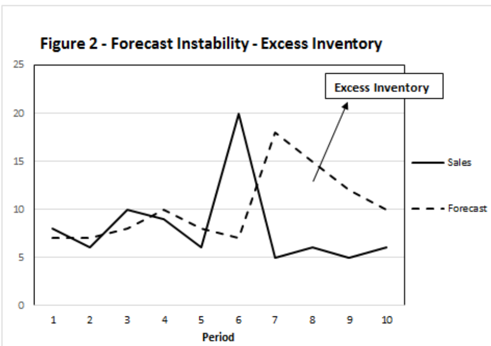


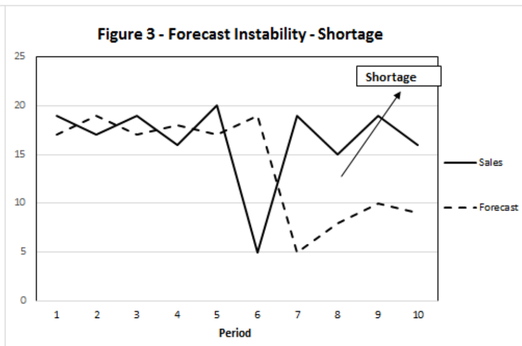
Forecasting function becomes more complex in a volatile business environment. After the 2008 financial market crash in the U.S. and the immediate global consequences, it became a total challenge to maintain even a reasonable level of forecasting accuracy. Under variable market situations, with random fluctuations, forecasting inaccuracy often results in either excess inventory or potential business loss due to stockouts. Under these circumstances, two approaches may help the analyst to gain some control over the forecasting error. One is by adaptive forecasting in which the parameter of the utilized forecasting model may be changed (P.G. Enns, et al, 1982). The adaptation to the real market fluctuations may take place as frequently as needed since the robustness of the mathematical forecasting models is often questionable. The second pragmatic approach should be necessarily involving the management judgment in the final business forecast quantities as they have a direct feel for the market swings and fluctuations (R. Fildes, P. Goodman, 2007; A. Davydenko, R. Fildes, 2013). Both of these approaches are used in this research and will be discussed later.

Review of Related Forecasting Issues

Demand patterns for products may fit into any of the following time series data (A.C. Tamhane, D.D. Dunlop, 2000): Stable, Trend, Seasonal or Random. Furthermore, two other factors impact the visibility into the forecasting process. One is the business cycle where the upswings promote economic prosperity and hence the possibility of liberal forecasting whereas the downswings of the cycles alarm the forecasting analyst to be more conservative. The second factor is the product life cycle which typically goes through the following five phases: 1) New product development, 2) Testing and introduction, 3) Rapid growth, 4) Saturation, and 5) Phase-out. Needless to say, the forecasting analyst must adapt to phases 3-5 when determining the market demand.

Random fluctuations in demand patterns, however, are the most troublesome for the accuracy of forecast. Figure 2 shows that a random spike in demand, possibly due to hot orders or some unforeseen circumstances at the consumer level may fool the forecasting model and it would take a few periods to establish control over forecasting error and as a result extra inventory is piled up. Figure 3 shows how a random drop in demand may incorrectly force the forecast to decrease for a few periods and hence creating shortages. It is much easier to anticipate real trends by understanding the business cycles, product life cycles and seasonal demand whereas random fluctuations are difficult to anticipate and they typically "shock" the system. Therefore, the forecasting method must be able to dampen the noise of the near past sales data and hence creating a stable forecast.





Unfortunately, there is not a single forecasting model that can handle the above forecasting challenges of time series data. However, experience has shown that the following three methods may be successfully applied for short term forecasting using the past sales with random fluctuations.

1. Moving Average Forecast (MAF): The past N periods of the historical data are averaged to compute a forecast for the next period. Advancing through demand periods, MAF includes the most current sales and excludes the oldest sales figure. As N decreases the resulting forecast becomes more responsive to the real demand patterns whereas for a stable forecast one should use a higher N value.
2. Weighted Moving Average Forecast (WMAF): This is the same as MAF except that one can assign a weight to each past sales figure to more correctly represent the current market conditions.
3. Exponential Smoothing Forecast (ESF): This model is shown by the following equation.

$$\mathbf{ESF_i = \alpha S_{i-1} + (1-\alpha)\, ESF_{i-1}}\text{, where}$$

S is the sales, i is the period and $0 \leq \alpha \leq 1$ is the smoothing factor. Low values of α yield a stable forecast against random fluctuations whereas high values create a responsive forecast to the actual sales trends.

Research Project Description

The objective of this project was to create a forecasting model for a market place that is often cyclic in demand pattern and yet it faces possible variation of a given cycle from year to year. Furthermore,
this cyclic forecasting model may face random fluctuations within a given cycle. Such demand patterns may typically occur for the suppliers of the agriculture and farming industry. Weather conditions and or governmental incentives/regulations for the farming industry may force the farming community to change the cycle of plantation and/or harvest operations. Too cold of a weather in the past has resulted in citrus fruit freezing in Florida and therefore the necessity of a quicker and premature harvest. On the other hand, excessive heat may force the vineyards to harvest the grapes sooner than a typical cycle. Too much rain or a case of prolonged draught may indeed change the farming cycles. And yet, unfortunate crop diseases may significantly impact the agriculture yield. The above situations may have a ripple effect on those companies that provide various tools, products and services to the agriculture industry.

Most of the agriculture business goes through at least two demand cycles per year and some face more, depending upon the geographic location and weather conditions. There are several forecasting and statistical models that can handle the prediction of demand for a constant occurrence of seasonal cycles within each year. However, the search of literature does not offer any forecasting model to handle cases when these cycles are subject to sudden changes, either random or prolonged, due to the reasons discussed above. Therefore, it was decided to create a forecasting analytic tool to assist the analyst in forecasting within the aforementioned business environment.

This project was an applied research activity to develop a forecasting model to specifically fit a cyclic business with variations within the cycles. Our client was a manufacturing company whose products are sold to the agriculture and farming business. The management required the proposed analytic predictive model to have an adaptive forecasting capability to the current market conditions and also must allow a significant management judgement into the forecasting process but such judgments would be all within the framework of utilizing the created analytic forecasting tool. Therefore, for each product and each period of forecasting the analyst should be able to search through a number of possible forecasting scenarios and select the one that best fits the current or near future demand by the agriculture business market. <u>For confidentiality purposes, we refer to our client as Company X and all the data presented in this article are scaled to be different than the original data.</u>

Analytic Model Development

The company had several lines of products, each line consisting of more than 20 products. Historical sales and forecast data for the past 15 years were obtained. The past forecast data were not based upon any objective approach. The management had subjectively forecasted for the families of products and used a historical % to forecast for the individual products within each family. Both historical sales and forecasts were quite different among product families. However, almost all products within their respective families had cyclic demand patterns. Therefore, the first step of analysis was to see if we could observe a consistent cyclic pattern of historical sales for each product. For this purpose, per product we performed a correlation analysis covering the past 15 years to see if the ups and downs of the past demand cycles across years had strong correlations. Table 1 shows a sample cross-tabulated correlation table for product XXX. The green highlighted cells for each two independent years show a statistically significant correlation for their demand patterns at P<0.05 while the yellow highlighted cells are for 0.05<P<0.10. We were only interested in positive correlations at P<0.05. However, a secondary choice would be to relax the level of significance requirements and include the yellow cells as well, if needed. Based on the advice from our client, we focused our attention to only the past recent six years when the company’s business and sales had reached a steady state and hence consistent cyclic patterns. According to Table 1, years 10, 12, 14, and 15 had statistically significant correlations at P< 0.05.

P.N. XXX	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14
Year 2	−0.44 0.157													
Year 3	0.733 0.007	−0.55 0.066												
Year 4	0.582 0.047	−0.23 0.482	0.46 0.133											
Year 5	0.836 0.001	−0.33 0.289	0.43 0.163	0.628 0.029										
Year 6	0.683 0.014	−0.55 0.063	0.69 0.013	0.493 0.103	0.439 0.154									
Year 7	0.469 0.124	−0.4 0.195	0.626 0.03	−0.07 0.839	0.317 0.315	0.112 0.728								
Year 8	−0.25 0.435	0.122 0.705	−0.1 0.754	−0.72 0.008	−0.42 0.17	−0.26 0.414	0.355 0.258							
Year 9	0.792 0.002	−0.35 0.258	0.639 0.025	0.474 0.119	0.474 0.12	0.63 0.028	0.245 0.444	−0.22 0.492						
Year 10	0.623 0.031	−0.43 0.161	0.866 0	0.498 0.099	0.306 0.334	0.566 0.055	0.435 0.158	−0.26 0.419	0.81 0.001					
Year 11	0.008 0.98	−0.31 0.323	−0.06 0.857	0.17 0.597	0.097 0.764	0.471 0.122	−0.33 0.294	−0.03 0.918	−0.18 0.574	−0.29 0.353				
Year 12	0.692 0.013	−0.64 0.024	0.729 0.007	0.551 0.063	0.533 0.074	0.558 0.06	0.535 0.073	−0.22 0.488	0.645 0.024	0.697 0.012	0.122 0.705			
Year 13	0.755 0.005	−0.4 0.192	0.887 0	0.235 0.462	0.398 0.2	0.668 0.018	0.676 0.016	0.107 0.74	0.674 0.016	0.749 0.005	−0.02 0.948	0.7 0.011		
Year 14	0.496 0.101	−0.49 0.107	0.889 0	0.246 0.44	0.29 0.361	0.544 0.068	0.597 0.041	−0.13 0.692	0.446 0.146	0.805 0.002	−0.12 0.703	0.6 0.039	0.798 0.002	
Year 15	0.593 0.042	−0.42 0.172	0.574 0.051	0.634 0.027	0.675 0.016	0.374 0.23	0.296 0.351	−0.6 0.04	0.501 0.097	0.651 0.022	−0.04 0.911	0.68 0.015	0.488 0.108	0.653 0.021

Table 1 - Correlation coefficient values for Product XXX among years

The next two steps were first to qualitatively verify the similarity for the shapes of the historical cycles for the selected years of 10, 12, 14, and 15 and second to ensure that the amplitude (level of sales) of the similar demand cycles were within a 2.5X range (as suggested by our client company). Figure 4 shows the annual cyclic sales patterns of product XXX for the past 15 years, along with the overall mean, median and trimmed mean of sales for each month. We verified that the above two conditions were satisfactory for the years 10, 12, 14, and 15. Therefore, these four strongly correlated, similar in shape and within a range of 2.5 X sales volume years were the leading indicator years and hence formed the predictive model.

Figure 5 shows how these four years behaved similarly in terms of cyclic sales while Figure 6 depicts the overall predictive model as an average and median values computed from these four best predictor years. Therefore, to forecast each month of the future year we can use the mean or median of the sales level of the same month as imbedded in the predictive model. We also have the additional option of using the past data for the same month as included in the years 10, 12, 14, 15 and applying forecasting rules such as MAF, WMAF or ES to them.

Similar analysis was conducted for each of the 20+ products within a given product family and the best leading indicator years were selected and summarized into a final predictive model.

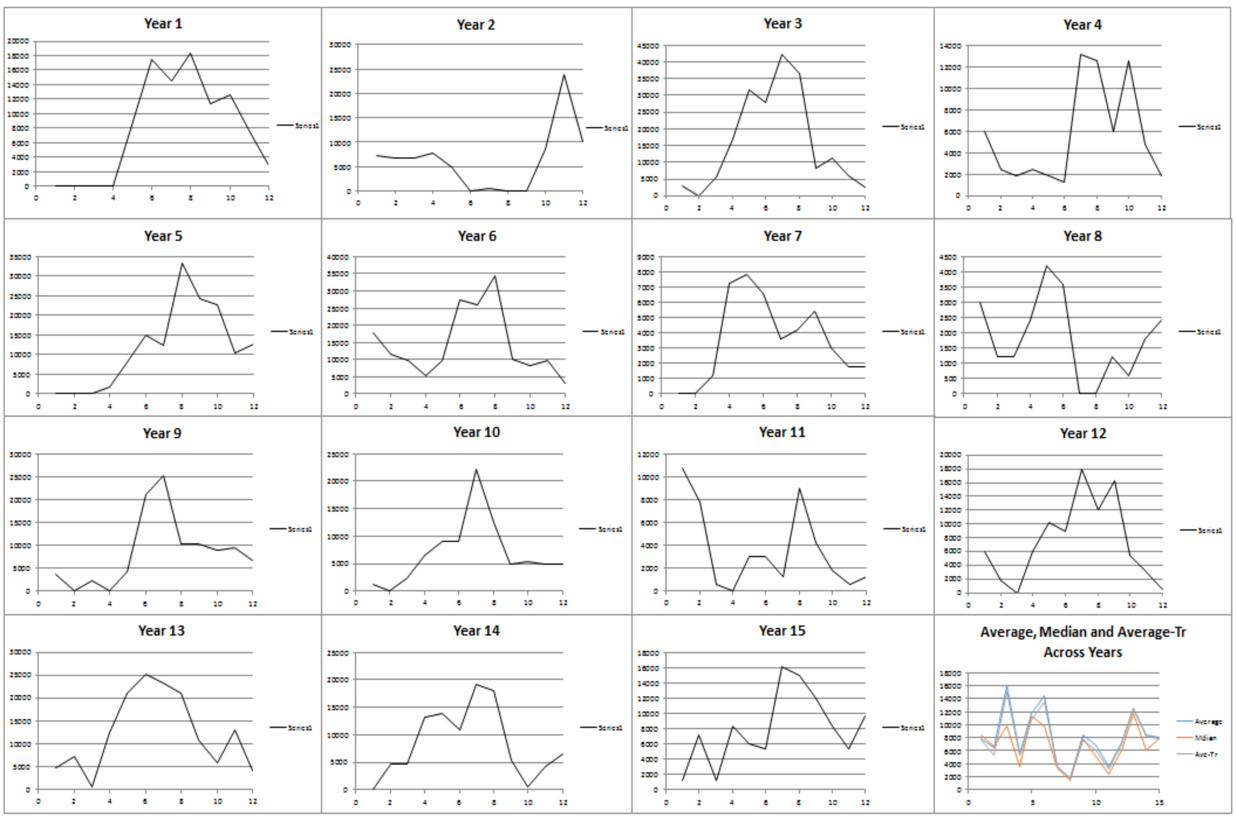
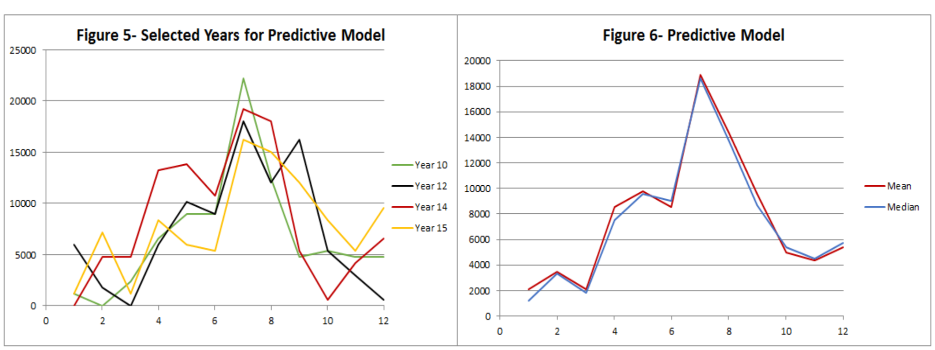


Figure 4– Historical Sales Cyclic Patterns for Product XXX



Analytic Software Approach

The algorithm for this forecasting analytic is too involved to handle manually and needed to be automated. A software tool in Visual Studio was created with the main objective of providing adaptive forecasting capabilities for all products and periods. Furthermore, the analyst can incorporate the management's input based on real-time field information into the utilization of this predictive forecasting software tool. In addition, the software is capable of computing the Bias, Cumulative Bias (CUMB) and Mean Absolute Deviation (MAD) as forecasting error/accuracy measurements. These three error indicators are defined as:

- Bias = Sales-forecast, per given period
- CUMB = ∑ (Sales-Forecast), for N designated periods
- MAD= ∑│Sales-Forecast│, for N designated periods

The analytic software includes plotting options for historical sales, forecasts, the above forecast accuracy measurements, the best leading indicator years as well as the overall predictive model (the mean and the median of the selected best years). It also has the capability of allowing the analyst to update the predictive model as new sales and forecast information are input into the computer.

In order to provide a simple set of sample computations for the algorithm of this analytic software tool, we have randomly generated a small set of data for the fictitious product ABC shown on Table 2. In this case, we have assumed that the algorithm has selected years 13, 14, and 15 as the best group of leading indicator years to forecast for year 16. Historical sales for the first fiscal quarter (January, February and March) of product ABC along with the past forecast figures for year 15, the previous year, are included.

Data	**Year**	**January**	**February**	**March**
Historical Sales	Y13	100	200	100
Historical Sales	Y14	200	300	200
Historical Sales	Y15	300	500	800
Historical Forecast	Y15	300	400	100

Table 2- Randomly generated historical data for product ABC, units

It is required to obtain the forecast for the first three months of Y16. Using the automated forecasting analytic, the analyst may select various options to adapt to the current market conditions. Example one is using the MAF technique with N=2 or 3 to forecast for January, Y16. The computations would yield MAF= (300+200+100) = 200 units, which is the same as the mean of the past three January sales stored in the predictive model. Or, MAF= (300+200)/2=250 units, if possibly we have a recent increasing trend. The second example deals with the forecast for February, Y16. Here, the management feels that 500 units of sales in Y15 is a reliable increase, compared to 300 units in Y14, and using the WMAF technique with the current marketing driven weight assignments would yield WMAF= 0.8(500)+ 0.1(300)+ 0.1(200)= 450 units. The third example is to forecast for March, Y16 by using an ESF method offered in the analytic algorithm. Suppose the Sales Department

provides an up-to-date information that 800 units of sales for March, Y15 was a random spike and hence not too reliable and should have only 10% weight. In that case, we give the actual sales 90% weight and ESF for March, Y16 would be
ESF= 0.10(800) + 0.9(100) = 170 units.

Another valuable aspect of the designed forecasting analytic is to facilitate for pyramid forecasting (PF) computations. As discussed in the INTRODUCTION section of this paper, desired revenue is typically set at the BP stage of the manufacturing company. The chief economist, CFO, and or marketing/sales VP will determine an annual financial revenue goal for the company which may further be divided by quarters and months for all product families. In PF method, the forecasts for different products are multiplied by their corresponding selling prices per unit and the forecasted potential revenue is rolled up to compare with the total revenue goals decided at the BP stage. Then, either plus or minus adjustments are forced down to the forecasts of individual products. Table 3 includes an example of this forecasting model, from the lower left box to the lower right box. Assume that product line-Z in Company X has only three products Z1, Z2 and Z3 with unit selling price of $2,000, $2,000, and $1,000, respectively. As it can be seen, the total of $1M sales from a forecast of 100, 300, and 200 units, respectively per a given month, is anticipated. However, the forecast must be adjusted because the revenue goal for line-Z is $1.4 M. Hence, each product must proportionally contribute to the extra $0.40 M sales. The analyst now has the capability of adjusting the original forecasts generated by the analytic software and replacing them with the new set of forecasts. This method would link the subjective revenue goals to the objective computed values and allows for a final resolution.

Compare: Line-Z revenue goal=$1.4 M/month Line-Z revenue forecast=$1.0 M/month →	Make $0.4 M upward adjustment to line-Z forecast ↓
Forecasted revenue:100x$2,000+300x$2,000+200x$1,000 =$1M/month ↑	Adjusted forecasted revenue (in$1,000) for Z1, Z2, and Z3: $80,000, $240,000, $80,000 ↓
Original forecast for product line-Z (units): Z1:100, Z2:300, Z3:200 ↑	Adjusted Forecasts (units): Z1:140, Z2:420, Z3:280 ↓

Table 3- Pyramid forecasting to adjust the monthly forecast generated by the analytic model

CONCLUSION

No single forecasting model can handle various marketing demand dynamics. This objective of this project was to create a model that would provide short-term forecasts for companies that face cyclic demand behavior but with possible random or real variations within a given seasonal cycle. Therefore, the forecasting analyst must be able to quickly adapt to the market fluctuations with much input by the management. For this purpose, a forecasting analytic algorithm was developed to satisfy these requirements with the advantage of providing various options and scenarios for the analyst to bridge the gap between the historical demand data and the current market conditions. A software tool was developed for the forecasting analytic and it is being successfully implemented at a supplier to the agriculture and farming industry.

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RESTRUCTURING THE SUPPLY CHAIN TO MEET CUSTOMER DEMANDS - THE SUPPLY CHAIN RESPONSIVENESS OF A SWEDISH WHOLESALER

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INTRODUCTION

If managed successfully, global sourcing practices could be considered a major competitive advantage for most companies today. Based upon supply chain management, SCM, and a holistic view of the supply chain, design issues such as selection of suppliers, location of facilities and distribution channels should be aligned with the marketing objectives of the company (Christopher et al., 2006). Global sourcing practices, driven mainly by opportunities for cost savings, has extended the supply chains and many Western European and US buying companies struggle with more supply chain parties involved, increased and unpredictable lead times, cultural dissimilarities, and information scarcity. At the same time end customer demands become more volatile and requirements on customised products with shorter delivery lead times increase.

If not properly managed and controlled, a global supply chain may easily jeopardise profit margins and competitiveness. Typically, given the focus on cost savings, there is a risk that companies design "efficient", rather than "effective" supply chains (Christopher et al., 2006). To improve effectiveness (rather than efficiency) in the supply chain, strategies for improved responsiveness are of fundamental importance.

The purpose of this paper is to explore the strategies adopted for increased responsiveness in a wholesaler's global sourcing practices.

As an empirical basis for the paper, a single case study of Swedish wholesale company selling workwear clothing and associated product is reported. To structure the presentation and illustrate the concept of responsiveness, the strategies are mirrored in a framework based on a literature review on supply chain responsiveness presented by Reichhart & Holweg (2007). The contribution of the paper consists of a clarification of the concept of responsiveness and suggestions for further research in the area of responsiveness.

THE CONCEPT OF SUPPLY CHAIN RESPONSIVENESS

The literature on responsiveness is vast and this paper does not attempt to provide a complete overview of this body of literature. Rather, it seeks to introduce the main dimensions of responsiveness that can help to link empirical findings of a case study to theory. As such, research on supply chain responsiveness rests upon several strategies within the SCM domain of research, such as lean thinking, agility, and build-to-order (BTO) strategies (Reichhart & Holweg, 2007). It aims for adaptation to external changes on the market place, typically changes in customer demands, and strategies for increased responsiveness are therefore based on a struggle towards increased customer orientation.

To position the concept of supply chain responsivenss, Reichhart & Holweg (2007) argues that it must be clearly separated from flexibility, which is defined as *"the ability of any system to adapt to internal or external influences, thereby acting or responsing to achieve a desired outcome"* (Reichhart & Holweg, 2007, p. 1148). Whereas flexibility is a wider term including a reaction on internal as well as external events, the concept of supply chain responsiveness is geared towards external flexibility. Such a flexibility could typically be classified (Slack, 1987) into (1) product flexibility, i.e. ability to introduce new products or change existing ones, (2) mix flexibility, i.e. ability to alter the product mix within existing product range, (3) volume flexibility, i.e. ability to change the aggregated output (number of products) and (4) delivery flexibility, i.e. the ability to change agreed delivery agreements (Reichhart & Holweg, 2007). Based on among others this external flexibility, Reichhart & Holweg (2007, p. 1149) define responsiveness as:

"The responsiveness of a manufacturing or supply chain system is defined by the speed with which the system can adjust its output within the available range of the four external flexibility types: product, mix, volume and delivery, in response to an external stimulus, e.g. a customer order."

Christopher & Holweg (2011) argues in a similar vein that in a turbulent environment there is a need for not only "dynamic flexibility" but also "structural flexibility", which here could interpreted as supply chain responsiveness. Whereas dynamic flexibility is occupied with coping with certain shifts in demands and technology within a given structure, structural flexibility is concerned with *"the ability of the supply chain to adapt to fundamental changes in the business environment"* (Christopher & Holweg, 2011, p. 70). For such a structural flexibility management must be able accept and cope with continuous volatility and change. The authors points out three decisive learnings for successful structural flexibility. *First*, companies need to accept volatility and adapt the company to it, rather than trying to avoid it. *Second*, the nature and turbulence must be understood, as well as its impact for the company's and supply chain's operations. *Third*, the search for economies of scale should not always be the overarching goal. In particular, Pil & Holweg (2003) highlight four areas where small-scale operations may instead be advantageous, especially in a turbulent environment, namely (1) proximity to local knowledge networks, (2) responsiveness towards customers, (3) development of human capital in the form of broader responsibility areas for younger management cohorts, and (4) exploration and testing of new technology.

Similar to Christopher & Holweg (2011), Hoyt et al. (2007) suggests the following five basic dimensions of organisational responsiveness, which here could be interpreted as fundamental prerequisites for increased supply chain responsiveness; environmental scanning, strategic planning, flexible manufacturing infrastructures, supply chain governance mechanisms, and multi-skilled workers.

To further structure and operationalize the concept of supply chain responsiveness and based on an extensive literature review, Reichhart & Holweg (2007) lists external factors that *requires* responsiveness and internal factors that enables companies *to be more* responsive. In comparison to Christopher & Holweg's (2011) and Hoyt et al.'s (2007) lists of *prerequisites*, Reichhart & Holweg's framework covers *actions*, i.e. what companies actually do, to become more responsive. The external factors are requirements on external flexibility (based on Slack, 1997) into product, mix, volume, and delivery flexibility as was presented above.

The internal factors that enable responsiveness are by the authors divided into two subgroups, of which the first is concerned with enabling responsiveness in individual "nodes" in the supply chain, and the second with the creation of responsiveness in the supply chain through the integration of individual nodes. Factors enabling responsiveness in *individual nodes* are (Reichhart & Holweg, 2007):

1. Demand anticipation: the ability to anticipate the node's actual demanded output
2. Manufacturing flexibility: the responsiveness of an individual manufacturing system towards other units within the supply chain
3. Inventory: buffer stocks that increase responsiveness in terms of increased volume, mix and delivery flexibility
4. Product architecture: different kinds of modularisation and postponement strategies

Correspondingly, factors enabling responsiveness through *integration of individual nodes* are: (Reichhart & Holweg, 2007):

5. Information integration: transparency of information among supply chain partners (i.e. individual nodes in the supply chain, such as a company, function, or manufacturing system)
6. Coordination and resource sharing: rearrangement of resources among individual nodes in the supply chain as a means to improve responsiveness
7. Organisational integration: Extensive communication and collaboration among supply chain nodes
8. Spatial integration and logistics: Co-location and geographical proximity can typically improve responsiveness in terms of shorter lead-times, delivery systems, etc.

METHODOLOGY

The findings of this paper are based on an explorative, single case study. The selection of the case companies has followed a theoretical sampling logic (Eisenhardt and Graebner, 2007). For the purpose of this paper, the case study aims to illustrate and exemplify how increased responsiveness in a global supply chain can be achieved. The case company has identified responsiveness in their global sourcing practices as one of their major challenges.

Data collection in the form of a workshop and four interviews were conducted during winter 2014-2015. The data about the company and their business has been collected mainly through semi-structured interviews with managers as well as operational employees. The informants were the supply chain manager, the demand chain manager, a purchaser, and a warehouse manager. Except for interviews, a one day workshop at the company was part of the empirical data collection. In addition, company presentations, official as well as confidential reports were handed over by the informants.

ABOUT THE CASE COMPANY

The case company belongs to a Swedish investment company listed on the Stockholm stock exchange market. The focus for this research is the sourcing function of a wholesale subsidiary that sells workwear fashion in a number of European markets, of which UK is the largest market, followed by Germany and Belgium. The company is in Europe a relatively well-established company with a strong premium brand. On the markets it conducts a differentiation strategy based on quality and reliability.

In addition to head quarters in Sweden, the company has a factory in Latvia and a central warehouse in Poland, operated by a logistics provider. About 80 employees reports to the supply chain manager, head of the company's sourcing function. Except for traditional tasks such as purchasing, demand planning, quality, CSR etc, this function also includes the factory in Latvia (about 50 employees), sales support and people employed in Asia. All goods are brought from the Asian suppliers to the central warehouse in Poland by boat, and thereafter transported by truck to the regional sales markets around Europe.

The case company has undergone a development from domestic, to international (European suppliers) to global sourcing, see Figure 1. Major contemporary supplier regions are Vietnam and Bangladesh, where finished items as well as raw material (textiles) are procured. In total, the company has about 50 suppliers, of which most of them are based on long term, collaborative relationships.

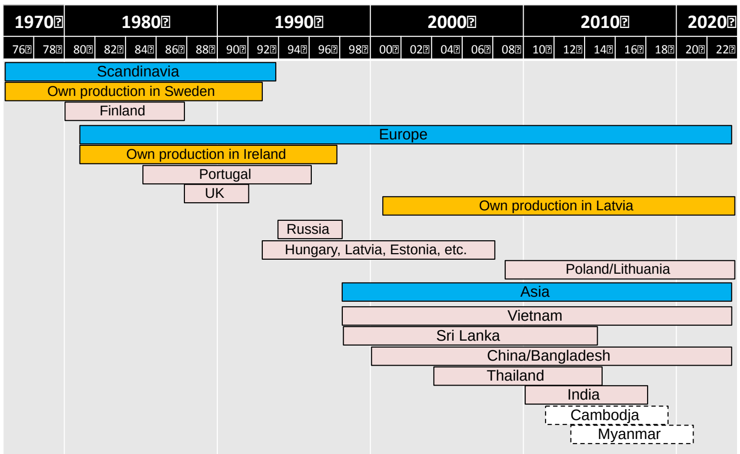

Figure 1: The case company's supplier markets (Source: internal company presentation)

The case company's industry has historically been characterised by relatively stable and predictable demands, with long life-cycles and a low degree of customisation. As a result of this, it has traditionally searched a competitive market position based on price (so has also a majority of the competitors done). To further differentiate on the markets, and avoid too much focus on price competition, the company has increased their efforts in market responsiveness in recent years. An internal market analysis conducted in 2014 came to the following three conclusions:

- The company experiences a not satisfactory ability to service their markets with current sourcing set-ups. Their global supply chain with long lead times of approximately 26 weeks makes it inflexible and vulnerable for disruptions.
- Customer demands when it comes to product availability and supply chain flexibility in terms of e.g. customization of products have in general increased in recent years and will become even more important in the future
- In addition to the general increase of demand for flexibility, the company has launched a new market strategy that means increased focus on direct sales to end customers (e.g. construction companies) instead of retailers. Such a change of focus requires even higher levels of flexibility and service performance in the supply chain. For instance, clothes with customer-specific colors and logos must be provided with short notice. Today's 26 weeks lead times is expected to be too long.

FINDINGS

The findings of this paper present some of the major strategies employed by the case company for increased responsiveness in the supply chain.

Operational regional managers

As a means to manage extended global supply chains that are geographically as well as culturally distant from the head quarters and customer markets, the case company has employed three Regional Operational Managers (ROMs) situated in Asia. As stated by the supply chain manager, one of the largest challenges having a global supply chain is to "make things happen". Accordingly, their overall task is to increase control and transparency, and facilitate coordination in the supply chain, and hence play an important role as middlemen between the head quarters in Sweden and the suppliers in Asia. Information sharing, and connect customers need to supply chain operations is crucial for supply chain responsiveness:

"For me everything starts with the customer. The distance between a customer and manufacturing in the supply chain can sometimes be very long, and I think it is important to keep [the supply chain] together and reduce the distance as much as possible. For this the flow of information is decisive." (Supply Chain Manager, author's translation)

More specifically, the tasks of the ROMs include control for quality and conduct audits for CSR, speed up the supply chain when needed, provide fast feed back loops on production issues and questions about delivery schedules. In terms of Reichhart & Holweg's (2007) enabling factors for increased responsiveness, the ROMs play a particular importance for increasing the suppliers' *manufacturing flexibility*. In addition, the factors of *information-* and *organisational integration* are sustained through the work of the ROMs.

Collaborative relationships

Collaborative relationships are advocated as a tool for responsiveness, in which a continuous dialogue based on trust and long term collaboration is believed to improve the situation. To achieve collaboration, the ROMs play an important role, but also other parts of the company are involved in this work, e.g. the purchasers, development department in Latvia, etc. Overall, the collaboration with suppliers of raw material as well as manufacturers incorporates a great number of the factors of responsiveness discussed by Reichart & Holweg (2007). To start with, *coordination and resource sharing* among different suppliers are opted for. The collaboration does not necessarily mean larger volumes for the case company. Rather, for products with relatively large volumes, the case company tries to spread their orders to a number of different suppliers. This helps to reduce risks (delivery risks, but also political and financial risks) in the supply chain, and facilitates responsiveness with respect to volume changes. To improve collaboration and responsiveness, continuity in existing supplier relationships is important, where not too much, nor not too little business are placed on each supplier:

"In a well-functioning relationship it is important to treat this relationship in a good manner and not reduce, nor place too much business [on this supplier]. To provide a balance and thus become an attractive customer to the suppliers you want to work with is important." (Demand Chain Planner, author's translation)

At the same time, for suppliers with (too) small volumes, the case company tries to increase their volumes, e.g. by giving many small production batches to the same supplier, in order to become a more important customer. This is expected to facilitate collaboration and a continuous dialogue with the supplier (*information- and organisational integration*), which in turn is expected to generate improved flexibility and lead time reductions, as the supplier will prioritise the company's demands.

To further improve their attractiveness towards larger suppliers, and avoid the need for late changes in product range, volumes as well as product mix, the case company strives towards improved forecast accuracy that can be shared with collaboration partners (*demand anticipation*). Indeed, it is a well-known fact that responsiveness goes hand in hand with the ability to produce correct forecasts as this enables long term planning and dialogue with suppliers.

Vertical integration

Another strategy for improved responsiveness discussed by the case company is a higher level of vertical integration, i.e. ownership of the upstream supply chain. The case company has for instance considered to invest in an own production unit in Asia. Using Reichhart & Holwegs (2007) language, to control this supply chain node would facilitate improvements of all four factors in individual nodes (*demand anticipation* through full within-company transparency, *manufacturing flexibility* due to in-house control of production, *inventory* as it can be prioritised to best gain the company's wishes, and *product architecture* as it can be optimised towards the company's own customer demands without interference from competitors' wishes). In addition, it is likely that an ownership would also contribute to the integration between the manufacturing node in the supply chain and the sales and marketing operations at the case company. For instance, the factors of *information* as well as *coordination and resource sharing* would probably be improved. In particular, the case company would be able to control the production unit's prioritisation when planning for instance production batches and relate it to the customers' needs. In addition, opportunities for service differentiation (and thereby increase delivery flexibility) is another improvement area.

Ownership of a manufacturing facility in Asia has however so far not been realised. Instead the factory in Latvia, although relatively small, constitutes an important strategy for increased responsiveness for the case company. The factory in Latvia is today mainly used for development, testing and special series production in smaller scale, and as a production capacity buffer for urgent orders of unlined products. In total, its production represents about 2% of the total sales volume. The presence of buffer capacity in the factory warrants an ability to respond quickly to unforeseen problems with delayed deliveries and quality issues, hence increasing the *manufacturing flexibility* as well as *coordination and resource sharing* (between the Latvia factory and other external factories in Asia) of the company. However, the major benefit of the Latvian factory is that the delivery lead times becomes shorter due to geographical proximity to customers (which corresponds to the factor of *spatial integration and logistics*). If raw material is present at the factory, the delivery lead times can be reduced from about 20-26 weeks to 4-5 weeks.

Except for ownership of factories in either Asia or Latvia, the case company indicates an additional strategy for increased responsiveness in the form of own inventory of raw material at the (external) factories in Asia. Through ownership of the raw materials in stock (the factor of *inventory* according to Reichhart & Holweg's model) lead times can be reduced by approximately 10 weeks.

"In some product segments, we are slowly heading towards a business model where we provide our textile suppliers with forecasts. Based on these we reserve semi-finished textiles [perhaps woven but not coloured] at our suppliers… and in Vietnam we also sometimes hold a small own inventory of textiles at our manufacturers…as a means to shorten the lead times." (Purchaser, author's translation)

European supplier alternatives

Except for the factory in Latvia, the case company has also recently been considering alternative, external manufacturing in Europe. As part of this work, total cost analysis for a European potential supplier has been conducted and compared to an existing one in Vietnam, based on the costs of raw material, customs, transport, tied-up capital and production. Interestingly, the calculations indicate that even though the Vietnamese supplier still is less costly, the difference is far from that big as could be expected. The major reason for this is above all the reduced tied-up capital in the case of the European supplier. Even more tempting becomes the European supplier alternative a few years from now, when taking the future pace of monetary inflation into consideration.

The expected lead time reductions of having European suppliers has been the major driver for the case company's search for European supplier alternatives. This benefit is captured in the factor of *spatial integration and logistics* discussed by Reichhart & Holweg (2007). Although already having a small production unit in Latvia, a larger European supplier also facilitates the factor of *coordination and resource sharing*. A combination of European and Asian suppliers for a certain product can be adopted, in order to divide "base" and "surge" demand (Christopher et al., 2006). This strategy enables a combination of low cost and reduced lead times.

Product categorisation

Although cost will remain the dominant performance criterion in the future supply chain, other criteria such as delivery service, innovative products with shorter life cycles and short lead times (i.e. variables for increased responsiveness) will be increasingly important for parts of the product range. To further identify and focus their efforts for increased responsiveness, the company has in recent years started to differentiate their products based upon the customer requirements on the product. In particular, product segments with lower volumes and need for customisation, e.g. customer branded workwear, must here be focused.

Based on a product categorisation, factors such as *product architecture* can be further developed and utilised as a strategy for increased responsiveness. In addition, the factors of *inventory* as well as *demand anticipation* may be improved, if a categorisation facilitates a focus on the "right" products.

Alternative transportation modes

Another strategy applied by the case company to reduce lead times from their Asian suppliers is to consider alternative transportation modes. By changing transportation mode, the factor of *spatial integration and logistics* could result in increased responsiveness. Today a majority of the goods is transported from Asia by boat to the central warehouse in Poland, which results in long lead times. Exceptions from the boat transportation are express deliveries by flight, which is expensive and only used in case of emergency.

In recent years however, the case company has initiated several studies on alternative transportation modes. One such promising alternative could be the Skybridge concept provided by DB Schenker, in which air and ocean freights are combined. For the case company's deliveries from Asia, the goods would typically be taken from the manufacturers to Dubai by boat, and from there further on to central warehouse in Poland by flight. Another transportation opportunity investigated by the case company is transportation by train from Chengdu in central China to Europe. This route would take approximately 2 weeks including time for customs and declarations. Another advantage would be that it is likely that also smaller shipments than full containers would be cost efficient.

CONCLUSIONS

This paper has explored strategies for increased responsiveness in a wholesaler's global sourcing practices. Supply chain responsiveness is an increasingly important topic in SCM research that can be achieved through numerous means and strategies. Based on a model borrowed by Reichhart & Holweg (2007), this paper has presented a number of hands-on strategies for improved supply chain responsiveness conducted by a Swedish wholesale company. As such, this paper contributes with empirical data on responsiveness strategies, which generates a practical understanding of the topic.

In the light of the empirical findings of this paper, a weakness with Reichhart & Holwegs model of supply chain responsiveness is that it lacks antecedents of responsiveness, i.e. before adopting strategies for responsiveness in the supply chain, what are the organisational prerequisites? Similar to Mentzer et al.'s (2001) argumentation that supply chain management should be preceded by a supply chain orientation, it could be argued that strategies for improved responsiveness should be preceded by a responsiveness orientation. To develop an even more holistic understanding for the concept of supply chain responsiveness, it could therefore be suggested that Reichhart & Holwegs model should be extended with antecedents of supply chain responsiveness. As briefly discussed in the theoretical framework, Hoyt et al. (2007) as well as Christopher & Holweg (2011) present examples of such antecedents.

Another contribution to research on supply chain responsiveness from the case study presented in this paper is a clarification of the role of a wholesaler's position in the supply chain. In recent years it has been argued that retail and wholesale companies are taking a more dominant role in their supply chains, often on the cost of the manufacturers (Renko & Ficko, 2010). With respect to responsiveness, the case study presented here gives another view. Without own production and hence not control of important nodes for creation and control of responsiveness (in particular manufacturing), the wholesaler becomes dependent on collaboration and in-depth communication with the manufacturers as a means to create a responsive supply chain. In addition, the power of the wholesaler often becomes limited due to its relatively small purchased volumes. Overall, the key for successful supply chain responsiveness is in the case company not to exert power. Instead the success is based on an appropriate relationship management in which suppliers of raw material, manufacturers as well as logistics providers are incorporated. In the light of this, this paper contributes with new knowledge about how relationship management can help to restructure the supply chain towards improved responsiveness. With the best control and information about end customer demands, the task for the wholesaler becomes to orchestrate the other supply chain members, despite limited possession of power.

The research presented in the paper is explorative and consists of one single case study. The research aims at first hand to demonstrate the importance of supplier relationship management in supply chain responsiveness, and does not present a complete palette of measures for how to do this. Future research should further develop the theoretical framework of supply chain responsiveness and thereafter verify it through more extensive empirical investigations.

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Section 3: Collaboration and relationships in supply chains

Negotiating successful buyer-supplier relationships: a practitioner perspective

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ABSTRACT
Nowadays it is a common premise that working collaboratively with upstream and downstream members along the Supply Chain (SC) affects not only the performance of the dyadic-level relationship, but of the SC as a whole. Subsequently, a significant amount of research has been devoted to understanding and improving the collaborative forms exhibited among SC members. There have been several approaches to clustering the elements of SC Collaboration (SCC) in order to understand the complex nature of their interaction (e.g. Slack and Lewis, 2002). Research undertaken by Barratt (2004) identified a very sound proposition of the key elements of SCC that need to be managed, largely clustered around collaborative culture (e.g. external & internal trust), managing change (e.g. cross-functional activities), and strategic elements (e.g. intra-organisational support). With over 750 academic citations since its publication, this work has proved to be an enduring benchmark of SCC research. Some ten years on, SCC certainly remains a topic of interest and debate (e.g. Ramanathan and Gunasekaran, 2014). For this paper, we have aimed to systematically identify and critically assess the scope of the outcomes of recent publications on SCC, by contextualising the main elements under investigation. This approach - in combination with the use of NVivo as an instrument to systemise the analysis - assisted in identifying pertinent and current themes of interest dominating the SCC literature. Based on the identified findings from this preliminary study, the paper provides a critical summary of the links among emerging research patterns that shape the SCC research landscape.

INTRODUCTION
Supply Chain Collaboration (SCC) has been recognised as one of the main topics in Supply Chain Management (SCM) research (e.g. Kampstra *et al.*, 2006; Ramanathan and Gunasekaran, 2014; Kache and Seuring, 2014), and remains a topic of interest and debate (see, for instance, Ramanathan and Gunasekaran, 2014). The importance of SCC is highlighted by the large volume of relevant publications. Figure 1 shows the number of publications on SCC over the decade between 2004 and 2014. From this alone it is evident that there is an increasing interest in the topic of SCC. Interestingly, in 2014 there were twice as many SCC related publications as there were in 2004.

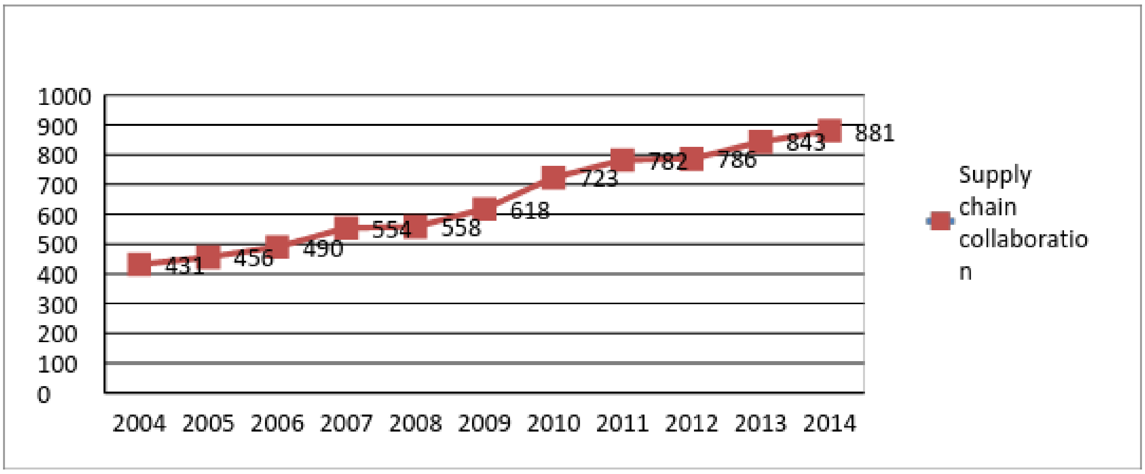

Figure 1: Number of publication of Supply Chain Collaboration

In prior research on Supply Chains, the terms integration and collaboration are often used interchangeably (Das *et al.,* 2006; Wiengarten *et al.,* 2010). While there is some overlap between the terms, with both referring to relationships between two or more firms working together to create value and achieve mutual benefits, SCC is considered a more effective construct with which to capture the joint relationships between firms and their Supply Chain (SC) partners (Cao and Zhang, 2011). We aimed to identify and critically assess the scope of the outcomes of recent publications on SCC and capture what has been the topic of interest within this concept. The following section provides the research objectives, followed by the methodology and the analysis. Implications and conclusions are provided at the end.

RESEARCH OJBECTIVES

Various approaches have been used to cluster the elements of SCC with a view to understanding the complex nature of their interaction (e.g., Slack and Lewis, 2002). With more than 750 academic citations Barratt (2004) identified the key elements of SCC. Focusing on Barratt's (2004) propositions, the question that guided our research can be expressed as: "What is the degree of research inquiry of the SCC elements in past research?" We examined the various elements of SCC based on the SCC elements identified by Barratt (2004), namely (1) collaborative culture (trust, mutuality, information exchange and openness and communication); (2) managing change (cross-functional activities, process alignment, joint decision making and SC metrics); and (3) strategic alignment (resource commitment, intra-organisational support, corporate focus, demonstrating business case and the role of technology). Barratt also argued that several of the SCC elements "have been to a large extent ignored due to their complexity, and deserve significant attention individually in terms of further research" Barratt (2004:40). He also argued that "further research is also required to develop a deeper understanding of the relationships between these elements of collaboration." Barratt (2004:40). Following on from this, we have aimed to identify and critically assess the scope of the outcomes of recent publications on SCC, by contextualising the main elements under investigation.

METHODOLOGY

To meet the objective of this research, we selected journal articles that were published in the period directly following Barratt's (2004) publication, up until the present day. This meant the papers analysed were collected from a period of 10 years (from 2004-2014). We specifically focused on papers published in academic journals in the field of SC and operations management. Only 3* and 4* journals were selected based on the ABS journal ranking quality list (fifty-third edition, 8 March 2015), and the journal articles were sourced from the online search engine of ABI/Inform Global. To ensure collection of relevant academic papers we looked for peer reviewed articles in scholarly journals (in English) containing keywords that were based on the SCC elements proposed by Barratt

(2004), as shown in Table 1: for example, "supply chain" and "collaboration", and the key element of SCC.

Table 1: Keywords employed for the papers

Elements	Keywords
Trust	"trust"
Mutuality	mutual*
Information exchange	"information exchange"
Openness & communication	"collaborative communication" or "open communication" or "communication quality" or "communication participation"
Cross-functional Activities	"cross-functional activit*" or "organi* support" or "management support" or "functional support"
Process Alignment	"process alignment" or "process* efficiency" or "process* effectiveness" or "internal alignment" or "external alignment"
Joint Decision Making	"joint decision*" or "decision synchroni*" or "joint problem solving"
SC Metrics	"supply chain measure*" or "supply chain metric*" or "supply chain indicator" or "supply chain key performance indicator" or "performance indicator" or "key performance indicator"
Resource Commitment	"resource commitment" or "sharing resource*" or "tangible resource*" or "intangible resource*" or "resource* investment" or "technology investment"
Intra-organisational Support	"intra-organ* support" or "management support" or "functional support"
Corporate Focus	"corporate focus" or "leveraging capabilities" or "shareholders"
Demonstrating Business Case	"demonstrating business case" or "business case" or "built support"
The Role of Technology	"technology role" or "technology combination" or "technology integration" or "collaborative technology"

This initially generated 1,646 citations from 618 articles. We subsequently read the abstracts through to avoid both duplication, as well as in order to remove articles not related to SCC considering the explicit conceptual scope of our study. As a result of this initial phase, 497 articles were found to potentially address the topic of SCC. These in turn were considered relevant to this study and read through. We downloaded only PDF readable papers (i.e. papers that we could edit in a PDF editor). Subsequently, to avoid analysing papers in which the keywords sought appeared in non-relevant to the analysis fields (e.g. list of references or biographical notes of the authors), we used the PDF editor facility and removed such text. The above ensured that only relevant papers were considered as part of our analysis. As a result, 34 papers were removed, bringing the total sum of papers relevant to our analysis to 463. We then proceeded with the analysis by importing these PDFs into NVivo.

ANALYSIS AND FINDINGS

Table 2 below indicates the number of papers analysed per journal. It becomes apparent that 140 papers on the SCC elements were published in ABS 4* papers, and 323 in ABS 3* journals. Considering the number of papers published over the ten-year period of 2004-2014, SCMIJ has most notably published approximately 41% of its papers on SCC (with papers addressing at least one of the SCC elements).

Table 2: Number of paper analysed by journals

Journal/ABS 2015	No. of papers
Journal of Operations Management (JOM)/4*	2
International Journal of Operations & Production Management (IJOPM)/4*	138
International Journal of Production Economics (IJPE)/3*	8
International Journal of Production Research (IJPR)/3*	6
Journal of Supply Chain Management (JSCM)/3*	90
Manufacturing and Service Operations Management (MSOM)/3*	4
Production and Operations Management (POM)/3*	11
Production Planning & Control (PPC)/3*	2
Supply Chain Management: An International Journal (SCMIJ)/3*	202
Transportation Research Part E: Logistics (TRPL)/3*	0
Total	**463**

Table 3 below and Figure 1 (next page) indicate the frequency of the SCC elements. It emerged from our analysis that the most dominant element analysed in past research has been *trust*, closely followed by *mutuality*. Interestingly, the least frequent elements considered were the ones of *SC metrics* and process *alignment*. Appendix A elaborates on both the frequency of the elements and the relevant publication instances per journal.

Table 3: Publications on the SCC Elements

	Elements	No. papers (N=463)	Proportion of all articles (%)
Collaborative Culture	Trust	339	73.22
	Mutuality	300	64.79
	Information Exchange	147	31.75
	Openness & Communication	66	14.25
Managing Change	Cross-functional Activities	49	10.58
	Process Alignment	18	3.89
	Joint Decision Making	68	14.69
	SC Metrics	16	3.24
Strategic Elements	Resource Commitment	34	7.34
	Intra-organisational Support	49	10.58
	Corporate Focus	37	7.99
	Demonstrating Business Case	22	4.75
	The Role of Technology	22	4.75

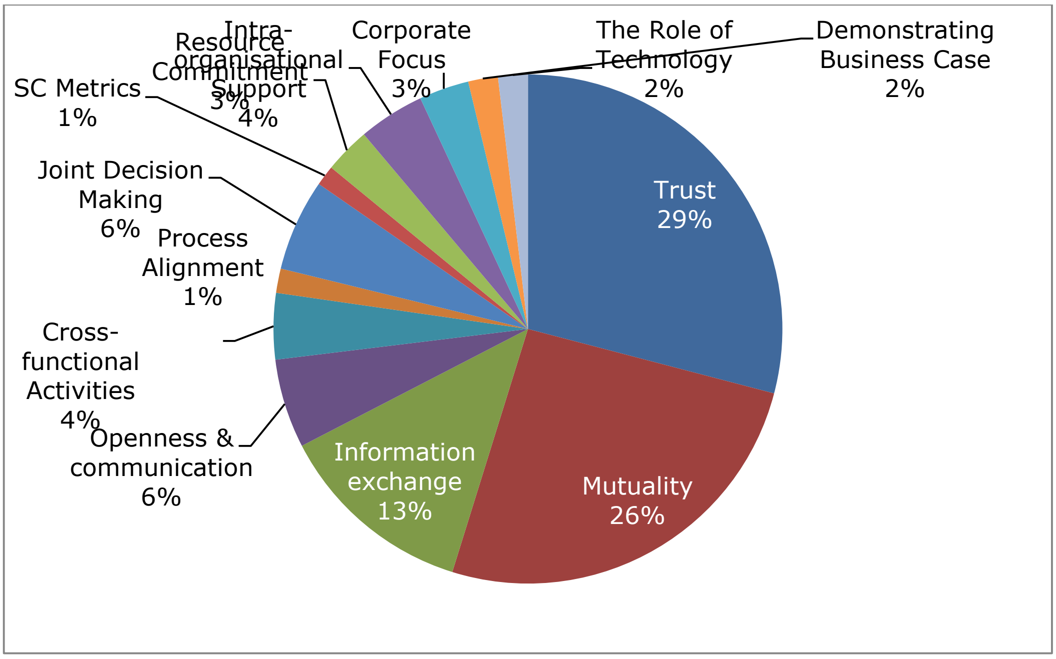

Figure 1: Frequency of the SCC elements within the journals under investigation

We wanted to investigate how much of the research has focused on a single SCC element, and, respectively, in how many cases there was a need to consider several elements (see Table 4). Out of the 463 papers, 119 of them focused on a single element, mainly on *trust* (175 references in 44 papers), followed by *mutuality* (63 references in 35 papers). These papers did not address the elements of *cross-functional activities*, *intra-organisational support*, and *process alignment*. Interestingly, only two references from 119 papers addressed the element of *SC metrics* and the *role of technology*. Out of the 344 remaining papers that focused on several elements, most of them focused on two elements only (130 papers), the most typical SCC elements being *trust* and *mutuality*.

Table 4: Focus on single and multiple SCC elements

Elements*	**Number of elements**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Corporate Focus	11	8	15	7	1	4	2	1
Cross-functional Activities	0	9	17	26	20	28	26	9
Demonstrating Business Case	6	13	14	5	0	3	0	0
Information exchange	35	86	173	170	12	10	4	6
Intra-organisational Support	0	9	17	26	20	28	26	9
Joint Decision Making	4	8	40	64	14	24	6	4
Mutuality	63	232	311	170	132	66	13	26
Openness & communication	76	6	34	51	9	51	2	27
Process Alignment	0	2	15	4	0	2	4	2
Resource Commitment	16	7	16	36	2	1	0	5
SC Metrics	2	3	4	4	1	2	0	0
The Role of Technology	2	3	66	45	4	1	0	0
Trust	175	1389	1437	751	298	84	16	56
Number of articles°	**119**	**130**	**122**	**61**	**17**	**9**	**2**	**3**

* *number of reference(s) in each paper*; ° *number of papers*

IMPLICATIONS AND CONCLUSIONS

The paper identifies key elements of SCC and the associated aspects that have been the dominant research themes during the past 10 years. In this way we have tracked emergent developments. We believe that the identification of the intersections between research outcomes and emerging patterns contributes to an informed plan for future academic research avenues. In particular it will allow us to cross reference and group relevant terms for SCC. It is also anticipated that the information on current issues in relation to the SCC elements will be potentially useful to SC managers in terms of identifying. We are now further developing the identified themes from this preliminary study to more thoroughly examine the SCC concept.

APPENDIX A

Table A1: Number of articles on SCC Element per Journal

	JOM	IJOPM	IJPE	IJPR	JSCM	MSOM	POM	PPC	SCMIJ
Trust	2	94	7	5	65	4	6	2	154
Mutuality	2	92	5	4	64	1	4	1	127
Information exchange	1	48	1	4	29	0	4	2	58
Openness & communication	0	16	1	1	25	0	0	2	21
Cross-functional Activities	2	16	1	1	3	0	1	0	25
Process Alignment	0	6	0	2	2	0	1	0	7
Joint Decision Making	2	21	3	3	13	0	1	1	24
SC Metrics	0	7	1	0	1	0	0	0	6
Resource Commitment	0	8	0	1	11	0	2	0	12
Intra-organisational Support	2	16	1	1	3	0	1	0	25
Corporate Focus	0	11	0	1	7	0	0	1	17
Demonstrating Business Case	0	11	0	0	2	0	0	0	9
The Role of Technology	0	5	1	0	5	0	2	0	9

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IDENTIFYING INTER-ORGANIZATION COLLABORATION TYPES AND RESEARCH ADVANCEMENTS IN SUPPLY CHAIN CONTEXT

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ABSTRACT
The main purpose of this state-of-the-art paper is to make a synthesis analysis on collaboration in supply chain by literature review of all relevant articles, conceptualizing collaboration in supply chain and providing implications for future research. Based on designed material collection standard, up to year 2014, a total of 1250 papers are used for descriptive analysis and a total of 509 papers are carefully reviewed for further classification, conceptualization and comparison analysis. Research in this field is in an increasing trend in general but most of collaboration in supply chain is still in a low level in research. Another interesting finding is that logistics seems to be the most promising supply chain stage for research about collaboration in supply chain.

1. INTRODUCTION
As the development of supply chain, collaboration in supply chain is more and more common, while research regarding collaboration in supply chain keeps increasing as well. The important role of collaboration in supply chain has been demonstrated by many researches before (Ramanathan & Gunasekaran 2014, Soosay, Hyland & Ferrer 2008); therefore it is valuable and significant to identify different types of collaboration in supply chains.

This systematic literature review presents a comprehensive overview of past research on collaboration in supply chains, bringing an understanding to this field as a whole. Review papers on collaboration in supply chains are mainly about the investigation on the performance of collaboration and integration in supply chain (Adams, Richey, Autry, Morgan & Gabler 2014, Vereecke & Muylle 2006) and only seven review papers in this topic could be found on popular scientific databases, e.g. Web of Science. However, none of the existing scholarly paper constructs an overview of research on supply chain collaboration through a systematic literature review method. Besides, there are no studies conceptualizing or identifying different types of supply chain collaboration. This research, by constructing a useful framework based on past research, is valuable to researchers working on collaboration in supply chains and companies seeking supply chain collaboration in different industries.

2. RESEARCH METHODOLOGY
This survey article is based on a systematic literature review by using a meta-analysis of scholarly literature on collaborations in supply chain context. Three steps were used for a content analysis, including material collection, category selection and text-mining.

2.1 Material collection
The process of material collection is divided into two parts. Initially, two internationally well recognized scientific citation databases, Web of Science (WoS) Core Collection and Scopus, were used for searching relevant papers on collaboration in supply chain context. These papers were used for basic descriptive analysis (year distribution etc.) and basic comparison. For further analysis, e.g. categorizing and conceptualization, only articles found in WoS were included. As Table 1 indicates, a topic keywords list for searching was designed so that to include all relevant papers while several specific research areas provided by WoS and Scopus were selected respectively to restrict the subjects of the paper. Only papers written in English language were included, the year range is up to 2014 and document type was restricted to "Article". It should be mentioned here that all reviewed papers were collected by searching their topics (Title, Abstracts and Keywords)

which were all provided by authors or database. However, not always that these selected papers matched exactly to the selected research areas as required for investigation possibly due to discrepancies in the classification of the paper by the databases. Therefore we may miss some articles which correspond to our need for the analysis while some articles not pertinent enough may be included.

Keywords list	Selected research areas in WoS Core Collection	Selected research areas in Scopus
"supply chain coordination" OR *"supply chain cooperation"* OR *"supply chain collaboration"* OR *"coordinati* supply chain"* OR *"cooperati* supply chain"* OR *"collaborati* supply chain"*	*Business economics* OR *Operations research management science* OR *Public administration* OR *Social sciences other topics* OR *Transportation*	*Business, Management and Accounting* OR *Decision Sciences* OR *Economics, Econometrics and Finance* OR *Social Sciences*

Table 1: Keywords list and Research area restrictions

Finally, a total of 1250 papers in WoS and Scopus from 1995 to 2014 were collected for initial descriptive analysis. Among these papers, 509 papers from WoS are selected for further detailed analysis.

2.2 Category selection

A systematic categorization of all articles is the major topic of analysis in this study; therefore some criteria for categorization are required initially. The criteria are

1) Each category should be meaningful for further investigation and comparison, which means evolving patterns chosen purposefully yet systematically to meet the research objective;
2) Each category should contain a number of papers, at least five percent of the overall;
3) Each category is capable of being divided into several sub-categories, each of which should at least contain a small group/number of papers.

Based on the criteria and an initial analysis of different aspects of all reviewed papers, a structural literature categorization and corresponding sub-categories are indicated as Category 1: Stages in supply chain, viz. *Manufacturing, Logistics* and *Retailing*; Category 2: Types of collaboration, viz. *Coordination, Cooperation, Collaboration, Strategic alliance* and *Joint venture*; Category 3: Industries, viz. *Textile and apparel industry, High-technology industry, Food industry, Chemical industry* and *Biology and pharmacy industry*; Category 4: Company scales, viz. *SMEs* and *Large enterprises*.

Considering the focus of this study to be exploration of different types of collaboration along different stages in the supply chain, a comparison between these two categories was carried out. Further a calculation of the proportion of articles employing different collaboration types along these three stages was obtained in the end. Manufacturing, logistics and retailing are the three most common stages in supply chain, and almost every paper on supply chain collaboration involves at least one of these three stages. According to Forest (2003), Mowery, Oxley and Silverman (1996), from "coordination" (sub-category 1 of different types of collaboration) to "joint venture" (sub-category 5 of different types of collaboration), the level of inter-organizational collaboration is interpreted to be increasing gradually. In this context, "coordination" is defined as "harmonious functioning of different parts for effective results. It includes helping each other but not changing the basic way of doing business"; "cooperation" is referred as "common efforts and association for the purpose of common benefit to help each other in specific ways"; "collaboration" is "to work jointly with others on a common goal that is beyond what any one person or group can accomplish alone"; "strategic alliance" is defined as "an agreement between two or more parties to pursue a set of agreed upon objectives needed while remaining independent organizations", and "joint venture" is "A business agreement in which the parties agree to develop, for a finite time, a new entity and new assets by contributing equity".

2.3 Text-mining

To extract papers from the corpus into different categories mentioned in section 2.2, text-mining technology was used. 509 papers were imported into NVivo, qualitative analysis software, for building the literature database and for further analysis, including data mining.

Categories	Sub-categories	Keywords for text search query
Category 1: Stages in supply chain	logistics	logistics OR transport* OR shipment OR shipping OR inventory
	manufacturing	manufactur* OR produce OR producing OR production* OR fabricat*
	selling	sell* OR sale* OR wholesale* OR retail*
Category 2: Types of collaboration	coordination	"supply coordination"~2 OR "business coordination"~2
	cooperation	"supply cooperation"~2 OR "business cooperation"~2
	collaboration	"supply collaboration"~2 OR "business collaboration"~2
	alliance	alliance*
	joint venture	"joint venture*"
Category 3: Industries	Biology and Pharmaceutical industry	biology OR pharma* OR medicine* OR drug*
	Chemical industry	chemical OR chemistry
	Food industry	food
	High-tech industry	"high tech" OR "high technology" OR "high technologies"
	Textile and apparel industry	textile* OR weav* OR yarn* OR sew* OR cloth* OR garment* OR apparel* OR wearing OR costum*
Category 4: Company scales	Large enterprises	"big company"~2 OR "big companies"~2 OR " large company"~2 OR "large companies"~2 OR "big enterprise"~2 OR "big enterprises"~2 OR "large enterprise"~2 OR "large enterprises"~2 OR "big firm"~2 OR "big firms"~2 OR "large firm"~2 OR "large firms"~2
	SMEs	"small enterprise"~2 OR "small enterprises"~2 OR "small company"~2 OR "small companies"~2 OR "medium enterprise"~2 OR "medium enterprises"~2 OR "medium company"~2 OR "medium companies"~2 OR SME?

Table 2: Keywords list for text searching queries in NVivo

One of the main functions in NVivo is text-searching query; this query could find all documents contained a specific word, phrase or concept from all documents imported into NVivo based on a designed text search criteria. This function was used as the first step of text mining. A list of keywords including wildcard characters were constructed for text search query, which all are special term and synonyms may be employed in different sub-categories, was designed as Table 2, so that all papers contain certain keywords would be coded into corresponding word node in NVivo after every text search query. Each word node represents a corpus of papers containing keywords belonging to a sub-category in Table 2. In each word node, number of references for every article, which equals the term frequency - how many times certain keywords appearing in an article, can be calculated in NVivo. Articles in each word node could be sorted by the number of references as well, which is useful for the next step in text-mining. It should be pointed out that a lot of references are coding in the reference part and header or footer part of the paper, the accuracy of term frequency is influenced by them, therefore they needed to be decoded manually.

Topic determining by term frequency is a simple but important method in information retrieval from a corpus of documents and it is easy to select papers from a node in NVivo by using this method, e.g. sorting the papers by term frequency and select all papers with term frequency over ten, etc. However, if one term appears in almost every paper of a corpus, although it has a very high term frequency in an article, this term can hardly determine the topic of the paper. Each term may have different significance of determining the topic of a document, therefore, another algorithm in text mining, term frequency–inverse document frequency (TF-IDF), is used in this study. TF-IDF can return (identify) documents that are highly relevant to a particular query. If a user was to input a query for a particular topic, TF-IDF method can find documents that contain relevant information on the query (Ramos 2003). Given a corpus of documents D, a term t, and one document $d \in D$, TF-IDF is calculated as:

$$\text{TF-IDF} = TF_{t,d} * \log(|D|/DF_{t,D})$$

where $TF_{t,d}$ is term frequency of t in d, equalling the number of times t appears in d; $|D|$ is the size of the corpus, and $DF_{t,D}$ is document frequency, equalling the number of documents in which t appears in D (Sparck Jones 1972, Salton & Buckley 1988).

Based on the formula and corresponding data, TF-IDF value of each article classified to a specific word node is calculated. Then articles are sorted by TF-IDF value in each sub-category. After examination of each node of papers, according to different categories, papers belonging to word node of category 1: Stages of supply chain and category 2: Types of collaboration and with TF-IDF value over 1 were selected into corresponding source node which contains all papers with corresponding sub-category topic, while papers belonging to word node of category 3: Industry and category 4: Company scales and with TF-IDF value over 2 were selected to corresponding source node. In the end, the selection result was validated by a random reading of papers in each source node of sub-category topic.

3. RESULTS

3.1 Descriptive analysis

Besides the search by a list of keywords together mentioned in section 2.1, articles were searched by different single keywords separately in both WoS and Scopus. The number of hits is shown in table 3, which could reflect an initial categorization and topic distribution of research on collaboration in supply chains. Coordination is the topic with most hits (802), while collaboration is the second (383) and cooperation comes to the third (78).

As figure 1 indicates, publications are shown an increasing trend in general with a period of sharp increase in the number of publications between 2005 and 2007. Further, it is clear in table 3 and figure 1, that the trend of distribution of articles either by keywords or by year of publication on Web of Science and Scopus is similar. This suggests that the further detailed analysis based on articles found on Web of Science could possibly reflect current research pattern on collaboration in supply chains.

Keywords	Number of articles		
	WoS	Scopus	Total
supply chain coordination	346	400	746
supply chain cooperation	22	26	46
supply chain collaboration	104	159	263
coordinati supply chain*	15	41	56
cooperati* supply chain	10	22	32
collaborati* supply chain	41	79	120
Total	526	724	1250

Table 3: Hits by different keywords in WoS and Scopus

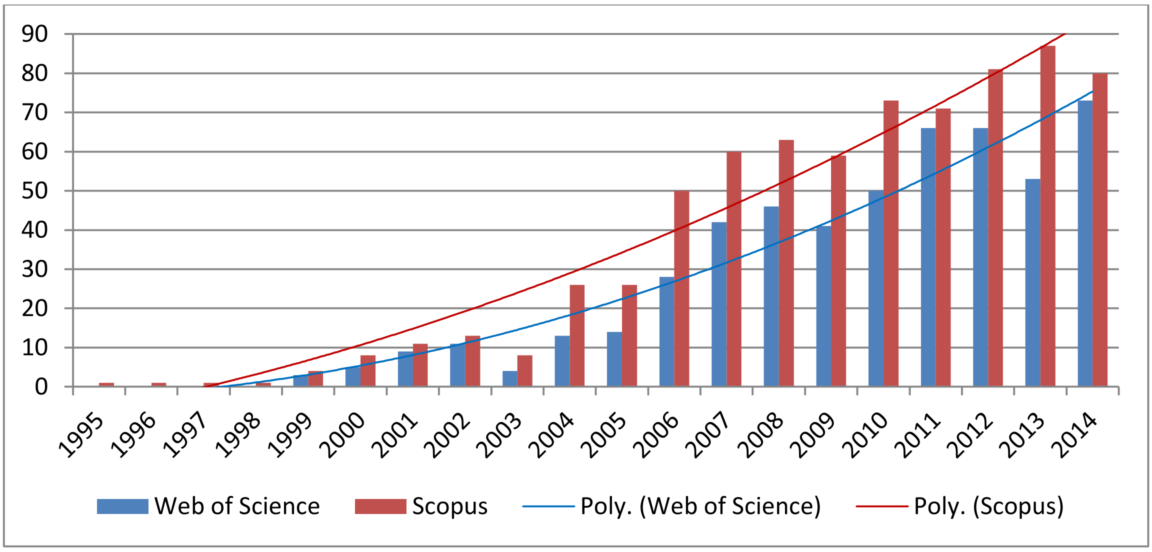

Fig. 1. Distribution of articles by year of publication

3.2 Results of literature extraction

Categories	Number of articles	Sub-categories (topics)	Number of articles
Category 1: Stages in supply chain	407	logistics	225 (55%)
		manufacturing	212 (52%)
		Selling*	295 (72%)
Category 2: Types of collaboration	257	Coordination*	142 (55%)
		cooperation	39 (15%)
		collaboration	78 (30%)
		alliance	38 (15%)
		joint venture	12 (5%)
Category 3: Industries	70	biology and pharmaceutical industry	6 (9%)
		chemical industry	7 (10%)
		food industry	17 (24%)
		high-tech industry	14 (20%)
		textile and apparel industry*	31 (44%)
Category 4: Company scales	22	large enterprises	14 (64%)
		SMEs	14 (64%)

Table 4: Distribution of literature based on the categories
(*The most common topic in each category)

Based on the method described in section 2.3 for topic extraction according the TF-IDF value of each article, articles were extracted into different categories and different sub-categories. Then, the statistics on the number of articles with focus on different sub-categories was obtained, as shown in table 4. The percentage of papers under each sub-category topic to that under the main category was calculated as well, which makes it clear to see the extent of scholarly discussion on each topic in each category. Selling in category 1, coordination in category 2 and textile and apparel industry in category 3 are the three most common topics in their corresponding category, while in category 4: company scales, the research articles focussing on large enterprise and SMEs are evenly distributed.

3.3 Results of comparison

By analysing papers appearing simultaneously in categories 1 and 2, a comparison matrix is generated, as shown in table 5. It shows the proportion of articles, in past research, employing different collaboration types or levels along the three stages of supply chain. Based on the literature extraction in section 3.2, coordination is the most frequent type of collaboration addressed in extant research. Coordination is also a leading topic of research respectively along the three different stages of supply chain alongside collaboration. However, if we analyse the matrix in an another way, selling evolved as the most common stage in extant research on supply chain collaboration, however it has not been the most common topic along different types of collaboration. Selling, for example, has gained most attention in articles focussed on coordination though it has a slight edge over number of articles on cooperation in manufacturing; whereas, logistics takes over the lead position in type of collaboration, type of alliance and type of joint venture.

	Coordination	Cooperation	Collaboration	Alliance	Joint Venture
Manufacturing	74	19	28	15	4
Logistics	55	15	45	21	5
Selling	108	24	38	20	5

Table 5: Comparison matrix between stages in supply chain and types of collaboration

A further analysis of the year-wise distribution of each cell of comparison in the matrix is shown in figure 2. Figures 2a, 2b, 2c, 2d represents the year-wise distribution of extant literature on different types of collaboration, viz. coordination, cooperation, collaboration and alliance along various supply chain stages. Due to the low number of publications on joint venture, it is removed from further year distribution analysis. In general, publications on coordination and collaboration are on an increasing trend, as demonstrated by the higher slop in figure 2a compared to that in figure 2c. However, publications on cooperation and alliance remain at the same level and have a low production from 2000 to 2014. Further, articles on coordination in the supply chain stage of selling have the highest number of publications almost at all time, except in 2007 when articles on coordination in the manufacturing stage is the highest. Yet another interesting pattern observed in figure 2a is in terms of drop in number of publications from 2010 to 2013 whereas a sharp increase from 2013 to 2014. Another interesting pattern is observed in publications on coordination, collaboration and alliance in logistics (lines B, H and K respectively) – being the top three most common types of collaboration researched in logistics. All these lines show a drop from 2011 to 2013, even though lines B and H later on show a rise from 2013 to 2014, line I cease to descent in its slope and remains at the same level in 2014.

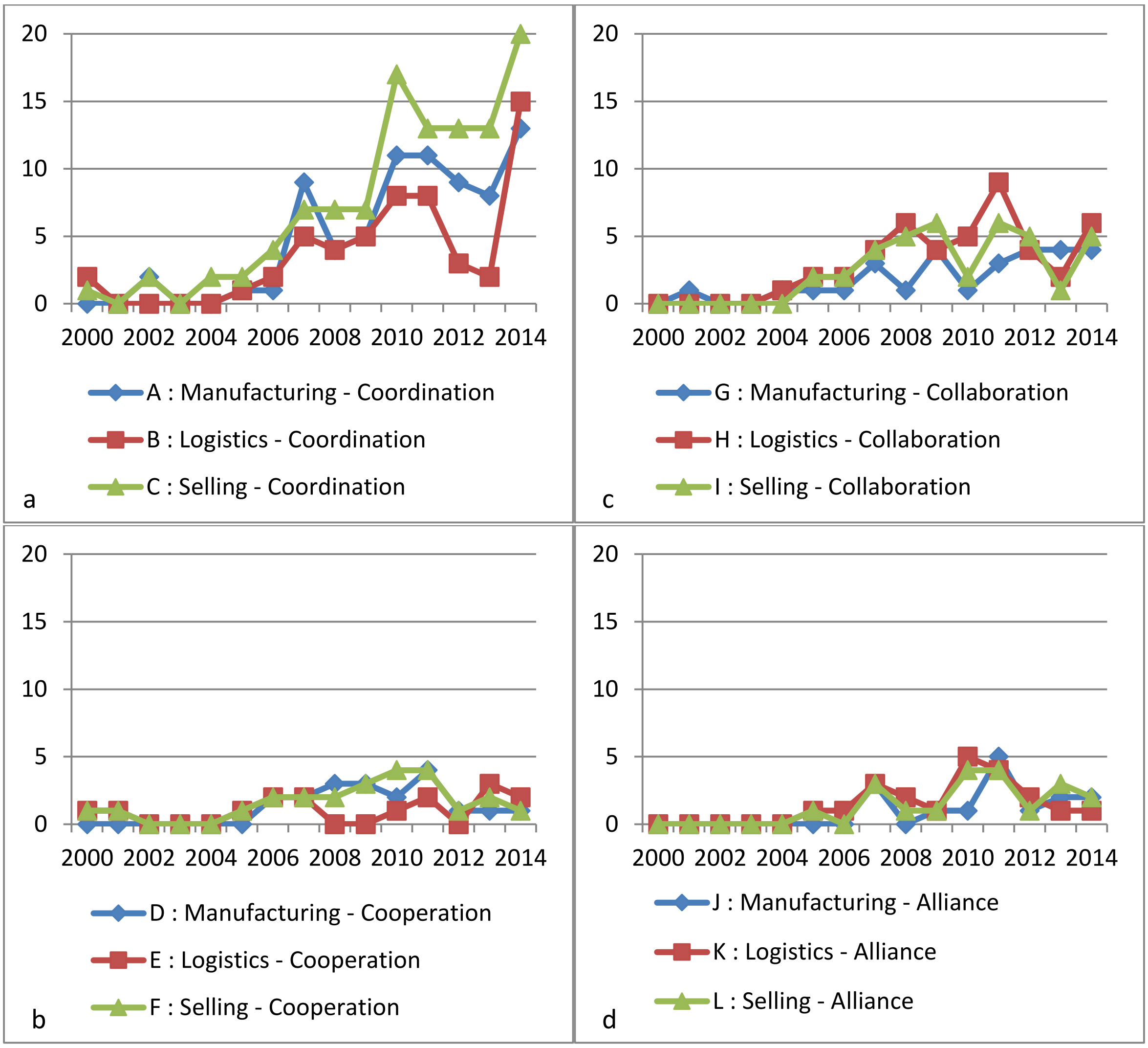

Fig. 2. Distribution of comparison between each type of stages in supply chain and types of collaboration

4. DISCUSSIONS AND CONCLUSIONS

In this study, a total of 1250 papers on different types of collaboration in supply chains are reviewed for descriptive analysis which shows a general increase in trend of research on this topic. A further analysis is undertaken based on 509 papers, extracted and classified along different categories and sub-categories.

According to section 3.2, coordination, which is the lowest level of collaboration, is the most common research topic among different types of collaboration claiming almost 50% of its share of total number of publications – same to the other four types thus showing its dominance. Furthermore, the decreasing trend of publication percentage distribution in different types of collaboration is same as the decreasing level of collaboration from coordination to joint venture, except the percentage rank of publications in cooperation which is not corresponding to its rank in collaboration level. Although this could possibly be explained by the use of some specific terms in supply chain literature, a more probable reason explaining this phenomenon is that today's research still concentrates on a lower levels of collaboration in supply chain. Based on section 3.3, the largest number of publications discussing different collaboration types in selling, the majority of them are focussed towards coordination. However, logistics, which has least publications in type of coordination, has more publications in the high levels of collaboration. Compared to manufacturing and selling, research dealing with logistics is apt to take advantage of higher level of collaboration probably due to its intermediary role in supply chain under most circumstances. Moreover, from figure 2, coordination is the most popular type of collaboration all along the supply chain in all time and there is not any trend that other types of collaboration will replace its dominant position in relevant research. However, although selling is still the most common supply chain stage topic in research, articles with logistics as the topic have shown a sharp increase in number from 2013 to 2014. Besides the increasing trend from 2013 to 2014 in figure 2a is probably due to the increasing number of articles on modelling in coordination and a wider variety of journals available for publishing papers on coordination in supply chains.

In conclusion, collaboration in supply chain in current research is still at a relatively low level, and there are still a lot of potential for investigating higher level of collaboration in future research. Along various supply chain stages, logistics is the most promising direction for future research considering it as a still under-explored area of research compared to manufacturing and selling. We can also see a closer collaborative relationship if the collaboration involves logistics partner in supply chain. Further, as papers employing mathematical modelling or other modelling methods are increasingly given more attention in the recent years, this research field could be more attractive to researchers within operational research with relevant modelling background. There are still several interesting questions to be explored for future research based on the data of this study, e.g. which two stages in supply chain shows more collaboration in research, what is the difference between collaboration in supply chain context and in business context, what methods are used most frequently and so on. They are expected to be discussed in future study.

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*A full list of all references for the literature database of this study could be requested directly to the corresponding author.

CONCEPTUALIZATION AND SCALE DEVELOPMENT OF COLLABORATIVE SUPPLY CHAIN

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ABSTRACT
Our study provides a comprehensive definition of collaborative supply chain. What is lacking in the literature is a framework for accurately defining the extent of collaborative supply chain .Previous definitions of Collaborative supply chain focus more on process integration and largely ignore the integration of information and communication technology as a crucial component for collaborative supply chain. Thus taking a broader snapshot of the literature, the current research study identifies seven interconnecting components which are core to its basic understanding: information and communication technology, Joint knowledge creation, Information exchange, Goal congruence, Resource sharing, Decision synchronization and incentive alignment. Expert's judges are used to evaluate content and face validity of collaborative supply chain measurement scale, which is useful to researchers who investigate collaboration among supply chain partners.

INTRODUCTION

Today, enterprises are seeking to build competitive advantage through supply chain collaboration, which leverages the resources and knowledge of suppliers and customers, and incorporates the flow of products and information across the supply (Cao et al 2010). Especially after the success story of Wal-Mart's collaboration with upstream suppliers Collaborative supply chain has become one of the common norms for many firms around the world (Ramanathan et al 2014 b).

Firms such as West-Marine, Procter & Gamble and Hewlett–Packard have proved the benefits of collaborative supply chain in terms of reduced cost, improved sales and improved forecast accuracy (Ramanathan et al 2014a). However despite many considerable efforts by firms and their business partners, collaborative supply chain still unachievable and its implementation, in general, has been slow .

In our study research two main parts may be defined. In first part we identify through an extensive literature review the main collaborative supply chain constructs. In the second part we develop an instrument to measure each construct (items) through previous studies and using expert's judges.

LITERATURE REVIEW: THEORETICAL PARADIGMS AND DESCRIPTION OF COLLABORATIVE SUPPLY CHAIN CONSTRUCTS

Theoretical paradigms

Diversity in the literature reflects the multidimensional nature of collaborative supply chain. According to the collaborative paradigm, a supply chain is composed of a sequence or network of interdependent relationships fostered through strategic alliances and collaboration. This research examines supply chain collaboration from four perspectives: transaction cost economics, resource based view learning and knowledge perspective and uncertainty reduction Cao and al 2010, 2011].

Description of collaborative supply chain constructs

Collaborative supply chain has been defined in different ways by different researchers. In our study , Combining both process and relationship focus and taking account of previous studies collaborative supply chain is defined as "two or more autonomous companies that form long-term relationships and work closely to plan and execute supply chain operations toward common goals, thereby achieving more benefits than acting independently and thus outlines a partnership where the parties work together, share information, resources, and risks, and make joint decisions to accomplish mutual beneficial outcomes".
From the literature review mentioned in Table 1 (see Table 1), the main constructs of collaborative supply chain are information and communication technology, information exchange , goal congruence, joint decision making , resource sharing , incentive alignment and joint knowledge creation among independent supply chain partners .

Table 2: Literature Review: Collaborative Supply Chain Constructs

Year	Authors	Information and communication technology	Information exchange	Goal congruence	Decision synchronization	Incentive alignment	Resource sharing	Joint knowledge creation
2014	Liao and al		×		×	×		
2014	Samyadip C et al.		×	×		×		
2014 (a)	Ramanathan and al		×		×		×	
2011	Cao M and al		×	×	×	×	×	×
2006	Bernhard and al	x						

INSTRUMENT DEVELOPMENT: USE OF EXPERT'S JUDGES

The instrument development stage via expert's judge consists of four main steps. First (1) Item generation via literature review (Cao and Zhang, 2011, Churchill, 1979). Then questionnaire items were assessed through (2) structured interviews with managers and academics in supply chain management. Next (3) the Q-sort method was used to assess face validity of the measurement with academician. To improve face validity (4) ranking of items with experts from academia and professionals was conducted.

Methodology

In our study content validity is ensured by an extensive literature review and face validity by expert's judges using hybrid approach Q sort method and the Zaichkowsky procedure. Many researchers used Q sort method on supply chain collaboration (Cao et al 2010).In this study we propose hybrid procedure integrating Q sort method and procedure described by Zaichkowsky's (1985.In fact These methods are very useful to assess consistency regarding how to use the expertise of judges to determine whether an item should be retained for further analysis in the scale development process (Hardesty and al 2004). In summary, Q sort method and Zaichkowsky's (1985) are the two dominant procedures that have been followed by researchers when assessing face validity of scale items. First procedure (Q sort method) is used to assign items in suitable categories and delete or reword ambiguous items and on the second procedure judges rated each item as ''completely,'' ''somewhat,'' or ''not at all representative 'to purify the scale development.

Table 3 presents the results of expert judging face validity

Table 3: Expert judging for face validity

construct	Initial number of items	Number of items after Q sort method	Number of items in the final scale	Decision rule for item retention
A: Information and communication technology	36	26	12	Items were rated: (1) clearly representative, (2) somewhat representative, or (3) not representative items were retained if at least 75 % of the judges rated an item as at least somewhat representative of the construct
B: Information sharing	52	39	9	
C: Goal congruence	9	6	5	
D : Decision synchronization	18	14	7	
E: Incentive alignment	8	4	4	
F: Resource sharing	12	7	7	
J : joint knowledge creation	5	5	5	
Total	140	100	49	

Proposed measurement instrument of collaborative supply chain

In this section we investigate the measurement instrument retained to characterize the collaborative supply chain concept. Thus we present the measurement scales retained for the seven collaborative supply chain components: Information and communication technologies, Information Exchange, Goal congruence, Decision Synchronization, Incentive alignment, Resource sharing and joint knowledge creation. For example for Information sharing 9 items are retained from 52 initial items (table 3)

Construct	Scale
Information exchange	1. We share strategic information with suppliers to implement measures to improve the level of our purchasing process (shared objectives, risks, improvement actions, situations of sales, business strategy, market trends, engagement) 2. We share our forecast purchase planning with suppliers with a view to common validation 3. We share information about our strategy and supply and storage objectives with our suppliers to improve the performance of our supply chain (eg, cost, time, quality, lean). 4. We always share with our upstream partners (logistics service providers), information on our inventory to coordinate and optimize the flow of supplies 5. Our company shares with our downstream partners (logistics service customers) information on the functioning and organization of logistics to develop a coherent strategy for distribution with that of our partners and for better synchronization of distribution activities (eg new platforms, new constraints, evolving strategy ...) 6. We share with our downstream partners (customers logistics providers), information on our product flow to coordinate and optimize the distribution (flow status, availability, constraints, risks). 7. 'We share with our upstream and downstream partners of knowledge, and ideas around the design of a new product to share skills (eg. Co-design, eve, risk, innovation) 8. We share with our upstream and downstream partners of knowledge, and ideas around the development or evolution of a product to share skills (eg co-design, eve, risks, innovation .) and develop a strategy consistent with the operation supply chain. 9. Information exchange often takes place informally and / or planned, is done at the right time and it is reliable, accurate, complete and sufficient

CONCLUSION

Our research makes several important and novel contributions, most notably, the development and face validation of a multifaceted scale for the measurement of collaborative supply chain. In fact the accurate definitions and measures of collaborative supply chain has provided a rich and structured understanding of what occurs in a supply chain or network. They also facilitate empirical research efforts because the relationships among constructs can be better captured with better definitions and measures .The definition and measurements can serve as a powerful tool for managers to form effective collaborative relationships. It can help companies to reduce the chance of collaboration failure by addressing these seven key dimensions of collaborative supply chain. Future research should apply the measures developed here for real case

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NEGOTIATING SUCCESSFUL BUYER-SUPPLIER RELATIONSHIPS: A PRACTITIONER PERSPECTIVE

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ABSTRACT
This paper focuses on the creation of buyer-supplier relationships and the associated activities that are required to maintain the relationship, including consideration of when relationships might go 'sour' as another perspective, by default, on what contributes to successful partnerships. After reviewing the literature to identify potentially important success factors, from which was developed a questionnaire, the paper presents the responses of 36 practitioners in the field. These responses provided new insights into the attitudes and actions from a negotiations perspective that contribute to supplier relationship management success. The insights led to the development of a basic model of negotiating and relationship management from a procurement process perspective.

BACKGROUND AND RESEARCH OJBECTIVES

Although substantial research has been carried out on supplier relationship management (Carr & Pearson, 1999; Chanchai & Young 2009; Cousins 2002; Humphreys, et al, 2008; Imanipour, 2012; Lamming, et al. 2005; Monckza, et al. 2008, Qrunfleh & Tarafdar, 2013), the role played by negotiations has to date been under-researched (Artz & Norman, 2002; Atkin & Rinehart, 2006; Fells, et al. 2015; Gattiker, et al., 2007). To fill this gap, we developed the following research objectives:

1. To determine the relationship between supplier selection, negotiation and relationship management
2. To understand the role of the negotiation approach in achieving a successful outcome
3. To determine success factors for negotiating and managing strategic supplier relationships

METHODOLOGY

The research approach taken was to carry out an extensive literature review of relevant academic sources, together with interviews with 36 purchasing managers from 8 large multinational companies (in the high technology and automotive industry; revenue of >1 billion Euros and >10,000 employees) in Europe and the USA. Each interview was carried out in a structured way using a 12-item questionnaire (described below) and lasted 45 to 60 minutes. For the literature review, the initial search terms included: strategic supplier, supply, relationship, building, success, factor(s), e-procurement, sourcing, negotiation, negotiating, contract, international, trust, commitment, communication, procurement, purchasing and development. Furthermore to limit the number of the sources, only those less than 20 years old were included.

To better understand the important factors for negotiating successful buyer-supplier relationships and drawing on the inputs from the literature review, twelve questions were developed (see Table 1).

Table 1: Interview questions

No.	Question	Researcher, Year
1	Through what channels and by what media do you conduct your negotiations with new and existing strategic suppliers?	van Weele, 2010; Dion, Banting, 1988; Gattiker, Huang, Schwarz, 2007; Atkin, Rinehart, 2006
2	How frequently do your communicate with the supplier? What channels do you use?	Dion, Banting, 1988; Gattiker, Huang, Schwarz, 2007; Drake, Haka, 2008
3	What objectives are you trying to achieve in negotiations?	Fells et al., 2015; Dion, Banting, 1988; Gattiker, Huang, Schwarz, 2007; Atkin, Rinehart, 2006
4	In negotiating a contract, how detailed do you try to write down the agreements?	Fells et al., 2015; Artz, Norman, 2002; Gattiker, Huang, Schwarz, 2007; Atkin, Rinehart, 2006
5	How do you try to take an active part in supplier performance improvements? How do you measure supplier performance?	Carr, Pearson, 1999; Humphreys, Williams, Goebel, 2008; Decideware, 2012; BCG, 2007
6	For successful strategic relationship management, three factors are mentioned very often: Trust, mutual commitment and good communication. What does it mean to build trust with the other party and what should each party do to achieve mutual commitment?	McQuiston, 2001; Imanipour, Rahimi, Akhondi, 2012; Monczka et al., 1998; Gattiker, Huang, Schwarz, 2007
7	What does it mean to have good communication with the supplier? How do you keep the lines of communication open?	McQuiston, 2001; Carr, Pearson, 1999; Humphreys, Williams, Goebel, 2008
8	To what degree do you share sensitive and/or supply chain related information with the strategic partner?	Monczka et al., 1998; Klein, Rai, 2009; Lamming et al. 2005; Carr, Pearson, 1999
9	What specific things have you done to build good relationships with your suppliers?	McQuiston, 2001; Monczka et al., 1998; Chanchai, Young, 2009; Humphreys, Williams, Goebel, 2008
10	What events can you think of that make the relationship with your supplier go sour?	McQuiston, 2001; Atkin, Rinehart, 2006
11	When you sense your relationship going sour, what can you do to prevent that?	McQuiston, 2001; Monczka et al., 1998; Carr, Pearson, 1999
12	In your experience, what are other success factors for building a successful long-term relationship with strategic suppliers?	McQuiston, 2001; Carr, Pearson, 1999; Chanchai, Young, 2009; Humphreys, Williams, Goebel, 2008

Research Process

This was organized as follows:
1. The list of interview questions was guided by the literature review. A pre-test was carried out by means of in-depth interviews with three academics. The questions were then modified accordingly to maximise clarity.

2. Interviewees were carried out by telephone, with the understanding that confidentiality would be observed (i.e. identities of individuals and companies would be concealed). This maximised openness and objectivity. The questionnaire was sent in advance to all respondents, enabling fuller answers to be obtained.

3. As part of the interview pre-amble, we asked the respondents to assume that in the procurement situation they described, the appropriate supplier has already been selected. The discussion hence started at the point of the actual supplier negotiations and ended with long term relationship management activities.

4. All questions were addressed in turn. Any misunderstandings were hence addressed immediately during the conversation.

5. During every interview the responses were written down immediately and transcribed, translated into English (as required) and summarized. All interviews were conducted within a period of eight weeks.

HIGHLIGHTED FINDINGS

The information gathered from the 36 interviews was extensive and data-rich. The full results can be found in Hofstetter (2013). By way of example, we have included a table of key quotes on all questions (see Table 2) and insights from the analysis of all responses for one selected question (agreement outcome). The interview responses have been assigned individual numbers ranging from Interview 1 (I1) to Interview 36 (I36).

Table 2: Key quotes and issues

	Interviewee Response
Communication channels – how do you negotiate? (Q1)	• I have noticed through my career that for all parties being able to put a face to a name is quite comforting and most of all, a hand shake and seeing facial expressions. (Interview 6) • With new suppliers, face to face is a necessity. There won't be any business with a supplier, which I haven't met before. (I27) • E-procurement is suitable for pre-sorting but not to finalize a contract. (I4)
Frequency of communication (Q2)	• It would be ideal to meet the big strategic suppliers once a month and to do regular phone calls. Phone is the best way to keep the communication up. Maintaining the good relations is very important. (I5) • In reality it is 2-3 times a year, but to do it quarterly would be best, in my opinion. Phone is also frequent and important, but mostly followed by an email for documentation. (I9) • I try to get in contact with the A-suppliers every week. Also, if it is just a courtesy call about the weather. That builds trust and good relations. Usually there is something to talk about. (I11)
Objectives sought from negotiation (Q3)	• Quality is, when the customer comes back, not the product! (I 33) • Gun to my head, I would choose quality over price, because quality problems pose a liability. But the KPIs and the performance I am measured by, is the price. (I6) • The goals price, quality, and delivery are equally important. At least that's the official party line. But when it comes down to it, price is number one. (I4)
Nature of	• We try to specify the duties of the supplier very exactly. (I3)

outcome (Q4)	• The contracts we close with strategic suppliers can have 500-1000 pages to cover everything. (I31) • If anything goes south we can exactly tell whose fault it is. (I1) • The more detailed the contract, the better the relationship will be. (I6)
Supplier performance evaluation (Q5)	• KPIs are based on the four clusters of quality, procurement, logistics and technology. (I33) • KPIs are tracked, evaluated, and reviewed monthly. (I8) • Comparisons can be best visualized through a supplier performance scorecard. (I10, I11) • 40% of respondents stated that they do not have dedicated supplier development teams or programs in place. • Feedback provided to suppliers gives them the opportunity to improve. (I4)
Trust building (Q6)	• Most mistakes/failures result from too little, too late or wrong information (I34, I35). • We are not looking for suppliers, we are looking for partners! (I15) • Transparency builds trust. (I17) • Transparency can be enabled through e-procurement solutions. (I12) • Both parties must have an interest in the relationship, otherwise it is very difficult to grow together and create benefits for both partners (I4, I15).
Communication quality (Q7)	• Purchasing managers should take any opportunity to make a courtesy call, meeting or any other form of communication (I6). • Contact needs to be on a regular basis, no matter whether it is via phone or via regular personal meetings (I16, I12). • The main thing is open communication and to convince the supplier to communicate issues openly without holding back information when there are problems. (I4, I34, I33) • A face-to-face meeting is a powerful tool. Hardly any major decisions are made over the phone. (I19)
Information sharing (Q8)	• In business situations with regular series production, best practice buyers share 12 to 18 month forecasts on quantities with their suppliers. (I2, I4) • The easiest way to share data with the supplier is via e-procurement systems. Online systems allow strategic suppliers to monitor all inventory data at the buyer's storage facilities and to constantly check inventory levels. (I10, I27) • A good supplier should be able to recover after a crisis or recession. By sharing information about market development and demand prospects, a buyer company can contribute to that. (I11) • Provide forecasts and involve suppliers early for them to best anticipate demand (I25).
Relationship building (Q9)	• Little things go a long way. (I11) • Everyone on the project worked hard and we showed appreciation. That way we built a good relationship with the supplier. (I11) • A supplier relationship lives with the personal relationships between people. (I27)
Issues in relationships (Q10)	• Prices can pose a problem when they are persistently increased ex-post during projects, or when the offered prices by the supplier are not competitive anymore. Even worse are price-increases that are unjustified, or the supplier refuses to explain the increased costs in detail. (I1, I9, I21) • Bad communication of what is required, or behaving arrogantly or pettily, can deteriorate the quality of a supply chain relationship, very quickly (I1).

	• Lack of cooperation in problem solving or seeming to hide things are serious issues. (I4, I19) • Not delivering on promises. (I3, I23)
Corrective action (Q11)	• Personal contact always helps with resolving problems. (I5, I8, I12) • When the problem between the supply chain partners is personal, between the representatives, this must be directly addressed. (I3) • Replacement of the contact person or key account person is sometimes the best way to fully repair a relationship. (I8, I28).
Other success factors (Q12)	• Have one permanent contact person instead of being passed around (I5, I13, I27). • A good long term relationship is always people driven (I3, I6, I 28). • Align the strategic roadmaps for future business direction by actively involving the supplier in new business (I4, I30).

Insights from question 4: Nature of Agreement Outcome

This question asked "in negotiating a contract, how detailed do you write down the agreements?" It examines issues associated with the degree of contract formality and completeness of the agreements between buyer and supplier. The focus lies on the topics that are subject to the contracts and on the degree of detail, to which agreements are written. All interviewees stated that their company had very specific and detailed contracts with their suppliers. Contracting is a meticulous process, with particular emphasis on the duties of the supplier (I1, I3). One manager explained that contracts are the backbone of the business relationship between buyer and supplier. Furthermore: The more detailed the contract, the better the relationship will be. It mitigates the business risk (I7, I6).

In seeking to cover any possible event contracts with strategic suppliers can extend to 500-1000 pages. Moreover, large international companies typically have contract systems containing several layers (I31, I17). Details in the contract system may vary, but typically there are three layers. The basis is a framework agreement, the second layer is standard contracts added to the framework contracts (directed towards specifics such as quality), and the third is detailed contracts related to a specific product. The product-specific agreement for the immediate product or project explicitly describes the component with all the technical parameters and requirements. This can also involve time planning, volumes, price development, project duration, and project-specific quality or logistics agreements (I6, I2). Figure 2 provides additional information on the contract layers and contents (Hofstetter, 2013).

Well written contracts contain clauses that require suppliers to make improvements proactively (I12). They also seek to cover the supply chain from end to end and arrange for intellectual property and patents to be retained by the buying company (I36). Contracts are also required for risk management purposes, addressing topics such as 'worst case' liability and warranty cases (I16). Experienced managers always retain the right to record meeting minutes and specific agreements made during the negotiation (I15, I31). Managers seek to assure that everything agreed upon is in the contract, not just in the emails associated with the negotiation process (I5, I11).

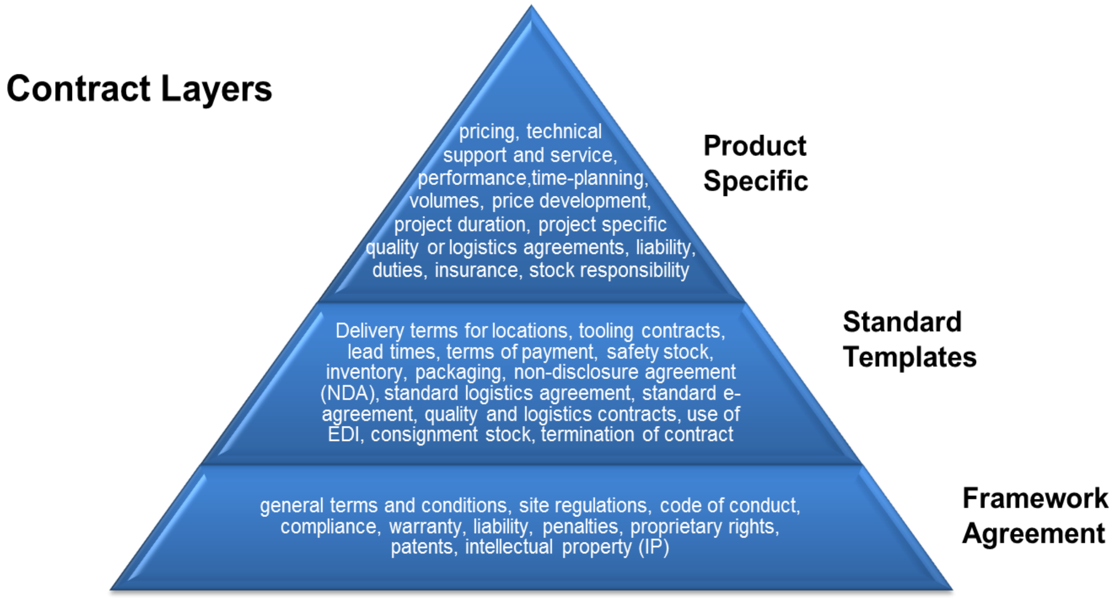

Figure 2: Contract Layers and Contents (Hofstetter, 2013)

IMPLICATIONS AND CONCLUSIONS

Following identification and analysis of the questions, we then sought to locate them within the overall context of the procurement process (see Figure 3).

PRE-NEGOTIATION	NEGOTIATION	RELATIONSHIP MANAGEMENT
• Supplier pre-selection assumed	• Purpose/objective (Q3) • How? Channels used (Q1) • Nature/form of outcome (Q4) generally *relates to the contract*	**Relationship building** • Communication – frequency (Q2) and quality (Q7) • Trust (Q6) • Commitment (Q6) • Relationship building activities (Q9) • Anything else? (Q12) **Relationship practicalities** • Information sharing (Q8) *relates to degree of trust and commitment on an ongoing basis* • Performance evaluation (Q5) *relates to mutuality and commitment* **Relationship repair** • Turning sour (Q10) *i.e. indicates what's missing* • Corrective action (Q11) *i.e. relationship builders*

Figure 3: A model of negotiating and relationship management from a procurement process perspective

This research has investigated what practitioners consider to be the important elements of negotiation and relationship management success. The in-depth interviews provided us with many insights, with issues such as trust, shared objectives and long term personal relationships being central factors. In terms of the next steps, the data needs to be more rigorously analysed, with the aim of developing a testable model of the relationship between buyers-suppliers, negotiation stages and relationship success.

Looking ahead to future research, it would also be interesting to more fully understand the role of trust, as well as the effect of emotions on behaviour and outcomes in a relationship management context.

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INFORMAL RELATIONSHIPS AND THEIR IMPACTS ON SUPPLY CHAIN MANAGEMENT

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INTRODUCTION

Interpersonal contacts have been identified as performing an important role in supply chain management, especially where the cultural concept of informal relationships has a major influence on both social and business norms. Perhaps the most studied type of informal relationship is *guanxi*, which derives from Chinese social-cultural norms and influences human behaviour in society. Examples in the context of supply chains include Cheng et al. (2012), who examined the impact of *guanxi* on supply risk management, and Li and Lin (2006), who endeavoured to leverage global logistics competence by applying *guanxi* in Chinese manufacturer networks. However, researchers have argued that the presence of informal relationships is by no means culturally unique to China or Confucianism culture (Walder, 1986), and other similar terminologies have begun to draw researchers' attentions in the context of supply chains. This includes *wasta* in Middle Eastern societies (Barnett et al., 2013) and *blat* in Russia (Abosag and Lee, 2013).

Given both the growth of studies on *guanxi*, and the diversification into other forms of informal relationships, there is a need to develop a consolidated view of informal relationships within supply chains, and particularly their impacts. Through a systematic literature review, this paper aims to examine the impacts from the use of informal relationships in supply chains, leading to the development of a theoretical framework for future research.

The paper proceeds by firstly giving an overview of the literature on informal relationships, before setting out the systematic literature review approach adopted. From this, the impacts are synthesised, leading to a theoretical framework anchored in social network theory.

LITERATURE REVIEW ON INFORMAL RELATIONSHIPS

Various studies have given definitions of informal relationships based on different scopes, such as 'personal relationships' (Herndon, 2008), 'personalistic networks' (Chung, 2005) and 'social connections' (Chen et al., 2011). In this study, it is defined as a social-cultural resource which is framed in the particular social network, acting as an 'invisible hand' and influencing social and business activities. Within this, emotional closeness (*ganqing)*, trust (*xinren)*, and favour (*renqing*) are defined core values of informal relationships (Lu et al., 2015). Studies in the marketing discipline substantiate the view that informal relationships, personal links and cultural diversity are major elements when differentiating business-to-business relationships (Fock and Woo, 1998). In the last two decades, with the development of supply chain management in the context of globalisation, informal relationships have been dramatically emphasised by both of academia and practitioners.

The nature of informal relationships can be considered through comparison with formal relationships. These focus on contractual mechanisms, often underpinned by transaction cost theories, to develop adequate controls to curb partners' opportunistic behaviours and reduce perceived risks (Geringer & Hebert, 1989; Williamson, 1985). Transaction ambiguity is reduced and transparency is increased by the clear contractual specification of each detailed term. Informal relationships are also claimed to help managers mitigate opportunistic behaviour in economic transactions, however, through mutual trust and obligations generated from network members (Park and Luo, 2001; Yang, 1994; Wong & Leung, 2001). Besides, the scope of the perspectives involved in these two mechanisms are different – contractual relationships tend to focus on the 'smallest possible unit of economic exchange' and it is a single transaction (Ai, 2006); on the other hand, people within informal relationship networks form strategic alliances (Ai, 2006) with a long-term orientation, under an expectation of repeated interactions and exchanges of reciprocal equity and favours (Leung et al., 2005; Luo, 1997). Furthermore, the motivations from informal relationships are far more than reducing risks and opportunism. It also helps to smooth transaction arrangements in procurement, production and long-term collaboration, gain access to new business opportunities and enhance personal and corporate reputation (Lu, et al., 2015).

Based on previous work examining the core values and motivations of informal relationships (Lu, et al., 2015), this paper answers the research questions of 'how' informal relationships impact upon supply chain management.

METHOD

The systematic literature review comprises identifying published academic research on informal relationships and supply chains, covering the period from 1994 to 2013 inclusive. The literature search covered the databases of five publishers of management related texts: Science Direct, Emerald, Taylor & Francis, Sage and Wiley. To identify relevant articles, two combinations of search terms were used. The first set of terms included the names given to different forms of informal relationship (*guanxi, wasta, jeitinho, 'pulling strings', svyazi, blat, wa* and *inhwa*). Meanwhile, the second set of terms covered various dimensions in supply chains, including supply, logistics, procurement and production. The use of specific names enabled a focus upon specific cultural practices while the second set recognised the broad range of activities within a supply chain. Each term from both sets, except *wa* (informal relationship in Japanese), was combined with each other, and this resulted in the identification of 308 relevant papers. The key term *wa* was not included in the main search stream because it can be short for other terms, such as West Australia. Therefore, an individual searching and filtering process was conducted to find relevant papers, and these were then included in the initial sample of 315 relevant papers. Filtering criteria was then to select papers containing both of the key terms in the main texts, and this resulted in 112 papers remaining. Further filtering to identify those papers where the substantive research was on informal relationships resulted in a final sample of 95 papers.

Initial coding of the articles focused upon various bibliometric details, research regions, industry, firm sizes and research methods. To identify various impacts of informal relationships in SCM, categories were inductively developed based on coding of the papers. To ensure the validity of this work, and particularly the accuracy and consistency of the categories and coding process, after coding the first 20 papers, the coding file and the papers were circulated in the research team, to check the reliability of this process. Also, the table containing all the attributes of impacts of informal relationships have been presented to the research team for further debating and checking of the logic and consistency of each cluster. This increases the validity of the coding process. Finally, the identified results also have been verified through 5 interviews with academia and practitioners, in order to improve the reliability for content analysis.

OVERVIEW OF THE SAMPLE

Since 2004, there is a dramatic increase of academic interest in this area and 90% of papers were published in the last decade (Figure 1). Many of these papers are in marketing and management related journals rather than located directly in the supply chain discipline. Additionally, many of these studies are general in nature, with 40% of papers undefined in industries and 57% not stating firm sizes. The research has been investigated in various regions, including Middle East, Australia, USA and Europe. However, China was still the primary research area with 74.7% of papers (including Hong Kong and Taiwan) conducted in this area. Thus, it is an emerging research topic in an exploratory stage where various research gaps can be fitted in.

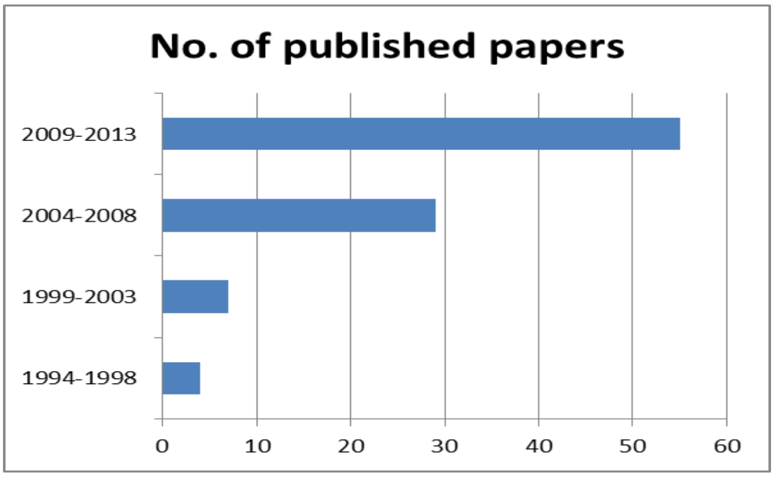

Figure 1: Profile of journal paper sample over time

Figure 2 shows the nature of authorships within the sample of papers. There is a clear dominance of Chinese based researchers, both for single and multiple region authorships, featuring on over 50% of the papers in the sample and therefore reflecting the large emphasis on guanxi within informal relationship research. Perhaps more surprising is the lack of collaboration between Chinese and other Asian based researchers, given that informal relationships are important in many Asian countries. Even where the research is carried out by researchers based externally to the country/region under examination (for example, North American based researchers looking at guanxi), there is still a cultural link to the focal region for at least one of the authors. This suggests that cultural understanding is an important requirement when carrying out research on informal relationships.

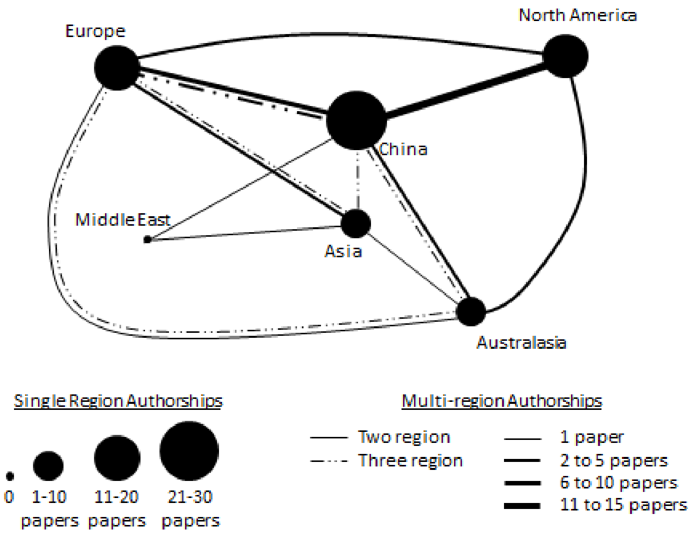

Figure 2: Authorships of papers within the sample

WHAT ARE THE IMPACTS OF INFORMAL RELATIONSHIPS?

Through the literature review, 134 variables were coded from the literature and synthesised into 12 clusters representing different impacts from applying informal relationships in SCM, including relationships with various stakeholders, procurement, production, reduce uncertainty, supplier management, IT, strategic goals, logistics, customer management, quality, employee management and knowledge and learning. The results can be seen in Table 1.

Cluster	***Impact of informal relationship***	***Coded variables***	***No. of papers***
Relationships	In social networks, firms tend to rely more on arm's length relationships, to engage in building good relationships and committing to formal and informal collaborations	Integrated supply chain networks, trust between buyer-seller, collaboration	48
Procurement	They improve efficiency, save time and ease the procurement of necessary production resources	Influence purchase decisions, negotiate payments/ordering quantity	31
Production	Informal relationships are important in internal integration, external adaptation and collaboration in production	Secure production capacity, diversity in production, efficiency in production	27
Reduce uncertainty	Informal relationships are increasingly serving as mechanisms to reduce uncertainty and increase predictability because the players are likely to hedge their risk by using private or particularistic channels	Increased tolerance, predictability, reduced conflict, reduced production/supply risk.	18
Supplier management	The personal relationship between individual buyer and supplier can dramatically influence supplier selection, development, and share strategically organizational values.	Managing supplier partnership values, supplier communication/ integration/financial performance/selection	16
IT	Information integration is necessary to help internal functions within the company identifying critical issues	Information sharing/integration/ technology	15
Strategic goals	Through close personal relationships, the supply chain strategically forms a variety of flexible and synchronising prototypes	Alliances in SC design, efficiently respond to market demand	15
Logistics	Global logistics competence and logistics infrastructure can be enhanced by leveraging informal relationships	Logistics competence, logistics infrastructure, timely deliveries,	11
Customer management	An organization can capture the operational benefits from including downstream parts of the SC	Access to new customers, match customer needs	7
Quality	Informal relationships with main suppliers could help acquire quality products and superior services	Acquire quality services, quality production	5
Employee Manage	Good informal relationships with employees are expected to provide engagement, collaboration and control the turnover rate	Relationship with employee, purchasing/ production workers	4
Knowledge and Learning	Good relationships foster understanding of knowledge and market signals	Enrich knowledge pool about customers, internal learning process	3

Table 1: Impacts of informal relationships

Relationships

Most of the papers have focused on the topic of relationships in SCM, including buyer and seller relationships (Dickson and Zhang, 2004; Giannakis et al., 2012) logistics outsourcing relationships (Chen et al., 2010) and collaboration with competitors (Wong and Tjosvold, 2010). By taking advantages of the core values, companies can develop the social network for its own benefit (e.g. building harmonious business environment) or for other purposes (e.g. an economic tool, Lee & Dawes, 2005). In relationship management, players tend to improve the levels of integration (Nonini, 2014) and collaboration (Ramasamy et al., 2006) in supply chain management, for exchange of mutual trust and benefits in the long-term. However, while the literature shows a strong emphasis on examining the impact on relationships, the empirical interviews suggest that reducing uncertainty is the primary impact. These impacts are discussed shortly.

Procurement

The literature suggests that informal relationships improve the efficiency and ease the process of procurement for necessary resources (Ramasamy et al., 2006, Chen and Wu, 2011). Firstly, decision-making for procurement selection and acceptance is very complex and informal relationships with suppliers can increase the trust level for product acceptance (Sternguist and Chen, 2006). Secondly, informal relationships serve as a social capital to access to tangible resources (e.g. materials, labour and physical resources) and intangible resources (e.g. knowledge and information about domestic markets) in procurement (Chen, 2009; Chan, 2008). Thirdly, it also helps to manage supply risk through increasing communication and reducing supplier's opportunism (Lee and Hamphrey, 2007). Finally, informal relationships create a greater margin for purchasing negotiations in terms of price (Giannakis et al., 2012), order quantity (Kam and Chen, 2011), and pyament deadlines (Chen and Wu, 2011)

Production

Firms are endeavouring to maximise their output with the minimum cost (Day & Wensley, 1988; Li and Sheng, 2011). Close ties with buyers, suppliers and even competitors provide such efficiency in SCM because firms can coordinate strategic planning and integrate production capabilities (Peng and Luo, 2000) with necessary resources, information and technology (Zhao et al., 2011). Information visibility is a particular contribution in utilising informal relationships (Chen et al., 2003; Cui et a., 2013) to access to market information and react to the trends. Production operations can be enhanced as well when management can understand the 'human mindset', show empathy for staff members and emphase the importance of informal relationships with both internal staff members and external business partners (Choi et al., 2012).

Reduce uncertainty

Actors rely on their social networks to manage uncertainty and increase behaviour preditability in economic sociology (Pfeffer and Salancik, 1978). In informal relationships, trust plays as the central value (Lu et al., 2015), serving as a governance mechanism that mitigates conflicts and reduces uncertainty in production (Ling and Li, 2011), supply and demand (Cheng et al., 2012), and information and technology turbulance (Chang, 2011). The usage and particular forms of informal relationships are also shaped by uncertainty rising from specific institutional factors which provide incentives to emerge a certain form/structure of informal relationship while resolving the uncertainty in the likelihood of interdependency within the social network (Chang, 2011) to increase the torelance level in the supply chain (Cui et al., 2013).

DISCUSSION

The above synthesis of the literature shows a diverse range of impacts that can result from informal relationships. However, it is not clear the extent to which the core values of informal relationships influence each of the different areas, and then further impact on business performance measures. Various theories have been employed to investigate the influence of informal relationships in more depth, and one theoretical lens for undertaking such research on informal relationships is social network theory (SNT). A social network can be defined as "a set of nodes…linked by a social relationship…of a specified type" (Laumann et al., 1978, p.458). In building a guanxi network, individuals are assumed to create certain levels of social cohesion with relevant actors, with strong and weak ties depending upon the purpose and the social structure of this relationship. Based on this perspective, the theoretical framework is presented in Figure 3. The starting point is the development of a informal relationship network.

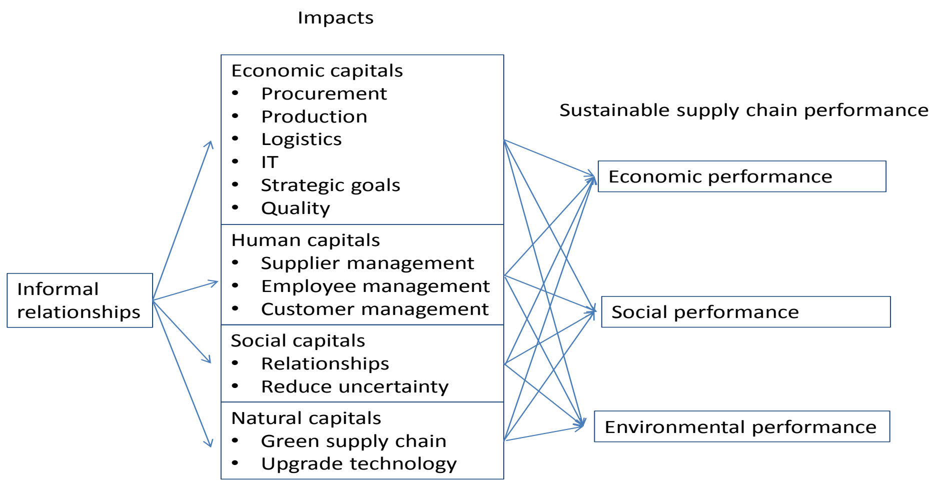

Figure 3: Theoretical framework for evaluating the impact of informal relationships on supply chains

The purpose of the social network is to build capitals, which Burt (1992) emphasises on financial, human and social capital. Financial capital refers to money related aspects, human capital includes natural abilities and skills while social capital refers to relationships with other players. However, with the recent growth of interest in sustainability issues, natural capital has also been proposed as a fourth type of capital (Ekins et al., 2003). The various categories found through the systematic literature review can be related to the development of one of these types of capital (Figure 3).

However, while considering these different types of capital is important in SNT, there is also a need to evaluate the impact on business performance. Therefore, a further set of connections to a range of performance metrics is proposed. These encompass sustainable supply chain management, given the increasing importance placed upon this by business and academia (Seruing and Muller, 2008). Aspects of measures that could be evaluated include (Global Reporting Initiative, 2015):

- Economic performance, market presence, indirect economic impacts (Economic)
- Labour practices, human rights, society (Social)
- Emissions, materials, waste (Environmental)

CONCLUSION

This review provides a synthesis of knowledge in understanding the impact of informal relationships in supply chain management. Trust is a determinant factor that is particularly highlighted in informal relationships, and affects formulations of various relationships. There are also connections between different impacts of informal relationships. For example, creating trust and reducing uncertainty can help players to build good relationships within interaction, which then would ease the process of procurement and production. Good relationships with players also motivate companies to engage in strategic planning and collaboration, to fulfill their business and stratetic goals. However, building good relationships is a hierarchical process where strong informal relationships are cultivated through repeated interactions and long-term satisfaction from both parties.

So far, the literature review shows that although knowledge of interpersonal networks has expanded significantly over the last decade, the study and analysis of informal relationships as a distinct influence in supply chains remains relatively embryonic where various research gaps can be identified for future research. For example, research could be extended outside China since other emerging cultures hold a similar perspective of emphasising informal relationships. Various impacts and supply chain paradigms could be compared and contrasted, and further distinguished with specific social-cultural norms. Research also could be developed in more depth, for example, to clarify firm size. Informal relationships within different sized firms, such as multinational companies and SMEs, are expected to be different. Further research could also examine in detail a specific supply chain dimension (e.g. procurement). The influence of powerand how informal relationships interact with formal relationships are other potential research areas. Finally, much of the emphasis in the research is on the positive impacts of informal relationships. However, negative issues may also need further research. For example, questions concerning transparency, fairness and business ethics are also arising (Chen et al., 2011) since gift-giving is one of the approaches to receive *renqing*.

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MULTIAGENT SYSTEMS TO PROMOTE TRANSPORT COLLABORATION IN DEVELOPING COUNTRIES: A LOOK AT AGENT BEHAVIOUR SETUP

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ABSTRACT
Transport stakeholders have always identified efficient transportation as the success and growth to their business. Collaboration have been seen as a means to promote efficient transport among stakeholders. However collaboration has always been seen to be lacking in developing countries. Multiagent systems (MAS) has of late been researched and prototyped by many as key to aiding future collaboration among transport and logistics partners (Robu et al., 2011, Moonen, 2009, Dullaert et al., 2009). The aim of this research is to look at agent setup to show that MAS can promote collaboration within the transportation industry of a developing country.

INTRODUCTION
The effective utilisation of capacity in all directions determines the efficiency of any freight transport business. The daily and continuous search to establish freight on any journey determines the success of any business operating a fleet. Transport operators deal with effective transport capacity utilisation differently, depending on factors like regulations, locations, distance, time, weather, economies of scale, and volumes. Developed countries through established infrastructure, capacity and technology, have means to deal with most of the mentioned factors. Problems that occur can be times when freight is not located on a planned leg or journey; carriers are re-routed to avoid an empty run often with the expense of extra mileage (McKinnon and Ge 2006). In developing countries the problem of not locating freight is in most cases driven by all the factors to be considered, and becomes a strenuous task. The exploration for possible solutions beckons, and a multi-agent based approach could be one.

Multi-agent systems (MAS) being single computer systems configured to represent and carry out tasks on behalf of a user (Wooldridge and Jennings 1995), have been explored, tested and implemented in transport environments. One of the main features of interacting with others as an autonomous unit gives it the trademark being a form of distributed artificial intelligence. The use of MAS has been augmented over the past decade, and improvements to achieve intelligent and useful transport systems have been achieved worldwide (Dullaert et al., 2009, Robu et al., 2011, Serna, Uran and Uribe 2011). The agents are setup with policies and strategies beforehand to resolve queries that are the best possible fit for users and others operating within the environment. As agents are operating in an environment driven by activities from others, features like proactive, reactive and social are often associated to them (Kwon, Im and Lee 2001). These features put MAS that could create collaborative transport environments. This study has explored Multi-agent systems that could reduce this limitation and promote collaboration among transport stakeholders.

LITERATURE REVIEW

The transport environment is a dynamic one, that requires the transportation of goods according to customer needs, but the next consignment after the initial delivery has to be organised as well. The decision for each consignment following a previous delivery has an impact on the long-term efficiency of the entire fleet (Crainic, Gendreau and Potvin 2008). Consignment decision-making managed over multiple fleets, with longer periods of time and an unpredictable environment, becomes more and more difficult to handle. Fleet management systems co-ordinated with built-in positioning systems allow for the re-routing of vehicles as new consignments arise (Crainic, Gendreau and Potvin 2008) thus making it easier. These systems are seen as the internal management of fleets and may be better to co-ordinate, but the collaboration with partners gives a different dimension to the availability and re-routing of vehicles. Transport and logistics are highly distributed activities. There is a lot of focus on the individual partner looking to improve their own supply chain, without considering others (Franklin, 2012). This is made worse in a case of a developing country where the level of understanding for collaboration and integration is lacking (Savage, Jenkins and Fransman 2012). Although Aitken et al. (2005) said that it is supply chains that compete and not companies, supply chain collaboration could increase the levels of service of all companies involved. Modern industries are forced to look at other methods to improve service to aid in future growth. The factor of cost saving is important, and collaboration is a method that could aid in this. Collaboration through sharing and integration with partners has been shown to have the potential to optimise transactions and carriers (Yilmaz and Savasaneril 2012). Transport is the integrator of supply chains and so becomes a critical factor and affects all stakeholders (Mason, Lalwani and Boughton 2007). Collaboration has become important and this section shows there has been some success in transportation internationally, regionally and locally.

Collaboration success internationally

Small shippers, according to (Yilmaz and Savasaneril 2012), have been in alliances with ocean liner companies like Hapag-Lloyd, NYK and OOCL, and United Shipper Alliances. Through some of these alliances many of the small shippers have claimed to reduce their Less-than-truckloads (LTL) and ocean transportation costs by 10-40% for their small ships (United Shippers Alliance, 2014). These alliances allow the small shipper the freedom of carrier communication and management, allowing an existence outside of the framework. Alliances have now evolved into bigger collaboration initiatives with other alliances outside certain trade routes (Grand Alliance, 2014). These alliances have developed into strategic strongholds in this industry and have accumulated decades of experience and knowledge (United Shippers Alliance, 2014, Grand Alliance, 2014). Other transport collaborator groups include System Alliance Europe that specialises in network distribution in Europe, through the harnessing of leading medium-sized logistics service providers. This group relies on guidelines presented to all member organisations that must be followed to provide guaranteed quality standards and transparent processes. The Canadian furniture industry has identified large cost savings through transportation collaboration and has demonstrated cost allocation strategies in these cases (Audy, D'Amours and Rousseau 2010). According to the National Shippers Strategic Transportation Council (NASSTRAC) Freight Transportation report 2013, 32.4% of shippers collaborate with their suppliers, and around 54% say they collaborate with other shippers. The report recognises companies like the Best Buy Co. who cut their shipment costs by 30% through close collaborations with their providers (NASSTRAC, 2013). Collaboration success is evident and systems to promote it are clearly needed. Multiagent transport systems (MAS) to promote collaboration do exist, however are seen to be unique in providing such service.

Multiagent systems

What makes these MAS intelligent platforms unique or different from other collaboration solutions is the capability to handle unforeseen events. Bernaer et al. (2006) who carried out research on MAS transport system gives the example of a feature of such a system. It should be able to handle unexpected events based on agents around as well as load matching and freight tracebility and an intelligent platform. Agents can have the characteristics of autonomy, reactivity, pro-activity and social ability (Wooldridge and Jennings 1995). Autonomy is defined as each agent operating without outside involvement, and controlling its actions and in-house states. The reactivity is the actions taken when the environment changes. Pro-activity is the ability to send own behaviour changes to the surrounding agents. Social ability represents the interaction that exists either between agents or agent and human (Serna, Uran and Uribe 2011). The mentioned features fit in well with the aim of optimising transport fleets and achieving sustainable distribution levels. Mckinnon and Ge (2006) mention that the reduction of empty runs relies on good networks and sharing of information. The features that the agents possess can reduce the human factor that often hinders networks and drive towards a more co-ordinated effort. There are other features namely: the ability to influence, self-learning capabilities, problem solving and co-operation as some examples (Moonen, 2009) that add to an agent's characteristics. Referring back to autonomy, there are four levels of it as described by Serna, Uran and Uribe (2011); strong regulation, operational autonomy, tactic autonomy, and strategic autonomy, with the main feature of the agents being able to react to their environment. The levels described form the basis for collaboration with other agents. These levels of collaboration and special features would depend on the goal of the agent within its environment. For instance, in an operational autonomy environment agents represent specialised services and react when needed, while a strategic agent would consider only operations that reach the goal of the organisation or person its representing. MAS assist with real-time issues because of their pre-configured, reactive and pro-active nature. Systems that operate autonomously allow for potentially uninterrupted service delivery, which could be favourable and could deal with some of the challenges that transporters have i.e. lack of information and visibility of freight.

METHODOLOGY

The research followed a literature and software study into the variations of transport MAS designed, tested and implemented. This formed the basis for an empirical component that evaluated selected systems and looked at the suitability of these to mimic a developing country's transport players. The evaluation also looked at agent behaviour and characteristics of MAS in a transportation environment. This was applied and modelled with the characteristics and processes of transport stakeholders in a developing country to assess outcomes of collaboration that was used or evaluated.

FINDINGS

Agent based software has been tested in a multi-modal transport scenario, as an intelligent communication support platform (Dullaert et al., 2009). Such a system can therefore act as an integrator that exchanges correct, reliable and relevant data. One of the most important characteristics though, is the real-time aspect that is very important in a transport and logistics environment (Dullaert and Van Landeghem 2007). Combining these systems with web-based services allows for platform independence and allows all stakeholders to have access with their in-house systems. The intelligent integrating capabilities have another benefit to a transport environment when the autonomous handling of queries by agents can have a twenty-four hours a day collaboration directive.

Agent characteristics in transportation

A dynamic environment like transportation makes it difficult to have central control of all information and use this for clear decision-making (Serna, Uran and Uribe 2011). Transporters are autonomous when distributed or on the move and so are seen as entities that could redirect and change course if and when needed. Changing or redirecting transporters needs a clear, concrete and overall view of the transport environment. Achieving this requires network connectivity to other entities that can send up-to-date information to others and allows decisions to be autonomous (Serna, Uran and Uribe 2011). Further, with negotiations and co-operation being normal activities in transport it matches some of the characteristics that make up an agent. An MAS has the capabilities and the algorithms to promote co-operative and negotiating features. The platforms provide more than just access to view, post or retrieve transporter information, they process information independent from users. The agents represent transporters, and though customised with user requirements, they independently carry out requests and events on behalf of the users. To carry out these requests and events it requires good communication between agents, and this needs good languages to use. Agent Communication Languages (ACL) is a common language designed by the Foundation of Intelligent Physical Agents (FIPA) and is often the preferred language in MAS. Farooq Ahmad (2002) describes the fields in the message format of the ACL: - Sender, Received, Reply-With, Content, Language and Ontology. Applying this to the transportation environment where a load has been made available through auction and the transporters, who are agents, are the bidders. The identification of the message from one agent is indicated at the start. In this instance it is an "information" message. The fields could be mapped as in the figures below.

inform {
Sender: Transporter (01)
Receiver: 3rd Party Provider (04)
Reply-with: Bid for load (#)
Content: Price (Bid Load (#)) $100)
Language: FIPA-ACL
Ontology: auction
}

Figure 1 - Transporter

- inform {
- Sender: 3rd Party Provider (04)
- Receiver: Transporter (01)
- Reply-with: Bid for load (#)
- Content: Approved (Bid Load (#)) $100)
- Language: FIPA-SL
- Ontology: auction
- }

Figure 2 - 3rd Party Provider

The response in the same format populates the fields based on information required. However to reply the receiver agent has to analyse information from all other agents in the auction. The analysis could be of several factors like the price or as in some systems, agents who have ratings they consider. The message formats bring about the complexity of the transport MAS, where the communication and the coming to a common understanding of agents needs understanding.

Agents mapped from transport process

Understanding the transport process and mapping it to software agents is important for developing a framework for the adoption of a system. Knowing where the requirement for a transport operation starts is important, as well as how information flows through the system. Processes are guiding the environment, and the more clearly it is defined the better it is for agent design. The process flow seen below, shows a basic transport stakeholders communication system to manage transportation. This flow example starts from a customer that requires a transport service. It also highlights the areas that should be considered in the modelling, which is the information areas and the capacity.

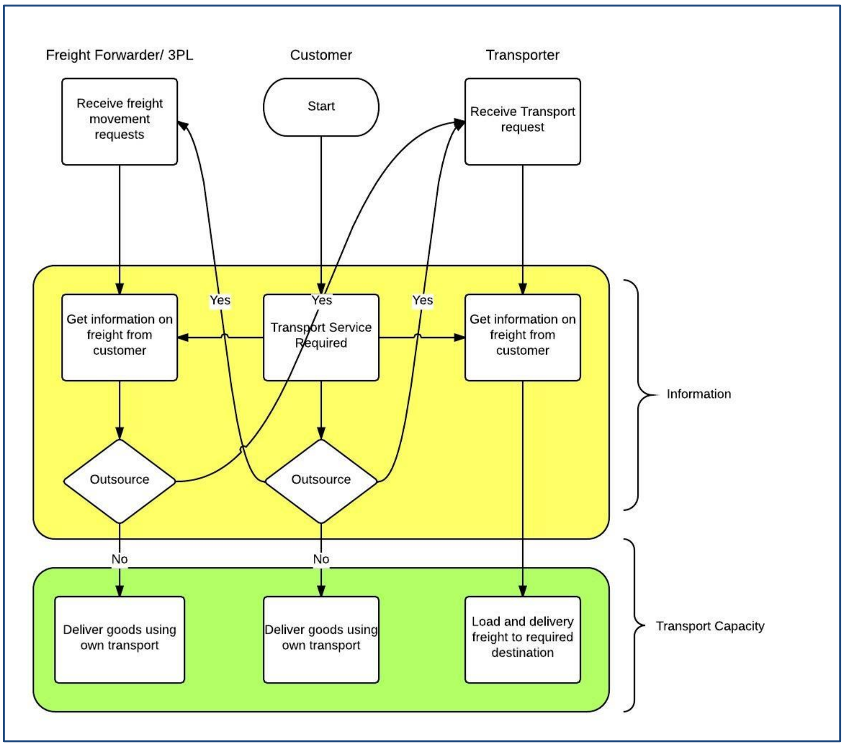

Figure 3 Transport agent process flow

To map agents from the process flow, one has to consider output and inputs form each entity based on their immediate neighbours or to whomsoever they are connected. The customer requests services, and therefore sends it to either the transporter or freight forwarder if they are outsourcing. However they can also assign their own fleet and deliver their goods. The forwarder and transporter both handle requests, however the former can issue a transport service to a transporter if outsourcing is one of their options. Based on this agents can have the following characteristics.

Transporter

- Request handler
- Service interpreter
- Fleet assign, deliver and monitor

Freight Forwarder/3PL

- Request handler
- Service Interpreter/Issuer
- Outsource
- Fleet assign, deliver and monitor

Customer

- Request Issuer
- Service Issuer
- Outsource
- Fleet assign, deliver and monitor

Figure 4 Characteristics of transport stakeholders

Transport agents collaboration environment

Agents that could have different states namely; cooperative, learning and/or autonomous. The ability to create agents that could be both programmed with parameters or could learn from its environment is referred to as smart agents. Another key feature to the successful setup of an agent environment is the creation of a knowledge base that adds to the overall design. It is used to aid future decision making by having the system build itself over time. The figure below demonstrates the framework for a agent system where transport stakeholders interact with other agents and with the knowledge base. The key to the system is to promote collaboration, which is what the system can offer through its solution. The agents sharing information with others and a central environment show the transparency with which the system operates. This transparency that all agents gain through interaction and from the knowledge base, can now allow for the interaction and collaboration to take place.

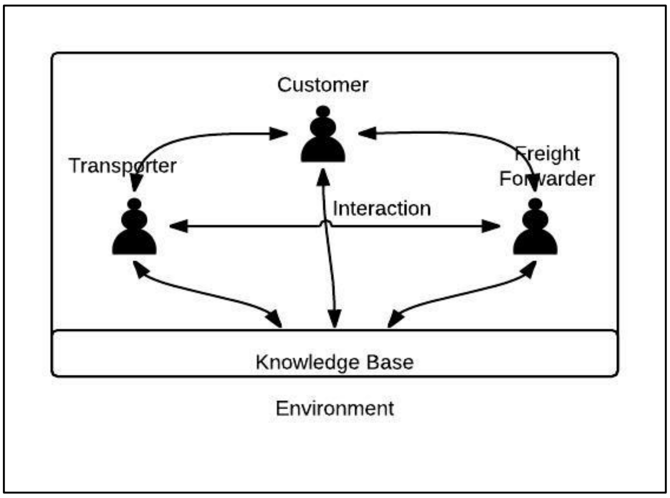

Figure 5 Agents interaction in environment

CONCLUSION

Agent software defined as independent operating entities that could operate within an environment, are at the forefront of distributed systems. The spawn of Multi-agent environments that through computational capabilities mimic human or organisation processes is suggested for transportation systems. Well-managed transport environments possess the features of autonomy and uncertainty that match a MAS requirement. Distinctive MAS with the feature to handle unforeseen events are favoured by many researchers i.e. (Moonen, 2009, Dullaert et al., 2009) in transport environments. Environments are seen as the platform upon which agents operate with various methods for modelling their behaviour. Typical 3 tier systems (application, middleware, infrastructure) describe these differing environments with requirements at each level according to the particular system goal. The main purpose of most transport MAS is to handle unforeseen events without human intervention. MAS that can equip agents with autonomy characteristics should achieve this. However communication is particularly important to achieve this. Agents need clear language guidelines to ensure formats are adhered to and operating environments are matched. Communication then facilitates the agent operations with regulation, and ensures analyses are performed for all agent entities, that is essentially feeding of each other's output and inputs. Taking from Farooq Ahmad (2002) that mentioned a few states an agent can possess namely: - Facilitators, Mediators, Brokers, Blackboards, Yellow Pages, Collaborative or Cooperative. Each of these possesses its own characteristics that are specific to its system environment. The MAS paradigm because of these states and interactive nature shows potential for several implementations in dynamic environments that operate in networks. To achieve multiagent interaction there has to be a common language, format for communication and ontology. Popular languages Agent Communication Languages (ACL) among others, basically refer to human linguistics communication analysis on statements that require actions (Farooq Ahmad, 2002). Setting up agent characteristics to successfully operate in communication languages requires frameworks defined within an environment. The frameworks guide communication, and allow characteristics to interact with others when needed.

MAS systems rely on achieving consensus as this guides collaboration among agents. Agents possessing these collaborative features can represent transportation stakeholders to achieve collaboration. However systems like MAS have not been applied within a developing country, and this research has set out to investigate its potential implementation to promote collaboration among transport stakeholders. Constructing the agents particularly based on the characteristic of a developing country depends further on the infrastructure framework it will operate within. Agent communication language parameters allow flexibility during setup, and thus can deal with typical transport characteristics. Ultimately although there is a difference from a developed world that is supported by established infrastructure, agents can be setup within a developing country to function within a collaborative MAS environment.

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EXPLORING THE RELATIONSHIP AMONG INDUSTRIAL CLUSTERING, BUSINESS ECOSYSTEM AND BUSINESS STRATEGY – AN EMPIRICAL STUDY ON THE FASTENER SUPPLY CHAIN IN TAIWAN

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ABSTRACT

ABSTRACT

Despite of the offshore migration of many fastener companies to China over the past 25 years, Taiwan still ranks top five in fastener supply with a total exporting value of $4.2 billion in 2012 after 60-year development of the industry. However, in recent years, Taiwan's fastener industry is facing international competition, the deterioration of the business environment and the international financial market volatility and other factors, so the industry is facing serious challenges. Therefore, how Taiwanese companies could develop their business strategy by scanning and adapting to the constantly changing environment is the primary issue of this study.

This study employs environmental factors, industry cluster, business ecosystem, and business strategy to analyze the fastener industry in Taiwan. Through examining these variables, we aim to find the key factors that affect the selection of business strategy. This study received 141 questionnaires and used SEM (Structural Equation Modeling) for statistical analysis. The results indicate that: (1) Environmental factors have impacts on industry clusters. (2) Environmental factors also have impacts on business ecosystem. (3) Industry clusters have influences on business ecosystem. (4) Business ecosystem has impacts on the development of business strategy. Based on the aforementioned findings, this study accordingly proposes some suggestions for fastener companies to overcome current difficulties as well as help them to develop suitable business strategies.

Keywords: Industrial clustering; business ecosystem; business strategy

INTRODUCTION

After the offshore migration of many fastener companies to China for over 25 years, Taiwan still ranks top five in fastener supply with a total exporting value of $4.2 billion in 2012 after 60-year development of the industry. Currently, there are about 1300 fastener manufacturers in Taiwan and 900 of them are located in a narrow strait stretching about 60 km in the southern part of Taiwan. The conglomeration of the same industry in a small area demonstrates the existence of "industrial clusters," where companies have the potential to share resources and to implement division of work. Moreover, most fastener manufacturers in Taiwan are small and medium enterprises (SMEs), and clustering facilitates the collaboration and resource sharing among them (Wu et al., 2012).

In a business ecosystem, firms develop into different roles setting after cooperating with others in different fields and integrate their resources and capabilities so as to achieve the value maximization (Iansiti and Levien, 2004[a]). Firms belong to a supply chain but resides in different geographical areas may form an ecosystem where each firm plays a certain role in business (Iansiti and Levien, 2004[b]). Thus it is apparent that clustering can facilitate firms to develop a business ecosystem but is not a necessary condition for such development.

Actually, clustering is merely a conglomeration phenomenon and differs from collaborative roles setting in a business ecosystem. Moreover, the formation of clustering and business ecosystem may be influenced by the business environment firms reside in (Iansiti and Levien, 2004[a]). Nevertheless, it is relatively neglected by previous studies regarding the impacts of clustering and business ecosystem on the formation of business strategy. Without knowing the impacts, we might be misled by the factors that affect business strategy. In this study, we endeavor to investigate the relationship among clustering, business ecosystem and business environment as well as explore the impacts of clustering and business ecosystem on business strategy.

LITERATURE REVIEW

Industrial environment is regarded as the business environment that a company faces, including customers, suppliers, distributors, competitors, industrial community, etc. It also concerns the general environment that may affect how businesses operate, e.g., the economic and social situations, the technology conditions, governmental regulations and policies, stakeholders (Jauch and Glueck, 1980). As a company locates in an industrial environment, it needs some forms of cooperation and competition among the firms to make the best us of the resources and to learn and improve as well (Bell et al., 2009). The environment may be the geographical area where firms form an industrial cluster. It could also be a supply chain, governmental regulations, and/or technology cooperation that help shape a business ecosystem.

Clustering is a phenomenon of firms that interacted and gathered in a specific geography and in specific industry (Porter, 1990). Firms in a cluster can usually cooperate or compete vertically and horizontally to achieve economies of scale, reduce risks and costs, and increase benefits. Clusters offer companies higher performance through better access to cheaper resources and through shared information to allow firms to grow faster with more opportunities available to them (Merselis, 2011).

Even though there is cooperation and competition in an industrial cluster, firms in the cluster might not have evolved into special roles, i.e., firms have not yet developed specific roles in the industry or in the geographic cluster. Moore (1993) is the first scholar who proposed "business ecosystem." He suggested that a company can be viewed as not a member in an industry but as part of a business ecosystem that crosses a variety of industries. In a business ecosystem, companies coevolve their capabilities and build a symbiotic relationship with one another. Iansiti and Levien (2004a) suggested that business ecosystem and biological ecosystem are similar and are characterized by a large number of loosely coupled participants toward a common destiny. They (2004b) also differentiated diverse roles of firms in a business ecosystem in order to work cooperatively and to create values.

A business strategy refers to the long-term goal of a business where resources are allocated and actions are taken to help achieve the goal. Croteau and Bergeron (2001) stated that strategy is the result of decision-making and it guides the direction of a company considering the internal / external environment, the organizational structure and the operational processes which affect the performance of a company.

Based on the industrial environment where a firm locates, it could develop into different strategies. For example, a company may pursue an overall cost leadership strategy or a differentiation strategy. They may also adopt an adaptive strategy, or a focus strategy, depending on the industrial environment such as competition status, governmental policies, self-positioning in a supply chain, etc. Clustering and business ecosystem have commonness in working cooperatively, independently but under some level of competition. Companies in a cluster focus on geographic conglomeration, while companies in a business ecosystem would develop into different roles. When developing business strategies, whether clustering or business ecosystem has larger impacts on strategy selection still remains unknown.

HYPOTHESES

After a review of related literature, we proposed a conceptual model having four constructs: business environment, industrial clustering, business ecosystem formation, and business strategy, and drew five hypotheses accordingly as follows.

H1: Environmental factors have a positive impact on industrial clusters

H2: Industrial clusters have a positive impact on business strategy

H3: Environmental factors have a positive impact on the role of business ecosystem

H4: The role of business ecosystem has a positive impact on business strategy

H5: Industrial clusters have a positive impact on the role of business ecosystem

Data were collected via structured questionnaires mailed to companies of fastener industry in Taiwan. A total number of 310 questionnaires were distributed in October 2014. After excluding non-usable data, the final sample size of this study was 141. Due to the small sample size, we used PLS rather than AMOS to test the hypotheses. Of the 141 sample companies, 56.7% has employees ranging from 51 to 100, 60% of the companies has capital of US$ 0.4-1.5 million, 81% of companies has been in business for over 26 years, and the major group of questionnaire participants are the staff with over 6 years of working experiences.

This research employs smart PLS to analyze confirmatory factor analysis (CFA) through the exploration of each dimension of the scale. CFA is performed to assess the composite reliability (CR) and the convergent validity of the 141 samples. Reliability is evaluated by the Cronbach's values, and all constructs are above 0.7. Convergent validity of the resulting scales complies with those proposed by Fornell and Larcker (1981), i.e., factor loading are significant and exceed 0.7, and the average variance extracted (AVE) of each variable surpasses 0.5. We compare the values of diagonal correlation (square root of AVE (average variance extracted) of variables) with those of correlation coefficients of variables. The results show the variables have discriminant validity.

Table 1 Correlation analysis

	BED	BEH	BEK	BEN	CLE	FOC	DIF	EFB	EFC	EFD	EFG	EFR	ICC	ICH	ICS	ICV
BED	0.958															
BEH	0.538	0.925														
BEK	0.796	0.741	0.937													
BEN	0.415	0.150	0.249	0.853												
CLE	0.258	0.113	0.346	0.214	0.870											
FOC	0.473	0.027	0.311	0.603	0.290	0.870										
DIF	0.310	0.207	0.319	0.070	0.110	0.004	0.933									
EFB	0.402	0.252	0.360	0.368	0.024	0.273	0.110	0.945								
EFC	0.278	0.151	0.471	0.269	0.446	0.211	0.159	0.137	0.916							
EFD	0.271	0.332	0.265	0.013	0.154	0.277	0.368	0.340	0.165	0.927						
EFG	0.328	0.090	0.220	0.394	0.141	0.264	0.302	0.659	0.262	0.459	0.973					
EFR	0.698	0.410	0.664	0.163	0.174	0.312	0.161	0.324	0.393	0.143	0.350	0.903				
ICC	0.131	0.152	0.067	0.098	0.035	0.073	0.382	0.209	0.041	0.601	0.511	0.039	0.936			
ICH	0.078	0.107	0.165	0.026	0.007	0.032	0.391	0.092	0.364	0.060	0.389	0.166	0.034	0.939		
ICS	0.071	0.058	0.083	0.037	0.113	0.150	0.462	0.285	0.012	0.180	0.046	0.011	0.132	0.148	0.892	
ICV	0.489	0.545	0.633	0.205	0.244	0.016	0.158	0.488	0.418	0.317	0.363	0.368	0.082	0.291	0.308	0.958

RESULTS

From the PLS results, only one of the five the hypotheses (H3) is not supported (see Figure 1), and this suggests that industrial clustering alone does not constitute business strategy of companies. Only when there is some kind of roles setting after collaboration and information/risk sharing activities among companies in the cluster, such as those of a business ecosystem, can business strategy be affected.

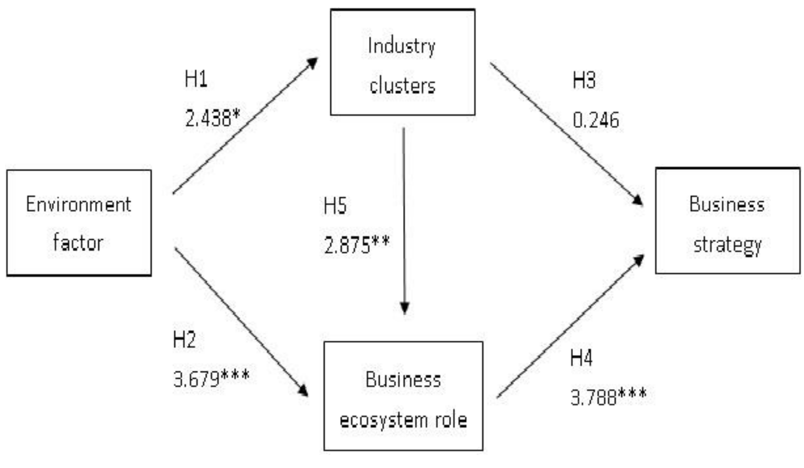

Figure 1 The conceptual model and hypotheses

CONCLUSIONS

Little research has endeavored to distinguish industrial clustering from business ecosystem and examine their impacts on business strategy. This study conducted an empirical study to explore the relationship among clustering, business ecosystem and business strategy and the findings suggest that building or participating at the business ecosystem to form business roles affect how businesses operate.

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FLOW POOLING AS LATERAL COLLABORATION

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ABSTRACT
The purpose of this paper is to analyse the Multi User Concept (MUC) approach, a combination of vertical and horizontal collaboration (lateral collaboration) across different actors in a supply chain. To analyse this concept a quantitative case study using modelling and simulation was made based on actual data from several companies in an automotive supply chain. On a supply chain level, the model shows significant advantages for the MUC approach in terms of cost and service levels. However for some of the actors, there is only very limited individual improvement. Hence they have no incentive to join with the other companies, meaning that the feasibility of the cooperation is placed in danger.

INTRODUCTION
Collaboration in freight distribution is regarded as a very effective and proven method to decrease distribution cost and environmental impact (Cruijssen et al., 2007b, Mason et al., 2007, Frisk et al., 2010, Hingley et al., 2011). Research points to potential savings in distribution ranging from 5 to 30% (Cruijssen et al., 2007a, Mason et al., 2007), motivating a large interest in horizontal collaboration from both industry and academia. In the industry, two projects in particular have gained a large amount of attention: "Starfish" (Palmer and McKinnon, 2011) and "CO3" (CO3 Project, 2013). Both projects points to large cost savings in the range 10-20%. The British project Starfish collected data from 27 companies in the UK retail industry (Palmer and McKinnon, 2011), showing a large potential of reducing costs through both co-loading, back-hauling and joint warehousing. The European Commission-funded project "CO3" was a large-scale initiative, aimed at stimulating horizontal collaboration among shippers (CO3 Project, 2013) by promoting success stories and provide tools such as legal frameworks for collaboration.

A majority of previous research has addressed collaboration in transportation, mainly long-haul or joint distribution. The literature display some success stories in the area, yet hardly any literature on failed horizontal cooperation in logistics has been found (Cruijssen et al., 2007b). It is not easy to successfully implement and maintain a horizontal cooperation in logistics (Schmoltzi and Wallenburg, 2011) and more knowledge in the area is desirable, e.g. how to deal with soft values as trust, relationship and conflict issues and if there is a need of an independent trustee.

This paper aims at making an incremental contribution (Corley and Gioia, 2011) to the literature on horizontal collaboration, by a case study on the Multi-User Concept (MUC). In the MUC, the Logistics Service Providers (LSP) take a more prominent role of pooling logistics flows across different suppliers which are positioned on the same supply chain echelon, but supply different components to their customers. In the case which provides the data for our analysis, we discuss 1st and 2nd tier suppliers of the automotive industry. Within the context of the manufacturing industry, we address the combination of both, vertical and horizontal collaboration, referred to as *lateral collaboration*.

As our primary research question we ask: Does flow pooling, based on a multi user concept of logistics service providers (LSP-MUC) provide positive effects on the supply chain performance? As a secondary research question that follows logically from the case of achieving a positive answer for the primary question, we also have to ask, why the concept is not used more in practice. To narrow down this rather broad question, we focus here on the performance criteria with regards to the cooperation idea within the supply chain idea and ask, if supply chain performance for the LSP-MUC concept is in line with the resulting performance effects for the single actors?

The approach pursued to provide answers on the research questions is based on a model of a multi-stage supply chain that consists of three different suppliers within the automotive industry and a logistics service provider as operator of a multi-user consolidation center. As data input for running the simulation, we used real information about logistics flows from three existing suppliers in the automotive industry that had been gained by a deeper analysis of these companies. The results discussed below were produced by first simulating the existing situation of separated logistics flows without any cooperation and comparing, in a next step, to a modeled situation in which the named actors cooperate by pooling their logistics flows in a multi-user concept. This approach has the advantage of providing rather realistic figures on the cost effects for the supply chain, and as well a realistic set of specific performance indicators for service quality. These figures can be separated into indicators for the single actors in the supply chain, and as well for the supply chain as a whole.

With our approach, we are able to address basic questions on the potential effects of lateral cooperation in supply chains and provide, based actual figures, some additional conclusions on the potential restrictions.

The LSP-MUC - A concept baed on Pooling and Cooperation

The idea of MUC is to apply supply chain thinking on physical distribution. MUC does not address single transport relationships in a dyadic view but take a holistic approach to goods flows. The concept elaborates upon existing ideas, but adds very specific aspects of pooling flows on different stages of the supply chain and thus issues of vertical and as well horizontal cooperation of different actors into one concept.

The basic idea of the concept that we call LSP-MUC is illustrated in Figure 1. The left side of the figure shows a hypothetical supply chain without the concept. The arrows describe the network relationships with respect to the movement of physical objects. In the network without MUC, each 2nd tier supplier delivers individually to its customers on the 1st tier level. And similar relationships exist between the 1st tiers and the OEMs. There might be also some deliveries from 2nd tier directly to the OEMs (omitted in the figure). The LSP-MUC sets the focus in the network on the physical flows of goods. Its idea is illustrated on the right side of the figure 1. In this network, an additional node, the rhombic drawn multi-user center is added. Such multi-user centers are modular warehouses that bundle the different goods flows of different supply chain stages.

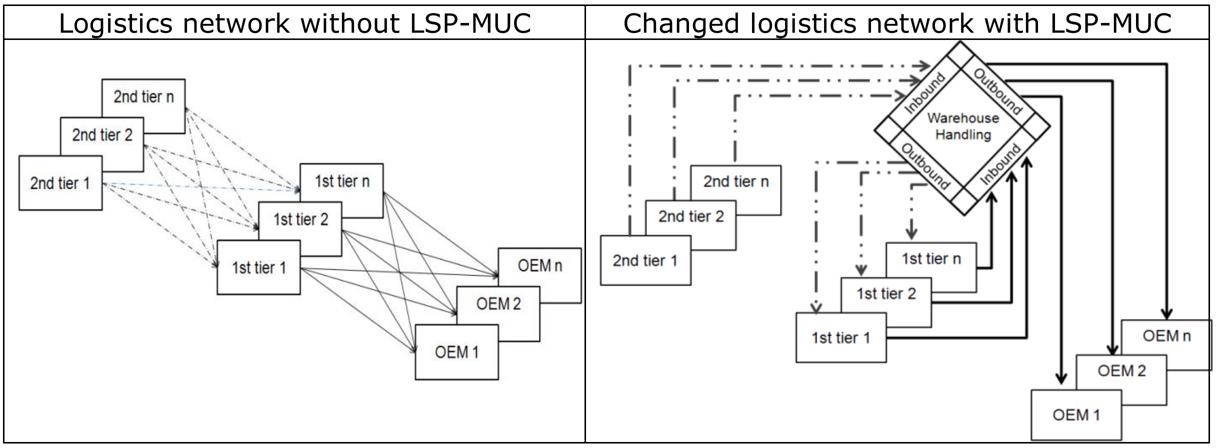

Figure 1: Logistics network without and with LDL-MUC

It is one characteristic property of the MUC that customers of at least two different supply chain stages, as in our example 1st tier and 2nd tier, share the MUC services. According to the modular approach new actors may be added to the concept step by step or are also excluded when necessary. In the illustration of our case study, the MUC is applied for – seen from the view of the MUC – bundling the inbound flows from 2nd tier suppliers into outbound flows to their customers, the 1st tiers (dotted lines). It is also applied to bundle the inbound flows from the 1st tier suppliers to outbound flows to the 1st tier customers, the OEMs (solid lines). Inbound and as well as outbound flows of the involved actors are thus handled in an integrated and cooperative concept. Besides the users, logistics service providers have a crucial part in the concept. The warehouse and the operations of the service are most typically provided by an independent logistics service provider, responsible for the inventory and the control of good flows.

MUC originates from the automative industry. One major difference of MUC, compared to existing concepts (e.g. crossdocking, joint distribution etc.), is the systematic control and design of different good flows across different stages and players. The existing systems typically just bundle either inbound flows or outbound flows. The MUC however tries, by a two stage view, to systematically create more options for pooling transportation needs and options, and for that purpose also integrates the transportation function with the stock keeping function. Stock keeping is however not added, but shifted from the suppliers to the logistics service provider. This planned and systematic pooling and intended overlapping causes intended redundancy in the systems and consequently promises economies of scale as well as economies of massed reserves or economies of flows (Ross, 1996). The other major issue refers to the cooperative character of the multi user concept. The classical cross docking or hub and spoke solutions are typically organized by one player within its institutional boundaries. Even when the activities are based on cooperation, as is for example the case in some transport alliances that share a joint transportation network structure, the bundling happens within one standard system that fulfills the same standard function for all involved actors. In logistics centers that provide similar value added services, the combinations of customers and in consequence potential synergies happen more by chance then as a result of a systematic pooling. Usually for the sake of avoiding complexity, the processes of different clients are handled separately from each other. In the MUC however, different independent actors of different stages of the supply chain are integrated systematically into a new integrated overall system that is additionally operated by an independent logistics service provider.

THE DATA, THE HEURISTICS AND SCENARIOS

To accomplish the intended comparison between the situation "as is" and the situation that would be achievable when installing a MUC, we created a framework for analysis that is based on three major elements.

First, we intended to obtain a problem description and data that reflects an existing real life situation as close as possible. We gathered actual shipment data on the inbound (from 2nd tier suppliers) and outbound (to the OEM) flows of three existing 1st and 2nd tier supplier in the automotive industry. The collected data provided information on the origin and destination of the shipments and as well as the weight, volume, delivery date and delivery cost of each shipment. In total, for a period of four months, 65 000 data records have been considered. Based on this data, we then modeled the inbound and outbound flows in a way that they reflect the existing cost and performance situation of the inbound and outbound flows as much as possible. After then changing the structure to the new MUC scenario, we were able to simulate the flows for the new structure, and create cost and performance figures that can be compared to the as-is-situation. The MUC location was chosen on the basis of a center of gravity analysis in combination with the real life options of existing warehouse locations of logistics service providers.

To undertake such a scenario modeling as described above, an algorithm was required that allocates, for each of the different scenarios, the existing shipment orders to the different types of available vehicles. With respect to the given situation, we classified this allocation problem as Capacitated Pickup and Delivery Problem with heterogeneous Fleet which is understood as a sub class of Rich Pickup and Delivery Problems with Time Windows, heterogeneous Fleet and multiple Depots. Due to the complexity of our modeling problem with triangular traffic flows and numerous constraints such as service degrees, capacities, heterogeneous fleet, multiple depots, we followed Cordeau et al. (2002) who suggest that only heuristics may provide adequate solutions. The used solution method is characterized as a state-of- the art metaheuristics called Variable Neighborhood Search (Shaw 1997) which is also known with variation as "Adaptive Large Neighborhood Search" (Ropke & Pisinger 2006) and "Ruin and Recreate" Heuristics (Schrimpf et al. 2000).

Based on a road network and a GIS that provides the routed distances and driving times, the heuristics in our framework allocates the existing transport orders to the available vehicles. In our case, three different types of vehicles that have had their home base in the same depot have been available:

- 4-ton (Short distance vehicle): with a maximum service time of nine hours daily, an average stop time of 20 minutes at each customer site, fixed cost of 230 € per day and variable cost depending on the driven distances of 0.38 € per driven kilometer;
- 15-ton-1-Work Shift (Long distance): with a maximum service time of nine hours daily, an average stop time of 35 minutes at each customer site, fixed cost of 360 € per day and variable cost depending on the driven distances of 0.60 € per driven kilometer;
- 15-ton-2-Work Shift (Long distance): with a maximum service time of 18 hours and 40 minutes daily, an average stop time of 35 minutes at each customer site, fixed cost of 590 € per day and variable cost depending on the driven distances of 0.60 € per driven kilometer;

For the allocation process, all restrictions, for instance, vehicle capacity and allowed driving time on a tour must be followed.

RESULTS OF THE SCENARIO ANALYSIS

The resulting figures of the scenario analysis are provided in Table 1. The first main column provides the "as is" situation for each of the single suppliers before the MUC has been established. The next main column shows the numbers for the total supply chain both as total figures for the "as is" situation and for the modeled MUC scenario. The last main column shows the changes in percentages.

Row			Supplier data As Is Situation			Total scenarios		Change due to MUC	
Row			Supplier 1	Supplier 2	Supplier 3	As Is Total	MUC Total	Increase	Decrease
A	Minimum number of Ramp operations		2	2	2	2	4	100.00%	
	Shipment analysis								
B	Number of Shipments	Total	83	360	250	693	1386	100.00%	
		Short distance vehicle	51	211	133	395	1156	192.66%	
		Long distance vehicle	32	149	117	298	230		-22.82%
C	Total Tonnages (kg)	Total	11'922.00	66'806.00	81'912.00	160'640.00	321'281.00	100.00%	
		Short distance vehicle	4'465.00	33'011.00	34'633.00	72'109.00	260'755.00	261.61%	
		Long distance vehicle	7'457.00	33'795.00	47'279.00	88'531.00	60'526.00		-31.63%
D	Average Tonnages per Shipment (kg)	Total	144.00	186.00	328.00	231.80	231.80	0.00%	
		Short distance vehicle	87.55	156.45	260.40	182.55	225.57	23.56%	
		Long distance vehicle	233.04	226.82	404.09	297.08	263.16		-11.42%
E	Ton-kilometers (tokm) (Direct distance/shipment * tonnage/shipment)	Total	2'707.29	18'395.34	17'271.40	38'374.03	43'325.54	12.90%	
		Short distance vehicle	615.59	6'298.38	1'433.62	8'347.60	20'866.09	149.97%	
		Long distance vehicle	2'091.70	12'096.96	15'837.78	30'026.44	22'459.46		-25.20%
	Tour Analysis								
F	Driven Distances (km)	Total	6'147.00	14'185.00	6'126.00	26'458.00	24'760.00		-6.42%
		Short distance vehicle	2'740.00	6'860.00	1'888.00	11'488.00	16'997.00	47.95%	
		Long distance vehicle	3'407.00	7'325.00	4'238.00	14'970.00	7'763.00		-48.14%
G	Driven Distances for empty runs (km)	Total	2'005.00	4'449.00	2'289.00	8'743.00	7'656.00		-12.43%
		Short distance vehicle	977.00	2'210.00	1'040.00	4'227.00	5'959.00	40.97%	
		Long distance vehicle	1'028.00	2'239.00	1'249.00	4'516.00	1'697.00		-62.42%
H	Stops (number)	Total	39	88	50	177	193	9.04%	
		Short distance vehicle	24	58	27	109	167	53.21%	
		Long distance vehicle	15	30	23	68	26		-61.76%
J	Number of Tours (number)	Total	11	24	11	46	51	10.87%	
		Short distance vehicle	7	15	6	28	42	50.00%	
		Long distance vehicle	4	9	5	18	9		-50.00%
K	Average Shipments per Tour (number)	Total	7.6	15.0	22.7	15.1	27.2	80.36%	
		Short distance vehicle	7.3	14.1	22.2	14.1	27.5	95.04%	
		Long distance vehicle	8.0	16.6	23.4	16.6	25.6	54.35%	
L	Avgerage Quantity per Tour (kg)	Total	1'083.8	2'783.6	7'446.6	3'492.2	6'299.6	80.39%	
		Short distance vehicle	637.8	2'200.7	5'772.2	2'575.3	6'208.5	141.08%	
		Long distance vehicle	1'864.4	3'755.1	9'455.8	4'918.4	6'725.1	36.73%	
M	Average Distance per Tour (km)	Total	558.5	591.0	556.9	575.2	485.5		-15.59%
		Short distance vehicle	391.4	457.3	314.7	410.3	404.7		-1.36%
		Long distance vehicle	851.8	813.9	847.6	831.7	862.6	3.71%	
N	Average number of Stops per Tour (number)	Total	3.6	3.7	4.6	3.9	3.8		-1.82%
		Short distance vehicle	3.4	3.9	4.5	3.9	4.0	2.31%	
		Long distance vehicle	3.8	3.3	4.6	3.8	2.9		-23.54%
O	Average Distance between Stops (km)	Total	157.3	161.0	122.4	149.4	128.4		-14.03%
		Short distance vehicle	114.2	118.3	69.2	105.4	101.8		-3.43%
		Long distance vehicle	227.1	244.4	184.3	220.0	298.5	35.65%	
	Cost Analysis								
P	Total Cost (€uro)	Total	7'055.40	15'761.80	7'590.24	30'407.44	26'086.66		-14.21%
		Short distance vehicle	2'651.20	6'056.80	2'097.44	10'805.44	16'118.86	49.17%	
		Long distance vehicle	4'404.20	9'705.00	5'492.80	19'602.00	11'967.80		-38.95%
Q	Fixed Cost (€uro)	Total	3'970.00	8'760.00	4'330.00	17'060.00	14'970.00		-12.25%
		Short distance vehicle	1'610.00	3'450.00	1'380.00	6'440.00	9'660.00	50.00%	
		Long distance vehicle	2'360.00	5'310.00	2'950.00	10'620.00	5'310.00		-50.00%
R	Variable Cost (€uro)	Total	3'085.40	7'001.80	3'260.24	13'347.44	13'116.66		-1.73%
		Short distance vehicle	1'041.20	2'606.80	714.44	4'365.44	6'458.86	47.95%	
		Long distance vehicle	2'044.20	4'395.00	2'545.80	8'982.00	6'657.80		-25.88%
S	Average Cost per tour (€uro)	Total	641.40	656.74	690.02	661.03	611.50		-7.49%
		Short distance vehicle	378.74	403.79	349.57	385.91	383.78		-0.55%
		Long distance vehicle	1'101.05	1'078.33	1'098.56	1'089.00	1'107.53	1.70%	
T	Average Cost per km (€uro/km)	Total	1.15	1.11	1.24	1.15	1.05		-8.70%
		Short distance vehicle	0.97	0.88	1.11	0.94	0.95	1.06%	
		Long distance vehicle	1.29	1.32	1.30	1.31	1.28		-2.29%
U	Average Cost per kg (€uro/kg)	Total	0.59	0.24	0.09	0.19	0.08		-57.89%
		Short distance vehicle	0.59	0.18	0.06	0.15	0.06		-60.00%
		Long distance vehicle	0.59	0.29	0.12	0.22	0.16		-27.27%
V	Cost per stop (€uro)	Total	180.91	179.11	151.80	171.79	135.16		-21.32%
		Short distance vehicle	110.47	104.43	77.68	99.13	96.52		-2.63%
		Long distance vehicle	293.61	323.50	238.82	288.26	383.38	33.00%	

Table 1: Results - MUC

The structural change of implementing a MUC is reflected by the indicators that describe the modelled supply chain. The minimum number of necessary ramp handling operations (row A) and the number of shipments (row B) double due to the now broken transport and the additional handling in the MUC. This also affects the theoretical transport performance, measured in tokm, which increases from 38’374 to 43’325 (row E) by 12.9 %. This figure tokm describes the theoretical transport performance of the scenarios as a combination of weight and distance. For each shipment, the theoretical determined distance from its origin to its destination is multiplied with the weight of the shipment. The single results are summarized to the total figure given in the table. The total weight (row C) of all shipments remains unchanged by implementing the MUC. However the number of shipments is doubled while at the same time the single shipment’s distances are split into one segment from original origin to the MUC and one segment from the MUC to the original destination. As the MUC is usually not located on the direct link between origin and destination, detours are required and the distances for the single shipments, as sum of both segments, lengthen. In total, the theoretical transport performance thus increases by 12.9 % (row E). To be at least as efficient as in the as-is situation, this new figure must be generated by the MUC system without generating extra cost. The average tonnage per shipment remains unchanged by the structural change. The noticeable shift between local and long distance transport vehicles however, indicates changes in the scheduling of tours and the resulting effects on the overall system.

When comparing the global results for the as Is situation with the new MUC situation, a number of significant changes may be observed. Despite the changed structure and the doubling of the transport segments, the number of required tours and the number of total stops do not increase by 100 %. The tours (row J) per day increase only by 10.9 % from 46 to 51. The stops (row H) increase only by 9 % from 177 to 193. This is a result of significant bundling effects that are realized when the different flows of the different suppliers are pooled by the MUC. Although the stops per tour are almost unchanged (row N) the average shipments per tour (row K) of 80.4% and the load in weight per truck (row L) of 80.4 % increase significantly. That means that each stop gets more shipments and more weight at a time, and it additionally illustrates the bundling potential. In total, as a result of the significant bundling effects, the total number of driven kilometers (by 6.4 % from 26’458 to 24’760; row G) and as well the number of empty runs (by 12.4 % from 8’743 to 7’656) are remarkably reduced.

CONCLUDING DISCUSSION

Regarding costs, the total transportation cost (rows P, Q, R) per day decrease due to the bundling effects by 14.21 % from 30.407,44 € to 26.086,66 € per day. The average costs for a short distance tour (row S) lie with € 383.8, slightly lower in the MUC scenario. The long distance transport costs increase slightly to € 1’107.5 per tour. But due to the high bundling effect, the costs fall for both relative to the kg as well as relative to each km (rows S, T). Because of the shift from long distance vehicles to short distances, we see an increase in the total costs for short distance traffic (row P) from € 10,805 to € 16,119. However, the total costs for long distance traffic are reduced from € 19,602 to € 9,968. Thus, the savings more than offset the cost increase in short distance traffic.

While the bundling effects and the changes in cost are directly visible by the numbers, the changes in the potential flexibility of the system require an additionally more qualitative discussion. For this, the shift from long distance to short distance vehicles and the related changes in the figures provide crucial information regarding the range and the mobility of the systems. In the new setup, the long distance vehicles transport significantly more load with fewer stops on each tour and in total significantly less tours. This means, there is a concentration that results in consequence in better load factors and better stop factors. In the short distance however, there is a significant increase in the total number of tours. But also for the short distance, each tour is better utilized than before. In particular, this steep increase in utilization from 2.5 to 6.3 is significant and works for the given capacity of 4 tons per vehicle only because of the better combinations of loading and unloading operations along the tour. At an increase in the load weights by a factor of 2.4, the average stop number increases only slightly. Thus, the number of unloaded shipments per stop has also increased significantly. This is also a way of saying that the new structure increases the chances of allocating shipments in a targeted and timely manner. The reason for the bundling is the superposition of the different transport streams of the individual actors. In other words, systematically higher redundancy is created.
Overall, this redundancy generates synergies and compensatory effects in many ways and therefore a considerably greater range of service provision than in a system without such a hub. The MUC allows for a better compensation for volume fluctuations in space and personnel needs across the partners involved. This also affects the mobility of the system. Due to the shift to short distance vehicles, which are also better utilized, a higher frequency

of available tours for the single shipments is to be expected. While in the old system, shipments may have to wait for other shipments to achieve a minimum utilization for a tour. The new system allows for more alternative and thus faster combinations. In times of peak demand, the flows may also be better balanced without additional build resources, according to economies of massed reserves (Mulligan 1983), that follow from the higher number of potential load, tour, shipment combinations.
Overall the cost savings due to the bundling appear so significant, that also alternative, less efficient transport processes - which are however on higher service levels - are possible, still without reaching the cost level of the as is situation. With respect to uniformity, the MUC system provides at least as good service levels with clearly less cost – with respect to transport volume and transport time. However, it has to be kept in mind, that the handling process itself is changed when a MUC is implemented. The broken transport requires at least two additional transshipment operations. That may impact quality with respect to damages of the transported goods. In the given case of the automotive industry, the handling is less critical. In other industries, for example the furniture industry, additional handling operations are typical sources for high quality risks.

Furthermore the costs for the operation of the MUC are not yet included in the cost calculation. On the one hand, there are additional costs to expect as additional operations and additional assets are required. On the other, these costs are now variable as the MUC concept is based on the outsourcing idea to a logistics service provider (e.g. Aertsen 1993; Murphy and Poist 1998, 2000, Skjøtt-Larsen 2000, Bolumole et al. 2007, Marasco 2008). Additionally, the suppliers may shift their inventory into the MUC by shuttling their products right after production. Some of the additional cost for the MUC are thus compensated by fixed cost reductions for assets and stuff at the supplier’s sites.

Comparing the new MUC situation with the as is situation of the single actors, it seems evident that the smaller partners benefit most from the cooperation, while the big ones do not gain too much in terms of benefits. For supplier 1 for instance, the cost per kg (row U) decreases from 59 cent to only 8 cent in the MUC scenario. However for supplier 3, the cost decreases from just 9 cent to 8 cent. When supplier 3 only gains very limited benefits – though from the total supply chain view they are significant – why should they enter into the cooperation? Even under the assumption that the suppliers are able to shift their total stock to the MUC and that there would be no additional cost for the operation of the MUC, there are transaction costs to expect, e.g., quality control, administrative costs and in addition LSP margins.

The next resulting questions refer then to the incentives that result from the cost sharing agree-ments and their validity for different volumes. For instance, there might be different behavior, when the cost sharing mechanisms are fixed for a time period or when they react on different volumes. Fixed prices for shipments for instance might create incentives to bypass the coopera-tion and ship efficient loads directly; thus factually destroying potential synergies. Such issues are typical for Hub and Spoke constructs. In the cooperation of logistics service providers, the single actors frequently optimize locally, and are thus only willing to ship the “bad” loads and excess loads to via the Hub. Other related issues are the typical soft issues of any cooperation such as risk of dependence and lock in, lack of trust and so on. In other words, there are numerous soft issues to address when establishing such a cooperative concept. However, our view in the discussed MUC case is limited to the transportation flows of the different actors in the chain. Compared to the cost of production and the related effects with respect to more flexibility and agility in production, transportation appears usually just secondary. So, other major benefits should be sought on the flexibility and agility that transportation may provide for the value adding activities; especially for the sourcing actors, in the supply chain. An integrated view on cost effects that integrate the production view of that actor in the sense of a total cost view would thus be of major interest. Additional works could address this issue and try to also include cost and flexibility effects beyond the transportation flows.

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Section 4: Environmental sustainability and green logistics

USING FUZZY DEA TO SELECT GREEN SUPPLIERS CONSIDERING CARBON FOOTPRINTS

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ABSTRACT

This paper adopts a FDEA approach to select suppliers according to their greenness. Production costs, lead time, and supply chain carbon footprints were used as the input criteria, and quality and demand quantity were used as the output criteria. The results show that suppliers with low carbon footprints exhibited poor efficiency, which may be attributed to the additional effort required to select raw materials. Suppliers must consider the balance between carbon footprint reduction and costs, and buyers must consider environmental criteria when selecting green suppliers.

***Keywords*:** Green supply chain, Carbon footprints, Fuzzy DEA.

1. Introduction

Recently, scientists have reported a gradual decline in the Arctic ice fields and dramatic changes in global temperatures caused by greenhouse effects. Countries worldwide have experienced constant flooding and droughts, such as the severe flooding caused by continuous rainstorms in Southern Thailand and the severe droughts throughout the United States. These natural disasters not only cause serious losses for the agricultural and animal husbandry industries, which ultimately increase food prices, but also gravely affect and disrupt global industry supply chains. Thus, such disasters pose tremendous threats to human safety and have a ripple effect on the global economy.

Carbon footprint reduction has become a leading method for global supply chains to mitigate their impacts on the environment and climate change. Contrary to traditional supply chain selections that focus on cost, quality, and price, green supply chain selections consider additional factors, such as environmental pollution and protection, and carbon emissions. With rising global environmental awareness, supply chains that do not follow environmental protection trends and reduce their carbon footprint tend to be eliminated. In addition to adapting to the technology of green supply chains and developing contingency plans, organizations must also select the best suppliers that meet corporate objectives and mitigate climate change. Therefore, selecting the best suppliers has become a crucial task for organizations.

Noci (1997) introduced a green retailer ranking framework to assess the environmental performance of suppliers. The primary assessment criteria included green ability, green image, and the costs and environmental efficiency of the overall product lifecycle. Amindoust (2012) found that the assessment criteria most frequently adopted were quality, price/cost, and delivery for the economic dimension, and environmental management systems and environmental ability for the environmental dimension.

This study takes into consideration a supplier's carbon footprint as an evaluation criterion to develop a green supplier selection model. The Data Envelopment Analysis (DEA) method is utilized by integrating the Fuzzy theory to address the bias caused by inaccurate criteria. The rest of this paper is organized as follows. Section 2 presents the development of the Fuzzy DEA (FDEA) model. Section 3 illustrates a numerical example to demonstrate the applicability of the proposed model. Section 4 concludes the research.

2. Model Development

This study used the supply chain performance assessment model developed by Liang et al. (2006) combined with the FDEA method proposed by Kao and Liu (2000) to produce a FDEA model that considers the supply chain carbon footprint. The fuzzy ranking method was used to select the most suitable suppliers.

2.1. Selecting Input and Output Criteria

Quantifiable attributes were used as the supplier selection criteria in this study. Amindoust (2012) investigated the results reported in sustainable supplier selection literature, and found that the assessment criteria most commonly used were quality and price/cost. Therefore, this study used quality, production cost, and carbon footprint as the supplier selection assessment criteria. Concerning production cost, the total costs invested by the production unit were used as the assessment criteria. Carbon footprint was selected as the key assessment criterion because it directly reflects the environmental impact an organization has on the environment.

2.2. Developing a fuzzy DEA model

This study referred to the model used by Liang et al. (2006) to measure supply chain efficiency (as shown in Fig. 1) and simultaneously considered the supply chains of buyers and sellers. C_A represents the carbon footprint input of Seller A, X_A represents the other outputs of Seller A, and Y_A represents the output of Seller A and the input of Buyer B. Conversely, X_B represents the input of Buyer B, and Y_B represents the output of Buyer B.

This model uses cooperative and non-cooperative concepts to assess the efficiency of a supply chain and its members. The non-cooperative concept was developed based on the structural concept of leader-follower and requires a "seller leads and buyer follows" or "buyer leads and seller follows" framework. The concept of the non-cooperative model features one party acting as the leader and controlling the strategies of the other party. The leader also determines the optimal strategy. Conversely, in a cooperative model, the buyer and the seller have the same right to control the entire supply chain.

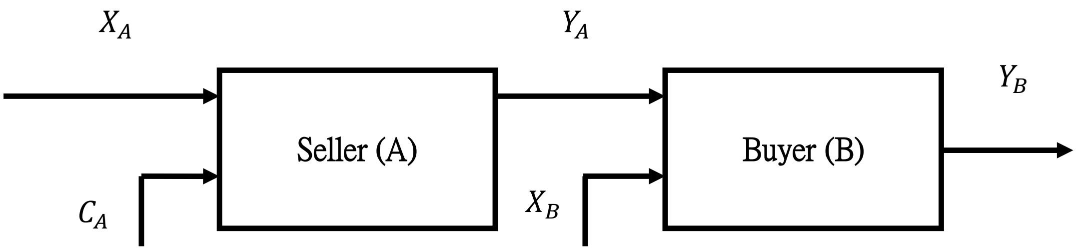

Fig. 1. The input-output process for the buyer-seller supply chain

The decision variables for the mathematical programming model that were used to calculate the supply chain carbon footprint, input-output parameters, and input-output symbols are defined as follows:

(1) Decision variables

V_A^T : Weight of seller inputs
V_B^T : Weight of buyer inputs
U_A^T : Weight of seller outputs
U_B^T : Weight of buyer outputs
U^T : Weight of buyer outputs in a non-cooperative model where the buyer leads
V^T : Weight of seller outputs in a non-cooperative model where the buyer leads
Z_A^T : Weight of seller outputs in a cooperative model
V_C^T: Weight of seller inputs that generate a carbon footprint
W_C^T: Weight of buyer inputs that generate a carbon footprint
E_{AA} : Seller efficiency in an environment where the seller leads
E_{AB} : Buyer efficiency in an environment where the seller leads
E_{BA} : Seller efficiency in an environment where the buyer leads
E_{BB} : Buyer efficiency in an environment where the buyer leads
V_P: Average seller efficiency in a cooperative environment

(2) Input and output criterion

C_{Aj}: Carbon footprint generated by seller j
C_{Bj}: Carbon footprint generated by the buyer from using seller j
X_{Aj}: Seller j's production inputs
X_{Bj}: Buyer input from using seller j
Y_{Aj}: Seller j's production outputs
Y_{Bj}: Buyer output from using seller j

(3) Parameters

$d : 0 \le d < \frac{1}{U_A^T Y_{AO}} = \frac{1}{E_{AA}^*}$

$g : 0 \le g \le \frac{1}{E_{AA}^*}$

$$k:\ 0 \le k < \frac{1}{E_{BA}^{*}}$$

Descriptions of the integrated FDEA models are provided below.

(1) Non-cooperative model where the seller leads: Seller efficiency

$$\begin{aligned}
&Max \quad \tilde{E}_{AA} = U_A^T Y_{A0} && (7)\\
&s.t.\ V_A^T X_{Aj} + V_C^T \tilde{C}_{Aj} - U_A^T Y_{Aj} \ge 0 \quad j = 1,2,\cdots,n\\
&\quad V_A^T X_{A0} + V_C^T \tilde{C}_{A0} = 1\\
&\quad V_A^T, U_A^T, V_C^T > 0
\end{aligned}$$

(2) Non-cooperative model where the seller leads: Buyer efficiency

$$\begin{aligned}
&Max \quad \tilde{E}_{AB} = U_B^T Y_{B0} && (8)\\
&s.t.\ V_B^T X_{Bj} + W_C^T \tilde{C}_{Bj} + d \times U_A^T Y_{Aj} - U_B^T Y_{Bj} \ge 0 \quad j = 1,2,\dots,n\\
&\quad V_B^T X_{B0} + W_C^T \tilde{C}_{Bj} + d \times U_A^T Y_{A0} = 1\\
&\quad \tilde{E}_{AA}^{*} = U_A^T Y_{A0}\\
&\quad V_A^T X_{Aj} + V_C^T \tilde{C}_{Aj} - U_A^T Y_{Aj} \ge 0 \quad j = 1,2,\dots,n\\
&\quad V_A^T X_{A0} + V_C^T \tilde{C}_{A0} = 1\\
&\quad V_A^T, U_A^T, V_B^T, U_B^T, V_C^T, W_C^T, d > 0
\end{aligned}$$

(3) The non-cooperative model where the buyer leads: Buyer efficiency

$$\begin{aligned}
&Max\ \tilde{E}_{BB} = U_B^T Y_{B0} && (9)\\
&\text{s.t.}\ V_B^T X_{Bj} + W_C^T \tilde{C}_{Bj} + g \times V^T Y_{Aj} - U_B^T Y_{Bj} \ge 0 \quad j = 1,2,\dots,n\\
&\quad V_B^T X_{B0} + W_C^T \tilde{C}_{B0} + g \times V^T Y_{A0} = 1\\
&\quad V_B^T, U_B^T, V^T, W_C^T, g > 0
\end{aligned}$$

(4) The non-cooperative model where the buyer leads: Seller efficiency

$$\begin{aligned}
&Max \quad \tilde{E}_{BA} = V^T Y_{A0} && (10)\\
&s.t.\ V_A^T X_{Aj} + V_C^T \tilde{C}_{Aj} - V^T Y_{Aj} \ge 0 \quad j = 1,2,\dots,n\\
&\quad V_A^T X_{A0} + V_C^T \tilde{C}_{A0} = 1\\
&\quad E_{BB}^{*} = U_B^T Y_{B0}\\
&\quad V_B^T X_{Bj} + W_C^T \tilde{C}_{Bj} + g \times V^T Y_{Aj} - U_B^T Y_{Bj} \ge 0 \quad j = 1,2,\dots,n\\
&\quad V_B^T X_{B0} + W_C^T \tilde{C}_{B0} + g \times V^T Y_{A0} = 1\\
&\quad V_B^T, U_B^T, V^T, V_A^T, V_C^T, W_C^T, g > 0
\end{aligned}$$

(5) Cooperative model: Joint efficiency

$$\begin{aligned}
&Max \quad \tilde{V}_P = \tfrac{1}{2}(Z_A^T Y_{A0} + U_B^T Y_{B0}) && (11)\\
&s.t.\ V_A^T X_{Aj} + V_C^T \tilde{C}_{Aj} - Z_A^T Y_{Aj} \ge 0 \quad j = 1,2,\dots,n\\
&\quad V_B^T X_{Bj} + W_C^T \tilde{C}_{Bj} + k \times Z_A^T Y_{Aj} - U_B^T Y_{Bj} \ge 0 \quad j = 1,2,\dots,n\\
&\quad V_A^T X_{A0} + V_C^T \tilde{C}_0 = 1\\
&\quad V_B^T X_{B0} + W_C^T \tilde{C}_{B0} + k \times Z_A^T Y_{A0} = 1\\
&\quad V_A^T, V_B^T, U_B^T, Z_A^T, V_C^T, W_C^T, k > 0
\end{aligned}$$

2.3. Using Fuzzy Ranking Techniques to Select Suppliers

Because the efficiency values calculated using the FDEA may remain fuzzy, these values must be ranked to identify the optimal or alternative suppliers. This study used the index designed by Chen and Klein (1997) to rank the fuzzy numbers.

$$I(\tilde{E}_j) = \sum_{i=0}^{n}\left(\left(E_j\right)_{\alpha i}^{U} - c\right) / \left[\sum_{i=0}^{n}\left(\left(E_j\right)_{\alpha i}^{U} - c\right) - \sum_{i=0}^{n}\left(\left(E_j\right)_{\alpha i}^{L} - d\right)\right], n \to \infty \qquad (13)$$

where $c = \min_{i,j}\left\{\left(E_{ji}\right)_{\alpha i}^{L}\right\}$ and $d = \max_{i,j}\left\{\left(E_{ji}\right)_{\alpha i}^{U}\right\}$. Therefore, the fuzzy efficiency value obtained can be inputted into equation (13) to determine the fuzzy index and rank the efficiencies.

3. Numerical Example

To demonstrate how this FDEA supplier selection model can be applied, a major 3C (computer, communication, and consumer electronics) company in Taiwan, Company A, was selected to verify the model's feasibility. Company A primarily sells consumer electronics products. In 2011, Company A reported a revenue of USD10 billion. The company continues to emphasize environmental protection, sustainable resource use, and ecology-related issues, in addition to vigorously endorsing green design, green procurement, green production, and green marketing. They lead by example and drive the industry to continue promoting sustainable management. Concurrently, they collaborate with suppliers to promote green supply chains, enhance green design, develop green products, and endorse green product recycling and energy-saving product designs. In this study, Company A selected a supplier of LCD monitor display modules by implementing the proposed decision model.

The ISO 14067 carbon footprint assessment standards were used to estimate the carbon footprint of the suppliers. During the product life cycle, one unit of a notebook computer produced by Company A generated 15 kg of CO_2, 8 kg of CH_4, 3 kg of N_2O, 2 kg of HFCs, 1kg of PFCs, and 1 kg of SF_6, produced a CO_2 equivalent (CO_2e) of 60,899 kg.

Due to varying product demands, Company A produced three notebook computer series with varying specifications, of which the largest differences were notebook size and monitor performance. Assembly of the LCD panels of varying specifications incurred varying lead times, carbon footprints, and production quantities. For sellers, panel production also incurred varying production costs, carbon footprints, and quality. The inputs and outputs for buyers and sellers regarding the various notebook computer series are shown in Tables 1, 2, and 3.

Table 1. The inputs and outputs related to the production of Product Series A

	Seller input	Seller output	Buyer input	Buyer output

	Production cost (USD)	Carbon footprint (kg CO_2e)			Yield (%)	Lead time (weeks)	Carbon footprint (kg CO_2e)			Production Quantity
1	63	221	346	450	86	4.2	35	42	58	8000
2	57	286	413	631	78	3.8	38	49	66	8000
3	61	243	405	663	92	3.9	41	53	63	8000
4	59	224	394	515	82	3.6	43	62	75	8000

Table 2. The inputs and outputs related to the production of Product Series B

	Seller input				Seller output	Buyer input				Buyer output
	Production cost	Carbon footprint (kg CO_2e)			Yield (%)	Lead time (weeks)	Carbon footprint (kg CO_2e)			Production Quantity
1	33	289	356	443	82	3.5	43	56	65	12000
2	37	246	385	452	92	4.0	28	47	52	12000
3	40	197	286	394	85	3.8	35	53	61	12000
4	44	158	217	338	90	3.6	38	41	56	12000

Table 3. The inputs and outputs related to the production of Product Series C

	Seller input				Seller output	Buyer input				Buyer output
	Production cost	Carbon footprint (kg CO_2e)			Yield (%)	Lead time (weeks)	Carbon footprint (kg CO_2e)			Production Quantity
1	42	257	339	398	93	3.0	31	39	48	15000
2	39	224	288	335	88	2.9	34	45	51	15000
3	39	172	225	296	85	2.8	27	32	46	15000
4	41	183	215	288	91	2.8	24	30	41	15000

The proposed FDEA model was implemented to determine a suitable supplier of the LCD monitor display modules. The results are presented in Table 4, 5, and 6.

For Product Series A, Supplier 3 exhibits the best efficiency in a seller-led non-cooperative environment. Supplier 4 demonstrates the best efficiency in a buyer-led non-cooperative environment and Supplier 3 shows the best efficiency in a cooperative environment. Concerning Product B, Supplier 1 shows optimum efficiency for both the seller-led and buyer-led non-cooperative environments, followed by Supplier 2. Supplier 1 also exhibits optimum efficiency in a cooperative environment. Regarding Product C, Supplier 4 exhibits optimum efficiency for both the seller-led and buyer-led non-cooperative environments, followed by Supplier 3. Supplier 4 demonstrates optimum efficiency in a cooperative environment.

From this information, the most suitable supplier can be selected. The second most efficient supplier can be selected as an alternative to minimize the risk of supply shortages.

Table 4. Fuzzy efficiency values for Product Series A

Supplier	Seller-led Scenario	Rank	Buyer-led Scenario	Rank	Cooperative Scenario	Rank
1	0.5550351	4	0.6891192	4	0.5550350	4
2	0.6387158	3	0.7687421	2	0.6491178	3
3	0.7327959	1	0.7120873	3	0.7350671	1
4	0.6924375	2	0.8038066	1	0.6936324	2

Table 5. Fuzzy efficiency values for Product Series B

Supplier	Seller-led Scenario	Rank	Buyer-led Scenario	Rank	Cooperative Scenario	Rank
1	0.9892085	1	0.9906240	1	0.9906263	1
2	0.7105178	2	0.7105180	2	0.7122995	2
3	0.5727183	4	0.5728886	4	0.5734343	4
4	0.6202664	3	0.6202666	3	0.6202666	3

Table 6. Fuzzy efficiency values for Product Series C

Supplier	Seller-led Scenario	Rank	Buyer-led Scenario	Rank	Cooperative Scenario	Rank
1	0.3735674	4	0.3735674	4	0.3829401	4
2	0.6655603	3	0.6655603	3	0.6759069	3
3	0.7281456	2	0.7281456	2	0.7323346	2
4	0.8904159	1	0.8904159	1	0.8904148	1

These empirical results show that the FDEA model developed in this study can effectively calculate and rank the efficiency of suppliers. The results also indicate that for Product Series A and B, the LCD monitor display module suppliers that generated a low carbon footprint exhibited poor efficiency. This may be attributed to how suppliers must invest more to improve the production process or select environmentally friendly materials when pursuing low carbon footprints in production. Conversely, suppliers that do not consider environmental protection can avoid these additional investments, and focus solely on manufacturing products.

Concerning the production of the three product series, the empirical results show that the four LCD monitor display module suppliers exhibited different advantages. For example, when producing Product Series A, Supplier 4 should be selected in a buyer-led non-cooperative environment, whereas Supplier 3 should be selected in a seller-led non-cooperative environment. However, in a cooperative environment where the buyer and seller jointly research and develop products, or a long-term partnership exists between the buyer and seller, Supplier 3 should be selected. Selecting Supplier 3 can enhance the efficacy and competitive advantage of the overall supply chain.

4. Conclusions

This study modified the DEA model introduced by Liang et al. (2006) that considers the supply chains of both buyers and sellers to create a FDEA model for supplier selection. Triangular fuzzy numbers were used to indicate carbon footprints, which resolved the issue of uncertainty when quantifying carbon footprints. Concurrently, buyer and seller performances were considered. Seller outputs were adopted as the buyer inputs to calculate the fuzzy efficiencies in cooperative and non-cooperative models to ensure that they closely reflected the buyer-seller relationships in actual supply chains.

Because previous studies have seldom considered using carbon footprints with other assessment criteria to select suppliers, and current supply chains consider the effects that carbon footprints have on the environment, this study examined the use of carbon footprints with other major assessment criteria. Only when these assessments are used in combination can the successful operation of green supply chains be realized.

The empirical test results and the practical findings that the cooperative concept is superior to the non-cooperative concept are similar to those reported by Liang et al. (2006) and the majority of academic studies. This confirms that the cooperative model can improve the operational performance of supply chains.

References (available from the authors on request)

SUPPLY FOR REMANUFACTURING: CONTRADICTIONS BETWEEN THEORY AND PRACTISE

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Abstract

Purpose of this paper:

Increasing demand, the volatility on commodity markets and the scarcity of resources challenge resource supply for industries. Therefore, remanufacturing becomes an alternative resource for spare parts. Despite the market potential for remanufacturing and existing tools and knowledge on reverse logistics, automotive remanufacturing suffers from supply issues. Identifying reasons for this issue encouraged for this work.

The investigation of issues of core supply for reman led to a procurement practice at an independent remanufacturer that is somehow contradicting literature, thus motivating this research. The objective of this paper is to elucidate the identified discrepancies and discuss their implications for a further research agenda.

Design/methodology/approach:

A pilot case in the remanufacturing industry showed somehow contradicting assumptions and suggestions between literature and practise. This case of an independent German remanufacturer induced a closer examination, with a literature review and an interview with the remanufacturer's CEO. Findings will lead towards additional case studies that iteratively support theory building, based on a grounded theory approach. Examples exist for the application of grounded theory in economics and SCM. The approach shall contribute to a better understanding of actual market barriers and to the evaluation of incentives in remanufacturing supplier relations.

Findings:

The case revealed two mayor insights. (1) The supply issue is real and forces the remanufacturer to build up his own production for new components in addition to remanufacturing. (2) The remanufacturer applies the deposit model in a differing way than assumed by literature. Although it is similar, the difference is essential because both the remanufacturer and the wholesaler profit from the changes.

Value:

Based on existing research on remanufacturing supply chains, this paper discusses theoretical solutions and identifies practical issues. The contribution of this paper is a first step towards a more in-depth study on relationships in remanufacturing. The paper provides insights from a case study that supports the theory development process as intended by the chosen approach. Therefore, the paper supports researchers in aligning their research to market practice. Practitioners could gain valuable insights due to increased transparency.

Research limitations/implications:

However, these findings are limited due to the early stage of the research. Still, the practitioner supported some assumptions and explained them in more detail. Further analysis would have to relate the findings to the character and importance of transaction cost, principal agent theory and related trust issues in supplier relationships. Conducting further investigations would contribute to knowledge on how the supply for remanufacturing can be improved and further ensured.

Future research regarding supplier relations in remanufacturing could cover surveys focussing on core prices and incentives. In addition, interrelations with other supply markets such as those for recycling would increase transparency further.

Practical implications:
Regarding the supply strategies and supplier relations, the research identified relevant differences between literature and practice as well as complements. Applied incentives and a different deposit system show how independent organizations establish trust based relationships in order to reduce costs in remanufacturing. Accordingly, industry might consider to revise or to adjust business models for remanufacturing.

INTRODUCTION

Industries are seeking for material supply alternatives in order to address issues of increasing demand (UNEP, 2013) and an increasing awareness for environmental impacts (Bethge *et al.*, 2014). Sustainability is gaining importance, not least because policy intervenes with the objective to reduce the environmental impact of end-of-life (EOL) products (Agrawal, 2012). At the EOL, the reuse of products is preferable from an economic and an environmental perspective due to reused resources (Östlin *et al.*, 2009). One strategy for reuse is remanufacturing (reman) (Thierry *et al.*, 1995). Reman is widely used in different industries because the "as-good-as-new" specification of reman products (APRA Europe, 2014) increases their marketability. The market success of reman products is supported by the anticipation of further increasing demand (APICS, 2014) and the general market potential of the circular economy (Ellen MacArthur Foundation, 2014). However, the reman market is experiencing supply issues of cores (EOL products). Identifying reasons for these supply issues motivates this research, according to Atasu *et al.* (2008) who mention that research regarding closed-loop supply chains should return to industry practise in order to uncover current practical issues instead of theoretically created problems. While formulating a research agenda a case study revealed interesting and somehow contradicting assumptions from literature regarding the use of deposits to foster core returns. The objective of this paper is to elucidate the identified discrepancies and discuss their implications for the further research agenda.

The following section summarizes relevant supply chain (SC) literature covering aspects that influence reverse flows. Thereafter, the problem section addresses supply issues in reman with an analysis of market forces and a reference to new institutional economics. Afterwards, the pilot case uncovers and explains the mentioned contradiction. Subsequently, the discussion of the findings motivates the proposed inductive-deductive research approach integrating elements of grounded-theory, supported by the "disruptive character" of the case study. The paper closes with an outlook on the research agenda.

LITERATURE

Open- and Closed-Loop Supply Chains

Closing the loop from the EOL to reman is a challenging task. Whether open- or closed-loop SCs, not only the core acquisition but also the physical return adds complexity to supply chain management, e.g. in face of supply and demand balancing (Daniel *et al.*, 2000). Literature indicates certain issues to improve the closed-loop business activities, such as the identification of sources of cores (Guide and van Wassenhove, 2008). Östlin *et al.* (2008) investigate operational issues in reverse logistics and claim lead-time an important issue even in deposit based reverse logistics. Remanufacturers use deposits to facilitate the reverse flow of cores. They charge a deposit for a spare part and repay the deposit in exchange for a core. Literature favours the deposits strategy to foster core returns (Östlin *et al.*, 2008). Other instruments to ensure return flows are leasing or renting contracts because of the missing transfer of ownership (Thierry *et al.*, 1995).

Literature on SCs and reman focuses on normative research (Prahinski and Kocabasoglu, 2006; Guide and van Wassenhove, 2008); operative aspects regarding system/network design (Jayaraman *et al.*, 2003) and capacity planning (Georgiadis and Athanasiou, 2013) or ownership issues influencing material flows (Hagelüken, 2007). Further research discusses strategies such as re-make or buy decisions from the OEM perspective (Martin *et al.*, 2010). Other studies so far have mainly focused on the retailer concerned with product returns or the remanufacturer and its process considerations (Jayant *et al.*, 2012). Östlin *et al.* (2008) and Jayant *et al.* (2012) mentioned the relationship dimension in context of reverse SCs. However, literature hardly considers intermediaries, such as brokers and agencies (Prahinski and Kocabasoglu, 2006).

Supplier Relationships and Procurement

When looking at relationships in SCs, literature conceptualizes them by the perspective of relationship marketing (Christopher *et al.*, 2002) or supplier relationships (Sheth and Sharma, 1997). In a SC, companies manage their procurement with strategies related to sales activities, for example order policies and procurement financing. The objective of these strategies is to reduce costs, e.g. of information or negotiation (transaction costs), and to ensure production. The relationship marketing is one approach to reduce those costs and to reduce risks by establishing "collaborative relations" between legally independent business partners. Furthermore, relationship marketing accepts the influence of individuals on business relations (Hougaard and Bjerre, 2002).

For example, in a case study analysis on different industries Östlin *et al.* (2008) identified different types of relationships in reverse logistics for reman, namely ownership-based, service contract, direct-order, deposit-based, credit-based, buy-back and voluntary-based; whereof deposit-based relationships are common in the automotive sector. Furthermore, the potential to maintain a relationship with the transaction partner is essential to ensure return flows of cores (Subramoniam *et al.*, 2010). In procurement relations, incentives are used to influence the transaction partner in order to achieve the own objectives (Biergans, 1984). For reman, such objectives could be pre-emption of cores or better terms of delivery. This procurement marketing complements supplier relations in this context. For the proposed research, supplier relations are relevant in order to identify commonalities and differences between literature and practise and to analyse the reman supply market.

INITIAL PROBLEM

Although markets for reman exist, and market projections are promising, the industry still claims supply issues and a lack of transparency (Weiland, 2012). This section briefly outlines the initial problem for this research in reman SCs focussing on independent remanufacturers (IRs). IRs are preferred due to the assumption that market organisations tend to be more efficient than hierarchy organisations.

Rather complex supply and procurement challenge reman processes (Östlin *et al.*, 2008). In literature, a greater number seems to favour deposits to manage reverse flows in case of automotive reman. Furthermore, research in reman focusses on operational models, with assumptions such as perfect substitution or no cannibalization. Such assumptions are difficult to map properly with the real world (Guide and van Wassenhove, 2008). In addition, for the initial reman of a new component the deposit approach might not provide sufficient cores because the market cannot establish a continuous and sufficient reverse flow of cores. Besides, deposits or core charges might not be economically attractive enough (Subramoniam *et al.*, 2010), because raw material prices could exceed deposits. For this reason (similar to Östlin *et al.*, 2008), different supply strategies might be dominant in reman, depending on the type of organisation or the type of core.

Analysis of the Market Forces

The relationships between suppliers and remanufacturers are most likely different in market than in hierarchy organisations. A better understanding of these differences could help to support reman as part of the circular economy. A brief analysis of the market regarding the IR following Porter's (2008) "five forces" model of competitive rivalry shall help to understand the importance of supplier relations. The section thereafter addresses the organisational differences with a reference to the New Institutional Economics (NIE).

Neither IRs nor OEMs/first tier remanufacturers (OERs) dominate automotive reman in Europe (Weiland, 2012). Both organisational types co-exist with IRs on the one hand and OER organisations such as BOSCH eXchange (Bosch, 2010) on the other hand. However, differences exist on the level of part categories; for example, OERs dominate the reman of starters and alternators with more than 50% market share in Europe while IRs remanufacture the vast majority of brake callipers (Weiland, 2012). If organisations integrate reverse logistics for reman, reasons probably relate to reduced uncertainty and supply risks (Subramoniam *et al.*, 2010); also other reasons could apply (e.g. legislation, competition). An OER already supplying the aftermarket has as well a higher potential to implement a reverse logistics network by which the OER could achieve a better core supply. Hence, an OER has easier access to cores and can use this advantage against IRs entering the market, building up market entry barriers (Ferguson and Toktay, 2006). This shows that the market forces especially of internal rivalry and the threat of entry depend mainly on the type of remanufactured component. This situation similarly applies to potential substitutes, which are either new or used products whereof both compete at different prices levels.

However, substitutes are relevant on the level of suppliers that have a high market power. Since there are no substitutes for cores, and together with the information asymmetry, this increases the bargaining power of suppliers. Furthermore, suppliers have different sales options (e.g. recycling) and the IRs are highly price sensitive because reman profitability depends on the core price. In addition, suppliers do not seem to depend notably on IRs; otherwise, the supply issue might be lower. This results in a high threat for IRs by suppliers. The bargaining power of customers is also noteworthy, though due to the focus of this research and scope of this paper this threat will not be analysed in detail.

Reference to New Institutional Economics

When observing market and hierarchy organisations relationships become relevant because relationships can establish a type of organisation somewhere between markets and hierarchies (Hougaard and Bjerre, 2002, pp. 60ff). New institutional economics (NIE) are assumed to provide a useful set of methods to approach the organisational aspects from an economic perspective (Hobbs, 1996). Within NIE, especially Transaction Costs Economics (TCE) and the Principal Agent (PA) theory (Richter and Furubotn, 2010) are approaches that could explain, for example, whether reman attracts rather IRs (market) or OERs (hierarchy), or why certain components are rather remanufactured by OERs and others by IRs. This observation includes, amongst others, aspects of asset specificity or different risk assessments, such as the handling of uncertainty about the quality of core returns or problems of risk sharing with suppliers. In addition, contractual observations of property rights apply for product returns (Thierry *et al.*, 1995). Since the car owner regularly has the right of property, remanufacturers try to incentivize customers to return the cores by charging a deposit. In addition, social dimensions arise when considering that relations also depend on individuals. One of such dimensions is trust (Beccerra and Gupta, 1999). Hence, the relevance and discussion of the relation between trust and TCE and PA are also present in reverse flows for reman.

PILOT CASE

Based on the findings from literature and the initial problem, an interesting pilot case of a German IR for starters and alternators was conducted. This IR company distributes in particular to the whole of Europe and to Russia and procures cores especially on the German market. The company collaborates with plants in Germany, Hungary and Rumania for the process of remanufacturing. However, other processes are located in Germany such as procurement, handling, distribution, sales, quality management as well as some final assemblies and special customer requirements. This section covers the case description. The further approach regarding the targeted research will be part of the last sections, namely discussion and outlook.

This case uncovers two major insights, amongst others. First, the supply issue is real and forces the remanufacturer to build up own production for new components in addition to reman, in order to meet their customers' demand. Second, the remanufacturer applies the deposit different from what automotive reman literature would assume. Although similar to the deposit-based relationship (Östlin *et al.*, 2008) the difference of this deposit system is essential because it leads to a potential win-win situation without any tied up capital.

Regarding the first central finding, the CEO of the investigated company believes that enough cores are theoretically available on the market but his organisation cannot acquire sufficient cores. From his perspective, different reasons apply: (1) OERs are not re-selling (nor remanufacturing) cores they acquired in return for aftermarket sales, or at least they do not sell them in Europe but elsewhere. (2) OERs even try to buy out the market in order to reduce the resource base for IR. (3) Acquisition prices are too high for profitable reman, i.e. dealers or dismantlers do have cores but do not offer them publicly (e.g. sales lists/catalogues). This situation led to the establishment of own production for new components (third party spare parts), which represent 20% of the company's sales. Further 25% of sales are new components from OEMs, although bought from markets outside the EU due to lower prices. Thus, only 55% of sales are own core remanufacturing, despite the fact that the remanufacturer would prefer to increase this number.

In addition, market volatility could endanger core supply if certain prices were rising, e.g. for copper in case of alternators, but that is not a present threat due to current low market prices. Besides, according to the CEO, the OER activities at the core market focus on reducing the profitability of independent reman but they are not addressing liability or brand issues. Further, the price competitiveness on the core market challenges the core dealing business and already led to a reduction of core dealers, according to the CEO.

Regarding the second central finding, the deposit system is different than suggested by literature. Regularly, the deposit system requires the wholesaler and the customers in the distribution chain to pay a deposit to the next higher level in the chain. That level of the chain pays back this deposit in exchange for a core. According to the CEO, this system has a weak point, namely, when the remanufacturer does not refund cores that do not match the minimum quality conditions for remanufacturing. Furthermore, the remanufacturer stated that this is regular business conduct of OERs. The deposit values bound at the remanufacturer put the wholesalers business model at risk because the wholesaler stores large amounts of components for the aftermarket, hence has according amounts of tied up deposits at the remanufacturer. Figure 1 (a) depicts this classic deposit system. The thicker arrows represent the flow of spare parts or cores while the thinner arrows represent the deposit flow. The grey triangle covers the transactions of cores and deposits between the remanufacturer and the wholesaler.

Due to the bound deposits, the studied remanufacturer designed a deposit system built on a "virtual deposit account", depicted in Figure 1 (b). The grey arrow in the upper triangle illustrates this central difference. This "virtual deposit account" (VDA) follows up on all component sales but without claiming the deposit value. Instead, the remanufacturer agrees upon a return quota with the wholesaler in advance. The quota is regularly about 60-70% of sales and represents the amount of cores that are in a good qualitative condition for reman. Yet, the remanufacturer has to acquire the missing 30-40% of cores on the core market. The remanufacturer intervenes only if the wholesaler does not reach the return quota (e.g. re-negotiations or sales stop). According to the studied remanufacturer, this is hardly necessary because the VDA provides more financial freedom to the wholesalers since remanufacturers who charge the deposit locked financial means of the wholesalers. In other words, the VDA is an incentive for the relationship and at the same time a business model that allows the IR to compete with OERs. Additional incentives by the remanufacturer are bonuses paid for core returns above the negotiated core return quotas.

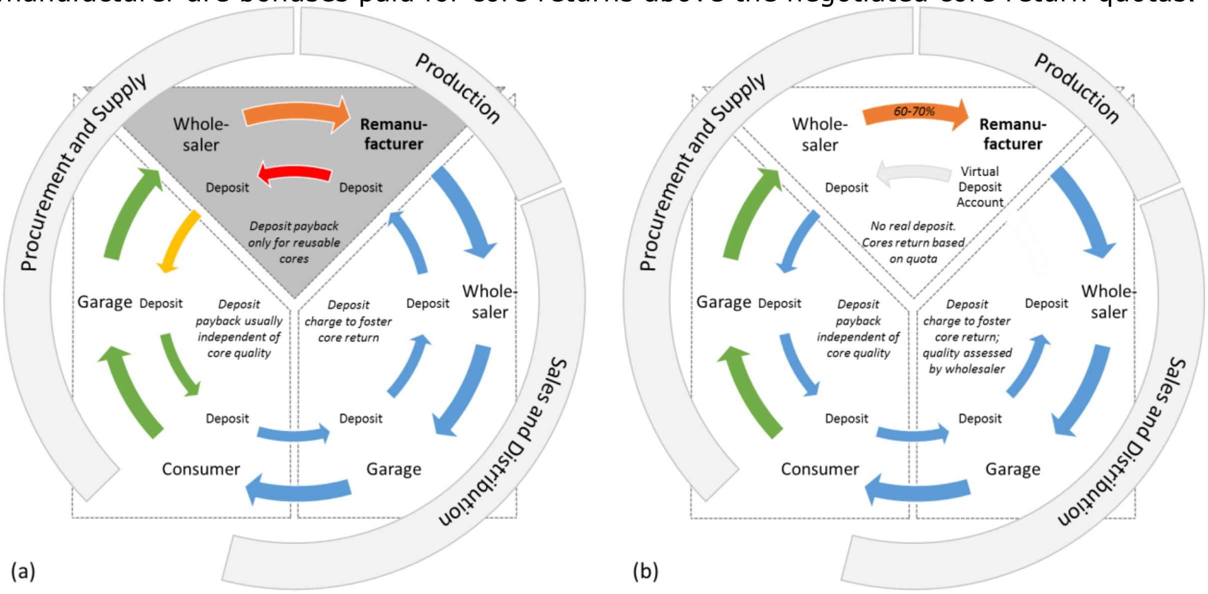

Figure 1: Closed-loop supply chains for remanufacturing:
classic deposit-based system (a) vs. the 'virtual deposit account' (b)

DISCUSSION

The pilot case underlined the existence of issues in supply and procurement. These issues stimulate the production of new products, which is supposed to be rather unsustainable. Furthermore, the procurement activities and incentive programs of the remanufacturer explain the necessity and the potential of relationship management. This is consistent with previous findings (Östlin *et al.*, 2008). In addition, the consolidation of core dealers supports the relevance of relationship management. The remanufacturer acquires around 30-40% of his cores on the market mainly via these core dealers. The fewer core dealers exist, the lower is the competition at this stage of the acquisition and procurement process and the higher is the dependency on the remaining core dealers by IRs.

The deposit approach practised by the studied remanufacturer with his wholesalers uncovers how IRs can gain market share by introducing new or at least adjusted business models. Given the internal rivalry on the reman market, the IRs tries to influence the relationship towards the suppliers through pro-active relationship management in order to improve the supply with cores. This increases the IRs competitiveness on the internal market again. The VDA is a solution different from the classic deposit and even more than the extended credit, as suggested by Östlin *et al.* (2008), because the VDA is trust based. Since the deposit is not charged, the remanufacturer has no tied-up financial means to use against the wholesaler but instead implies a trust based relationship where the VDA incentivises the wholesaler. With a return quota of approx. 60%, this VDA acknowledges that some of the potentially returned cores cannot be remanufactured due to quality issues. According to the remanufacturer, the wholesalers accordingly value the VDA with well-sorted returns in terms of core quality. Hence, the system lowers transaction costs of the remanufacturer in acquisition and sorting of returns. As mentioned before, also the supplier reduces costs e.g. due to lower inventory costs. The CEO further estimates that an aftermarket wholesaler would need two employees to manage deposit accounts. In case of the VDA, the wholesaler could save such costs too. The latter is another incentive for the wholesaler to collaborate with the IR instead of collaborating in a deposit-based system of an OER.

However, such a trust-based system as the VDA might attract "free riders" who try to benefit from it by returning less cores than agreed and instead selling them on the core market. A moral hazard would arise because of the risk mismatch between the remanufacturer and its suppliers. Although theory would assume this problem, it does not seem to threaten this IR to reconsider his business model. In such case, the investigated organisation would cease the relationship. Savings on overall transaction costs probably cover potential loss caused by misuse of the VDA. Though the motivation for complying with VDA seems trust based, it is not yet fully explained how the approach overcomes potential opportunism and moral hazard.

Further, the incentives foster the relationships and show how relations create ties between IRs and wholesalers, for example by bonuses for additional cores compared to the negotiated individual core return quotas. Further, the IR has to maintain relationships not only to the wholesalers but also to core dealers, both are different transaction partners. This increases efforts in relationship management. All these relationship-related activities are targeting the reduction of transaction costs for information, acquisition and quality control (sorting) while enabling for a win-win situation. These activities are procurement marketing related. Thus, selective procurement activities can further strengthen supply for reman.

However, further investigation is necessary to identify and understand those factors that improve supply for reman also in the future. While resources seem to be drawn from the European market and the price competitiveness presumably reduced the number of core dealers, remanufacturers have to enforce their relationship management in order to consolidate core supply. Potential moral hazard raises additional questions and the role of trust is not yet clear in this particular field of reman procurement. Therefore, the initial research question is as follows: what characterizes supplier markets for independent reman procurement and how do remanufacturers apply supplier relationship management? Related to this question are further aspects, for example, whether the price is the only relevant factor for suppliers and which other factors could support supply for reman?

The pilot case was a "disruption" because it contradicted literature in some respects. The case led towards a closer examination leading to the proposed research. An inductive-deductive approach with elements of grounded theory (GT) will be followed in order to close potential knowledge gaps regarding supplier relations of IRs. GT will help to build a macro-image of the study ground potentially challenging the common understanding of reverse logistics and closed-loop SCs in reman literature. Examples exist for the application of GT in the fields of SCM and sustainability management (e.g. Carter *et al.*, 2004; Carter and Dresner, 2001; Crook and Kumar, 1998). This approach shall contribute to a better understanding of actual market barriers, as well as to evaluate the efficiency of incentives in reman supplier relations. GT propagates a "planned but flexible" approach by constantly revising and adjusting previous assumptions (Glaser, 2007). At the end, this approach aims at developing a "middle range theory" with the purpose to unfold practical benefits (Crook and Kumar, 1998). A combination with survey-based research is intended.

CONCLUSION AND OUTLOOK

This paper elaborated on challenges and opportunities of automotive reman with an emphasis on market organisations, i.e. independent remanufacturers (IRs). A literature review and a discussion on current issues in reman led to a pilot case. This case from an IR confirmed supply issues but surfaced some contradictions with literature. Regarding the supply strategies and supplier relations, the research identified relevant differences between literature and practice as well as complements. The virtual deposit and the applied incentives show how independent organisations establish trust based relationships in order to reduce transaction costs and to ensure core supply for their production.

In general, the pilot case with the IR supported the research objective and broadened the perspective on reman business. However, these findings are limited due to the early stage of the research. Moreover, further analysis would have to relate the findings to the character and importance of transaction cost, principal agent theory and related trust issues in

IR supplier relationships. Still, the practitioner supported and explained some aspects and assumptions in more detail. In addition, insights into the industry practise both increase transparency and support the knowledge gain and theory development process as intended by the chosen approach.

Following a grounded theory approach, this pilot case represents a first step for further analysis. Besides an extended literature review, next steps will take into consideration the results from the discussed case in order to develop questions for upcoming case studies that will further clear the vision on reman supply markets and hence support the theory development process. Additional case studies with remanufacturers, ideally with both independent and OEM-related remanufacturers, will support a closer mapping of theoretical and iteratively developed knowledge with industry practise. This research might lead to a revision and/or proof of certain aspects, especially regarding the deposit system. This research aims at developing a framework for procurement marketing in automotive reman in order to foster market driven business in the circular economy.

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CHALLENGES IN HUMANITARIAN LOGISTICS MANAGEMENT: AN EMPIRICAL STUDY ON PRE-POSITIONED WAREHOUSES

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Abstract

Purpose of this paper:

The ultimate goal of humanitarian relief logistics is to deliver the right supplies in the right quantities to the right locations at the right time, so save lives and reduce human suffering within given financial constraints. Pre-positioned warehouses at strategic locations are essential for this purpose to ensure the availability of supplies when required and to facilitate faster responses. However, some NGOs find it risky to operate pre-positioned warehouses because it is both complicated and expensive given the limitations in finance and resources. Indeed, pre-positioned warehouses for humanitarian relief create various types of risks, but they haven't been fully explored yet. This study, therefore, aims to investigate the challenges in humanitarian relief operations relating to pre-positioned warehouses. In specific, this research focuses on the interactions between various risk factors within the humanitarian logistics management in order to understand how those challenges are generated and enhanced.

Design/methodology/approach:

The study adopted multi-phase mixed methods, combining semi-structured interviews and Interpretive Structural Modelling (ISM). Firstly, it explored the main risk factors of pre-positioned humanitarian distribution centres by interviewing with practitioners in the humanitarian aid organisations. 25 Face-to-face and telephone interviews were administered with 25 personnel at the managerial or higher level in the organisations. Secondly, the risk factors found out in the interviews are analysed by ISM, an analytic framework to encapsulate the relationships of specific elements in a complex system. After receiving the opinions of 10 experts on the pairwise relationships among the risks, the stepwise process of ISM generated the interactive structure of these risk factors.

Findings:

The interviews unpacked 17 representative risk factors that have considerable impacts on maintaining pre-positioned warehouses, such as high inventory cost and failure in forecasting. The directed graph from ISM showed that the risks consist of three levels, namely threats to the values of humanitarian logistics operations (Level 1), disturbances in logistics activities (Level 2) and disruptions by external factors (Level 3). Among them, Level 2 risks were enhanced by three closed loops of risk interactions, mainly centred on high transport cost.

Value:

This research empirically identified various risks in operating pre-positioned warehouses for humanitarian logistics and created a structure of risk interactions in order to understand how the challenges are generated and enhanced.

Research limitations/implications (if applicable):

This study confined its scope of research to the risks stemming from operations of pre-positioned warehouses. Future research can expand the research scope to the entire process of humanitarian relief logistics.

Practical implications (if applicable):
The risk profile can provide a checklist for humanitarian logistics practitioners to assess the level of risks in their operations. Given the levels and feedback loops of risk factors, they can also find out which risk factor should be intensively mitigated to reduce the risk level.

INTRODUCTION

The ultimate goal of humanitarian relief logistics is to deliver the right supplies in the right quantities to the right locations at the right time, so save lives and reduce human suffering within given financial constraints (Beamon and Balcik, 2008). Pre-positioned warehouses at strategic locations are essential for this purpose to ensure the availability of supplies when required and to facilitate faster responses (Balcik et al., 2010). It has been suggested that, in the long run, such an approach leads to the reduction of delivery costs by regular replenishment using inexpensive maritime transport (Gatignon et al., 2010). However, some NGOs might find it difficult to operate pre-positioned warehouses by because such approaches are both complicated to organise and operate, and expensive to fund, particularly given the limitations in finance and resources for most NGOs (Balcik and Beamon, 2008). Indeed, pre-positioned warehouses for humanitarian relief create various types of risks, many of which haven't yet been fully explored.

In this respect, this study aims to investigate the challenges in humanitarian relief operations relating to pre-positioned warehouses. In specific, it focuses on the interactions between various risk factors within humanitarian logistics management in order to understand how those challenges are generated and enhanced. For this purpose, this study explores the main risk factors of pre-positioned humanitarian distribution centres by using interviews with practitioners in humanitarian aid organisations. Based on the risk factors identified in the interviews, the interacting relationships between risk factors are mapped with the aid of the directed graph created by Interpretive Structural Modelling (ISM). As a consequence, the results of ISM help to understand the different levels of risk and the root causes of risk amplification in humanitarian relief logistics. Compared with studies on commercial distribution centres, less research has been conducted for humanitarian logistics distribution centres. To this end, this research will provide a comparatively novel and meaningful approach in the context of humanitarian relief logistics.

LITERATURE REVIEW

Humanitarian relief logistics is defined as the process of 'planning, implementing and controlling the efficient, cost-effective flow and storage of goods and materials, as well as related information, from the point of origin to the point of consumption for the purpose of alleviating the suffering of vulnerable people' (Thomas and Kopczak, 2005). Indeed, logistics serves as a bridge between disaster preparedness and response (Thomas, 2003); therefore, humanitarian logistics is crucial to the effectiveness and speed of response for major humanitarian programs.

The comparison between commercial and humanitarian supply chains has been studied by researchers from a number of different perspectives. Humanitarian logistics, as well as business logistics, encompasses a range of activities, including: preparedness, planning, design, procurement, transportation, inventory, warehousing, tracking and tracing, distribution, recipient satisfaction bidding and reverse bidding, reporting and accountability, and customs clearance (Gustavsson, 2003; Thomas and Kopczak, 2005). The basic principles of managing the flow of goods, information and finances that have been established by commercial logistics are also valid for humanitarian logistics (Kovacs and Spens, 2007). The unique characteristics of the disaster relief environment, and a comparison and contrast between commercial and humanitarian relief supply chains are discussed by Beamon (2004), Thomas and Kopczak (2005) and Van Wassenhove (2006).

Humanitarian logistics is characterised by large-scale activities, irregular demand and unusual constraints (Beamon and Kotleba, 2006). The problems can range from a lack of electricity supplies to limited transport infrastructure including 'controlled' environment with some minor variability (e.g. traffic congestion) (Kovacs and Spens, 2009). Commercial logistics are normally planned in advance of demand and relatively well established while relief logistical decisions are made within shorter time frames (Balcik and Beamon, 2008). They usually deal with a predetermined set of suppliers, manufacturing sites, and a stable or at least predictable demand, which are all unknown in humanitarian logistics (Cassidy, 2003). Many businesses are driven by customers (i.e. demand) in commercial logistics, while humanitarian organisations are mostly driven by donors (i.e. supply) (Tomasini and Van Wassenhove, 2009). The customers (aid recipients) actually have no choice and, therefore, 'true demand' is not created in humanitarian logistics (Kovacs and Spens, 2009).

In the initial days of the deployment phase, most of the critical supplies arriving at the site of a disaster are sourced from an organisation's global pre-positioned stocks (Balcik and Beamon, 2008). Cost is one of the reasons for pre-purchasing the supplies as they are able to purchase them at a reasonable price (Salisbury, 2007). Once a disaster occurs, demand increases dramatically and suppliers will often raise their prices in response. Relief organisations adapt the in-advance purchase strategy and then store in a pre-positioned warehouse to enable them to react quickly (Beamon and Balcik, 2008). There are several challenges that relief organizations faces in order to ensure the smooth flow of the relief logistics. Difficulty in creating an effective pre-positioning plan includes uncertainty about whether or not natural disasters will occur and, if they do, where and with what magnitude (Rawls and Turnquist, 2010). Consequently, operating a pre-positioned warehouse could be financially prohibitive and there are only a handful of relief organisations who can support the expense of operating distribution centres (Balcik and Beamon, 2008; Salisbury, 2007).

Although pre-positioned stocks may be useful, they may be restricted as they require considerable financial investment (Chaikan, 2003). For this reason, some of the NGOs tend to focus on operational disaster relief activities rather than disaster preparedness (Thomas, 2007). Balcik and Beamon (2008) suggest that some NGOs avoid using a pre-positioning strategy because it is both complicated and expensive. They also indicate that the total volume of demand satisfied from the pre-positioned inventory is generally much less than the total volume of supplies sent to the disaster region over the entire relief horizon. Salisbury (2007) argues that internal transport capacity is one of the most limited resources in determining the capacity where third-party logistics contractors (i.e. 3rd Party Logistics) need to be involved.

For large-scale quick-onset disasters, it is impossible to meet the entire emergency demand solely from pre-positioned stocks (Balcik and Beamon, 2008). The difficulty to initiate or to maintain a pre-positioned warehouse strategy is due to the uncertainty of disaster occurrences, funding tendencies in the sector and the costs associated with operating distribution centres (Oloruntoba and Gray, 2006; Balcik and Beamon, 2008; Balcik et al. 2010). A warehouse would be useless if it is easily exposed to frequent disasters in an at risk area. Rawls and Turnquist (2006) and Ukkusuri and Yushimoto (2008) modelled pre-positioned warehouse locations, considering that the facility would not be destroyed/damaged by the disasters. The national stability of the country would provide predictable policy management for an organization to manage (Kayikci, 2010).

The literature has also discussed the limitations and the restrictions of a prepositioned warehouse strategy in humanitarian logistics. However, the discussions on the attributes are scarce and do not analyse how they influence each other. This led to the authors conducting a series of interviews with practitioners to identify the risk elements that affect pre-positioned warehouse strategies and to develop a structural model of those elements to understand the ultimate challenges in humanitarian relief logistics.

METHODOLOGY

This research aims to investigate the challenges in humanitarian logistics of pre-positioned warehouses, and is addressed by multi-phase mixed methods combining semi-structured interviews and interpretive structural modelling (ISM). The risk factors found in the interviews become the basic elements of ISM, leading to an ample structure to demonstrate the characteristics of the challenges.

Phase 1: Semi-structured interviews

Since the empirical studies on the risks and vulnerabilities within humanitarian logistics are scarce in the literature, semi-structured interviews were conducted as an exploratory research method with supply chain managers and officers in humanitarian aid organisations. The qualitative interview is more flexible and conversational than quantitative methods in that it allows new questions to be brought up as a result of the interviewee's response during the interview. The objective of the interviews was to better understand the application of the pre-positioning strategy for the humanitarian organisation broadly and to identify the unforeseen issues and opinions of operating or planning the pre-positioning warehouse strategy for humanitarian relief logistics.

Face-to-face and telephone interviews were administered, with 25 personnel at the managerial or higher level in their organisations. Electronic mail and video calls were made to confirm the factors that were identified and the respondents were asked to give their opinions on the risk factors of their warehouse strategy. The objectives of the interviews were to understand the application of the pre-positioning strategies for humanitarian organisations and to identify unforeseen issues and opinions of operating or planning the pre-positioning warehouse strategy for humanitarian relief logistics.

Phase 2: Interpretive Structural Modelling (ISM)

The risk elements found in the interviews were analysed by ISM, an analytic framework to encapsulate the relationships of specific elements in a complex system (Vivek et al., 2008). ISM offers an insightful development of the collective understanding of those relations so that complex interconnections of risk events can be portrayed within a model (Faisal et al. 2007). In this respect, ISM can be seen as the most appropriate method to describe the challenges in humanitarian logistics by creating a holistic risk structure with risks and their interactions. ISM is a step-wise process comprising of seven steps to reach a final model (Faisal et al. 2007; Pfohl et al., 2011) as outline below. The elements for Step 1 were initiated by semi-structured interviews, and then the contextual relationships for Step 2 were decided by a series of panel discussions of 10 humanitarian experts.

Step 1. Identification of elements: The elements that constitute the challenges in pre-positioned warehousing were identified and operationalized by semi-structured interviews. Each element was labelled by a number for the analysis.

Step 2. Contextual relationships: The contextual relationships between the elements were determined by the opinions of 10 humanitarian logistics experts. They were captured by statements using

Step 3. Structural Self-Interaction Matrix (SSIM): A SSIM can be generated by substituting contextual relationships of each pair with legends like V, A, X and O for each (*i*, *j*) entry. V will be used when element *i* leads to element *j*, whilst A will be used when *i* is led by *j*. If there is no relationship or a mutual relationship between *i* and *j*, X and O will be assigned respectively.

Step 4. Reachability Matrix: A reachability matrix converts each (*i*, *j*) entry of the SSIM into number 0 and 1. When element *i* directly or indirectly leads to element j, number 1 will be put into (*i*, *j*) entry. If *i* doesn't lead to *j* at all, 0 will be assigned to the entry.

Step 5. Level Partitioning: Given the reachability matrix, the reachability set (RS), antecedent set (AS) and intersection set (IS=RS∩AS) of each element will be generated. The elements whose RS is the same as IS will be set aside as the top level. New RS, AS and IS of each element will be sought without these elements, and then:

Step 6. Digraph: A directed graph or digraph can be drawn using the reachability matrix and partitioned levels. The elements can be laid vertically and horizontally according to the levels, and then connected by arrows based on the numbers in reachability matrix.

Step 7. ISM-based Model: The final ISM-based model can be generated by substituting the numbers in the diagraph with the original titles of the elements.

FINDINGS

The interviews with 25 experts revealed that various risks are intertwined to generate great challenges in operating pre-positioned warehouses. There were 17 risk elements that were most commonly mentioned by the interviewees.

(1) High Asset Maintenance Cost includes the storage, transportation, labour and any other costs that relate to operating the warehouse system. Due to these difficulties, small relief organisations with financial burdens cannot risk operating a pre-positioned warehouse system.

(2) High Inventory Cost includes those related to storing and maintaining inventory over a certain period of time. As the demand in humanitarian relief operations is uncertain, there always lies a high chance of the relief items to be hold for long time which will influence the cost.

(3) Uncertain Demand: Most of the demand in humanitarian relief operations is unpredictable which leads to uncertain demands. Due to this, humanitarian organisations have difficulties identifying the beneficiaries and the relief items.

(4) Failure in Forecasting Stock Level: Humanitarian relief organisations normally do not have the system to forecast the stock level as they are reluctant to invest the cost. Due to this, most of the small and medium size organisations forecast stock level manually which often mislead to predict.

(5) Lack of Confidence in What to Stock: Some humanitarian organisations standardised the basic relief items to stock in their warehouse. These standardised items were organised through lots of years of experience. However, most other organisations prefer to purchase and deliver at the disaster occurrence country or neighbouring countries. The main reason for this is not only to save cost and reduce time but also not confident of what to stock.

(6) High Transport Cost: Relief items are sent to pre-positioned warehouse via sea transport which would take several weeks and save transportation cost. However, the relief items are sent to the disaster occurred area via air transport from the pre-positioned warehouse. Eventually, pre-positioned warehouse strategies would increase the delivery cost due to th need for air transport.

(7) Difficulties in Justifying Funding: People who donate financially want to know whether their aid is properly used. They prefer to see that relief items are purchased and delivered to the people in need instead of supporting the operation cost, especially in maintaining the warehouse. Donors who are often not aware that their contribution also supports the whole relief chain processes, rather they think that the donations are used only to purchase relief items. Donors are reluctant to support the organisation if the money is used for the whole relief supply chain. Relief organisations experience difficulties in explaining the importance of operating a pre-positioned warehouse strategy.

(8) Limited Space: The space available in the warehouse is limited to store relief items for some humanitarian organisations. Some organisations do not have proper warehouses and store the relief items somewhere else such as in the basement of a building or garage. Even those organisations which own their warehouse facility areoften looking for more spacious warehouses to hold more relief items.

(9) Infrastructure: The quality of the infrastructure for pre-positioned warehouse would be a concern for humanitarian organisations as some of the potential warehouses are located in the underdeveloped countries or near disaster prone areas. Such areas also tend to have lower quality infrastructure.

(10) Stock Out: Humanitarian organisations try to stock relief items as much as possible to support the people in need when immediately a disaster occurs as the casualty tally is often high. Even though they try to stock to the maximum level in order not to be short of relief items, the aid they need to support populations is always high and the need is likely to be more than the stocked items. For this scenario, humanitarian organisations are always concerned with the possibility of stock out situations.

(11) IT Breakdown: IT is a crucial source for communication within the organisation especially when a disaster occurs. Accurate information on the number of relief items, types of relief items, destinations, types of transport, etc. are important to reduce time

and cost for efficient relief operations. Humanitarian organisations prefer their pre-positioned warehouses to be located in a country with acceptable IT equipment as some of them are located in vulnerable countries with poor IT quality.

(12) Dependency on Logistics Service Providers (LSPs): Some major humanitarian organisations outsource their logistics operations to logistics service providers as most of them do not have the expertise, skills and know-how relate to this matter. Everything should be stand-by mode to deliver the relief items within 48-72 hours of the disaster occurring. Dependency arises from these highly-demanding requests from humanitarian organisations with no logistics expertise.

(13) Poor Quality of Goods: The deterioration of relief items is influenced by many factors including the nature of the quality of the relief goods, the climate and the environment at the site. A very hot climate not only affects the relief items but also the labour force in the warehouse.

(14) Poor Performance of LSPs: As some of the humanitarian organisations outsource their logistics operation to logistics service providers, it sometimes matters who the LSP contract with. Small mistakes or delays will influence the delivery time.

(15) Local Staff Quality: The low performance of locally-hired staff could be caused by miscommunication, cultural differences, different working conditions, etc. However it is considered important for managerial level logisticians to be competent in logistical skills and knowledge. Even though they would be deployed from the humanitarian organisation in many cases, they still have to work with qualified local staff for efficient management.

(16) Natural Disasters: Some humanitarian organisations tend to locate their pre-positioned warehouse closer to the disaster vulnerable countries to reduce cost and time. However, some are aware that being close to those areas would put the warehouse in danger due to the natural disasters. To avoid the warehouse being destroyed by natural disasters, some humanitarian organisations prefer to locate the warehouse in an area that would be less influence by such disasters.

(17) Social Instability: Social stability of the country is important to prevent any unexpected theft or pilferage. Some of the relief items stocked in the warehouse are very valuation items; for example, radio-telecommunication systems, medicines, armoured vehicles, food, etc. Security of the location is concerned to be important in pre-positioned warehouse strategy.

Given these 17 risk elements, interpretive structural modelling was conducted according to the 7 steps previously mentioned. As a result, the final ISM-based model is as shown in Figure 1.

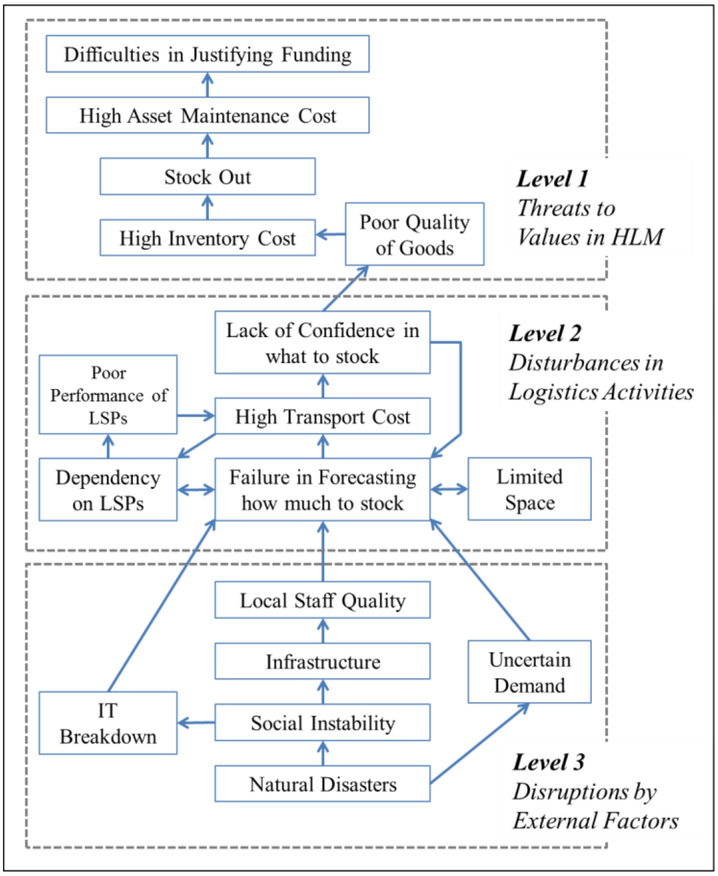

Figure 1. ISM-based model

DISCUSSION

From the ISM-based model, it was identified that the challenges in operating pre-positioned warehouse operations consist of three levels of risk elements: (1) threats to values in humanitarian logistics management, (2) disturbances in logistics activities and (3) disruptions by external factors. The interactions between these levels are uni-directional, where Level 3 leads to Level 2, which in turn, leads to Level 1.

Level 1 consists of the risks which relate to values, cost and quality, that humanitarian logistics organisations pursue. Being the risk consequences, they are dependent upon other risks. Among them, difficulties in justifying funding is placed at the top, which means that organisations feel the pressure from donors once pre-positioned warehouses malfunctioned. One difference from commercial logistics is that delay or time loss is not captured within this level, which will be partly because pre-positioned warehouses clearly aim to reduce the lead time.

The risks **in Level 2,** on the other hand, are mainly initiated by logistics activities and operations, which encompass forecasting, transport, warehousing and outsourcing. The ISM-based model demonstrates that there are three feedback loops which enhance the level of challenges within level 2, as can be seen in Figure 2. Interestingly, all these feedback loops were generated around high transport cost. The reason can be attributed to the fact that reduction of transport cost is one of the main purposes to operate pre-positioned warehouses. With the warehouses, the majority of relief items can be transported via sea leg whose cost is cheaper than any other transport modes given the high volume of items. However, failure in logistics activities directly and indirectly affects the transport cost by adding transport frequencies and/or by using more expensive transport options.

For example, dependency on LSPs based on limited knowledge on logistics often leads to the opportunistic behaviours of LSPs, which result in poor logistics performance. Additional transport cost will be required to rectify this issue, which in turn undermines the bargaining power of humanitarian organisations under budget constraints in the relationships with LSPs (feedback loop 1). In order to eliminate this risk circle, some NGOs pursue tighter partnerships with competent LSPs. Other two feedback loops are closely related to the humanitarian organisations' capability to control the logistics process. The incapability of forecasting the accurate stock level will result in additional transport cost for 'hot delivery' of relief items, which increases the level of their reliance on LSPs. As the organisations lose their control over logistics process, accurate forecasting becomes difficult (feedback loop 2). In the same vein, lack of confidence in selecting items to be stored can lead to forecasting failure and to high transport cost. The budget constraints emanating from high transport cost cause jeopardy in the item selection process (feedback loop 3). In the interviews, humanitarian organisations find it difficult to make accurate forecasting due to their incapability in logistics operations as well as the unpredictability of events requiring humanitarian relief.

Last but not least, the **Level 3** risks are external to humanitarian organisations, but have significant influences on Level 1 and Level 2 risks. This level of risks is also frequently mentioned in the supply chain risk management literature as environmental risks. However, the difference is Level 3 risks can be considered both as risks to logistics operations and as the events where humanitarian relief is required.

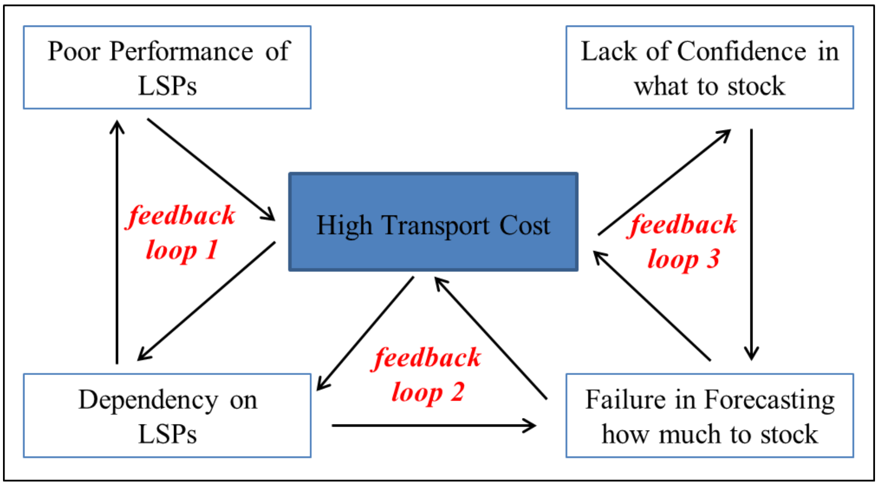

Figure 2. Three self-enhancing loops in the model

CONCLUSION

This research empirically identified various risks in operating pre-positioned warehouses for humanitarian logistics and created a structure of risk interactions in order to understand how the risks are generated and enhanced. As a result, 17 risk factors, 3 distinctive risk levels as well as 3 self-enhancing risk loops were discussed in this research. This is a first study which investigated the risks in humanitarian logistics using a structural model, which can be a ground for future research about humanitarian logistics risk management. In addition, the risk profile can provide a checklist for humanitarian logistics practitioners to assess the level of risks in their operations. Given the levels and feedback loops of risk factors, they can also find out which risk factor should be intensively mitigated to reduce the risk level. This study confined its scope of research to the risks stemming from operations of pre-positioned warehouses. Future research can expand the research scope to the entire process of humanitarian relief logistics.

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THE ATTITUDE TOWARDS ENVIRONMENTAL SUSTAINABILITY OF LOGISTICS SERVICE PROVIDERS: A COUNTRY COMPARISON

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ABSTRACT
Environmental sustainability is an area of increasing importance for third party logistics (3PL) companies. Nevertheless, there is still a great deal of uncertainty on how 3PLs implement sustainable strategy and actions and how these companies translate green efforts into practice. The purpose of this paper is to shed light on environmental sustainability practices undertaken by a sample of 3PL companies in Italy and the UK. Comparative studies among 3PL companies operating in different countries/markets could help in understanding differences and commonalities of environmental efforts as well as influencing factors affecting green investments. The results indicate that 3PL in both countries are focused on the adoption of initiatives in the area of operational efficiency of transport and distribution activities. The green efforts of UK companies are much more driven by cost efficiency and the need to mitigate company risk. The Italian 3PLs are more pressed by actions undertaken by competitors. In addition, the key role played by customers in driving the implementation of green logistics initiatives clearly emerges.

INTRODUCTION
In the 21st century, greening the supply chain has become an increasing concern for many businesses as well as a challenge for logistics management (Zhu et al., 2008). As a result, it is necessary to expand efforts to mitigate the negative consequences for the environment arising from the transport and logistics activities. From this point of view, 3PLs are called to drastically reduce their externalities through effective actions. In response, an increasing number of 3PLs have started to adapt their operations and strategies to be more effective from a green perspective (Lieb and Lieb, 2010). This transformation can increase the competiveness of 3PLs but it may impose challenges and concerns. From the research point of view, there is a great deal of uncertainty about the deployment of green strategies by 3PLs and the drivers and barriers affecting their adoption (Wolf and Seuring, 2010). In addition, the extant literature on green practices in the 3PLs' industry provides findings predominantly from a single country perspective. Given the importance of the Italian and UK logistics service market in the European competitive scenario, comparative studies between logistics service providers operating in different countries may be beneficial. This is particularly relevant for the Italian and UK markets where most of the internal freight traffic is moved by road transport. The cross country analysis could be of help in understanding differences and commonalities of green practices adopted by 3PLs located in different EU countries as well as drivers and barriers. The main aim of this paper is to explore environmental practices in a sample of eight 3PLs case studies (four from Italy and four from the UK). This research takes the logistics service providers' perspective and it specifically examines the type of green initiatives implemented along with factors (barriers and drivers) affecting the adoption of such initiatives. The following section presents a systematic literature review on environmental sustainability in the 3PL industry and the results allow to identify two research questions. The third section summarises the methodology used. The main findings obtained from the case study investigation are presented in the fourth section. Finally, conclusion and implications deriving from the study are drawn in the fifth section.

LITERATURE REVIEW

In order to map the existing state of knowledge on sustainability strategies and actions adopted by 3PLs a systematic literature review was carried out for the period 2000-2014. The search strategy was based on two bibliographic databases (i.e. Scopus and Web of Science). To identify relevant articles, a structured keyword search was performed. In particular, the keywords "green", "sustainab*", "energy efficiency" and "CO2 efficiency" were used in combination with "logistics service providers", "third-party logistics", "3PL", "LSP", "road freight transport", and "road freight haulier". A total of 198 papers were initially identified. In the second step, the output obtained from the two databases was compared and this led to the elimination of 38 duplicate papers leaving a total of 89 papers. In a further step, two inclusion/exclusion criteria were established. The first criterion related to the inclusion of peer-reviewed journals articles published in scientific journals only. The second criterion involved the specific inclusion of papers with a management focus. This led to the identification of the final sample that included 32 articles in total. In a final step, it was possible to identify the following five topic areas:

TA1. Papers dealing with factors affecting the adoption of green initiatives by 3PLs (eight articles)

TA2. Papers dealing with innovation and ICT tools supporting the adoption of green initiatives by 3PLs (four articles)

TA3. Papers examining the implementation of green initiatives and the impact on 3PLs' performance (eight articles)

TA4. Papers discussing energy efficiency in road freight transport companies (seven articles)

TA5. Papers discussing buyers' perspectives and collaboration when sourcing green 3PL services (five articles).

The review of papers included in the TA1 suggests that there is a lack of consensus on key issues. The papers analysed reported both internal and external factors triggering and facilitating sustainability actions by 3PLs, but it is not clear what type of barrier slows down the adoption of those actions. There has been no comprehensive assessment of the forces that influence a 3PL's decision to undertake green initiatives. Finally, most of the papers in this area are based on questionnaire surveys and there are no contributions using the case study method or other qualitative techniques.

The lack of papers in the TA2 suggest that this may be a promising field of future study. No research has yet assessed the potential of specific ICT tools to improve the environmental performance of 3PLs.

In relation to papers included in TA3 the extant literature is quite limited and offers a fragmented picture of green 3PLs' initiatives. Some papers focus on one single measure (e.g. intermodal transport) while others provide classifications of green initiatives adopted by 3PLs. The classification provided by Lieb and Lieb (2010b) is empirically derived on the basis of interviews carried out with 3PLs' CEOs. That proposed by Perotti et al. (2013) includes under the heading of green supply chain practices initiatives that seem to have an impact predominantly within the boundaries of the firm (e.g. warehousing, green building and internal management). Similar measures have been classified by Colicchia et al. (2013) using the "intra-organizational" and "inter-organizational" dimensions. There remains no comprehensive taxonomy of green initiatives, however. In addition, most of the papers analysed are based on questionnaire surveys, while only more recent works used case study or other qualitative methods. Overall, the analysis of the impact of green initiatives on 3PL's performance is at an early stage and needs to be assessed more in-depth.

The papers included in TA4 provide an interesting picture of the progress so far achieved in this field. Nevertheless, the selected papers show a fragmentation of research efforts. While some authors focus on describing the state of implementation of energy efficiency initiatives in some countries/regions (see

Liimatainen et al. 2014 and 2012), others have investigated the role of information technology applications in reducing fuel consumption and CO2 emissions (e.g. Baumgartner et al., 2008; Léonardi and Baumgartner, 2004).
Finally, the analysis of papers comprised in TA5 demonstrates that there is a general consensus that buyer influence on 3PLs' green initiatives is limited and sustainability has not been fully incorporated in the sourcing decision-making process as yet. Most of these studies took the perspective of the buyer company. There have been few attempts to analyse the mechanisms required to set-up collaborative green initiatives based on dyadic buyer-3PLs relationships.
The literature review allows to identify the following two research questions:
RQ1) what type of green initiatives are adopted by 3PLs?
RQ2) what are the main factors, both barriers and drivers, affecting the adoption of green initiatives by 3PLs?
Given the importance of the Italian and UK logistics service market in the European competitive scenario, comparative studies between logistics service industries in different countries may be beneficial. The cross country analysis could be of help in understanding differences and commonalities of environmental sustainability practices adopted by logistics service providers located in different EU countries as well as drivers and barriers.

METHODOLOGY

The investigation conducted in this research was based on multiple case studies. The case study methodology is well acknowledged to gain a deeper understanding of a phenomenon under development or whose dimensions are not yet fully understood (Yin, 2003). Additionally, the multiple case approach allows for the comparison of two or more business situations to support explorative investigations (Eisenhart, 1989; Yin, 2003). As per the case sample, we decided to compare an equal number of companies in the two considered countries for performing a balanced country comparison. We selected eight different companies overall. We consider this number of case studies to be sufficient to capture variations in theory and concepts, being the main purpose of this research explanatory and theory building in nature (Aastrup and Halldórsson, 2008; McCracken, 1998; Strauss, 1987). Companies were selected in the domain of the so-called Third Party Logistics (3PLs) service providers (Evangelista et al., 2013). In order to capture the richness of specific data and compare and contrast practices and attitudes in two different geographical contexts, we selected companies founded and based respectively in the Italian and UK logistics service market. To this aim, we focused on medium-large companies while large organizations with multinational culture and operations were excluded from the study. The selection of the companies was based on the following specific criteria:
a) including companies differing in the range of services provided;
b) including companies with different emphases on environmental sustainability.
To ensure reliability, a formal interview protocol was developed. It contained a mixture of open and multiple choice questions. In each case, the interview protocol was submitted to the supply chain director and to the professional figure responsible for the sustainability issues. A pilot test was performed before the interviews with a panel of practitioners and experts in the field. Some questions were fine-tuned in order to increase their clarity and effectiveness to the aims of this study. Interview reports were produced to enable data analysis. Moreover, triangulation of data was carried out through the concurrent examination of company documents such as internal presentations, reports, and external documentation, as well as web sites. Discrepancies among different sources of information were resolved through a recalling of the respondents. A cross case analysis was then performed, to uncover themes, patterns of commonality and key differences (Ghauri, 2004). In order to analyse the data, we relied on templates for the thematic analysis of the interviews (Crabtree and Miller, 1999; King, 1998; Miles and Huberman, 1994). For confidentiality reasons, the name of

the case companies has not been disclosed and each company has been referred to by using the acronym of the country (IT or UK) followed by a sequential number. Table 1 provides the summary profile of each of the case companies included in the sample in terms of range of services provided, company size (employee ranges according to the latest definition of SMEs provided by the EU Commission), geographical reach and main ICT tools adopted.

		IT1	***IT2***	***IT3***	***IT4***	***UK1***	***UK2***	***UK3***	***UK4***
Services provided	Transport	x	x	x		x	x	x	x
	Warehousing		x	x	x	x	x		x
	Distribution				x		x	x	
	Value added services		x	x	x	x			x
	SCM services				x				
Company size (employees)	Micro (1-9)								
	Small (10-49)								
	Medium (50-249)	x	x	x	x	x	x		x
	Large (> 250)							x	
Geographical reach	Regional								
	National							x	
	Europe	x	x	x		x			x
	Global				x		x		
ICT tools used	Location-based technology (EDI, GPS, bar code, RFID)	x	x	x	x	x	x	x	x
	Connectivity technology (LAN, WLAN)	x		x	x	x	x	x	x
	Relational technology (ERP, CRM)				x	x	x		x

Table 1: Profile of the case study companies

FINDINGS FROM THE CASE STUDIES

We have arranged this section consistently with the main focus areas of the research questions of this study: adopted green logistics initiatives, drivers and barriers affecting the adoption of such initiatives.

Adoption of green logistics initiatives

The Italian case study companies implement a range of environmental actions.
IT1 is predominantly characterised by the adoption of initiatives focused on vehicle use and aimed at reducing empty running and improving vehicle loading. The company also adopts actions related to the choice of low energy transport modes and intermodality, energy efficiency, recycling materials and packaging and employee training. This company shows a limited sensitivity toward environmental aspects as it adopts an approach mainly based on cost efficiency. This reflects the limited breadth of services offered by this company that is a purely road haulage firm (see table 1). Most of the actions undertaken by IT2 involve areas such as reducing empty running and improving vehicle loading, modal choice and intermodality, energy efficiency, recycling materials and packaging and environmental training and information and it provides information on carbon footprint. In addition IT2 is active in the area of supply chain re-organization using transport planning systems and changes in the logistics system. The company also uses the environmental management system (ISO 14001). This company shows a higher level of green concern in comparison with the previous one that may be connected to the wider range of services. Finally, the action undertaken by IT3 and IT4 show an increasing environmental awareness and an emphasis on actions involving environmental supply chain re-

organisation, Supply Chain collaboration and collaborative planning and environmental control.

The companies belonging to the UK's sub-sample show a number of diverse implemented initiatives. UK1 concentrated on the adoption of initiatives mainly related to the increased environmental efficiency of transport, warehousing and distribution operations, showing awareness also of the opportunities offered by intermodal transport. This clearly reflects its close link to port operations, which offer the possibility to leverage intermodal port centric logistics. The training of employees is another top priority for UK1, along with the implementation of an Environmental Management System, being these essential elements of the company's culture. Likewise, UK2 seems conscious of the importance of enhancing the environmental efficiency of transport and warehousing operations. However, rather than focusing on the internal training of employees, they focus more on transport planning and Supply Chain collaboration on shared green targets initiatives together with customers and supply chain partners (e.g. subcontractors). UK3 has a comprehensive approach to environmental sustainability. Its focus is on vehicle use, energy efficiency, recycling, training and supply chain re-organization, with the specific aim to increase the overall efficiency of their activities. Furthermore, they are exploring the possibility to rely on intermodal transport with customers' specific solutions and port centric approaches.

Area	***Initiative***	***IT1***	***IT2***	***IT3***	***IT4***	***UK1***	***UK2***	***UK3***	***UK4***
Vehicle use	Changing vehicle specifications						x	x	
	Reducing empty running	x	x	x	x	x	x	x	x
	Improving vehicle loading phase	x	x	x	x	x	x	x	x
Transports modes and intermodality	Using lower energy transport modes	x	x	x		x	x		
	Greater use of intermodality	x		x		x	x		
Energy efficiency	Renewable energy (including alternative fuels)	x	x	x		x	x	x	x
Recycling materials and packaging	Increasing waste recycled		x	x		x	x	x	
	Reducing packaging		x	x			x		x
Warehousing and green building	Eco-friendly building design					x		x	x
	Energy-efficient material handling equipment					x	x	x	x
	Use of alternative energy sources in warehousing			x	x				
	Efficient land use								x
Environmental training and information	Employee training (including eco-driving)	x	x	x		x		x	x
	Customer/supplier training		x		x	x		x	
	Information on carbon footprint		x		x			x	
Supply Chain re-organization	Transport planning		x	x	x		x	x	x
	Changes in logistics system		x		x			x	x
Supply Chain collaboration on shared green targets	With customer				x		x		
	With other 3PLs				x		x		
Collaborative planning and environmental control	Environmental Management System (ISO 14001)		x	x	x	x		x	
	Emission off-set programs				x				x
	Setting lower GHG targets			x	x			x	x

Table 2: Green initiatives adopted by the case study companies

The only area not covered is related to Supply Chain collaboration on environmental sustainability. UK4, consistently with the core business of the company, focuses on the development of green solutions especially for the warehousing activities, which encompass also the re-design of its logistics network for improving their carbon footprint.

Drivers affecting the adoption of green logistics initiatives

As per the drivers affecting the adoption of green initiatives by the Italian case companies, IT1 indicated that governmental support was the most influential driver affecting the adoption of green initiatives together with the support of management and the entrepreneur/owner and initiatives implemented by competitors. In addition to government, management and entrepreneurial support, IT2 indicated that an increasing level of green commitment of customers was considered as a stimulator of sustainability actions. Finally, for IT3 and IT4 the most influential drivers were green initiatives implemented by customers and competitors. These companies need to maintain and improve relationships with customers and for this reason they are paying greater attention to customer sustainability programmes. In addition, the actions undertaken by competitors are also considered a further incentive to adopt more effective sustainability initiatives.

Taking into account the UK's sub-sample, it is possible to highlight some specific features. Companies UK2, UK3 and UK4 stressed the importance of environmental sustainability as a lever for compressing operations' cost. All UK's companies agreed on the great importance of green logistics initiatives for improving customer relationships and increase company profitability, along with the possibility to improve the company's image. Medium/high importance is also given to the improvement of supply chain effectiveness as a driver. On the other hand, the UK's sub-sample seemed aligned on the low importance given to the competitors' initiatives as a trigger for going green. Interestingly, UK1, UK3 and UK4 see green initiatives as a lever for reducing company's risk – for being able to cope with unexpected changes in regulations and increased competition.

Drivers	***IT1***	***IT2***	***IT3***	***IT4***	***UK1***	***UK2***	***UK3***	***UK4***
Cost reduction	○	◑	◑	●	○	●	●	●
Improvement of customer relationships	○	◑	●	●	●	●	●	●
Improvement of the overall customer supply chain effectiveness	○	○	●	●	●	◑	◑	●
Green initiatives implemented/requested by customers	○	●	●	●	○	◑	●	●
Green initiatives requested by top management/strategic board	◑	●	○	◑	●	○	○	◑
Green initiatives implemented by competitors	●	○	●	●	○	◑	○	○
Green initiatives implemented by 3PLs partner	○	◑	◑	●	●	◑	○	◑
Increase of the company's profitability	○	○	◑	●	●	●	●	●
International, national, regional or local regulations	○	●	◑	◑	○	●	●	◑
EU, national, regional funding/economic incentives	●	●	◑	◑	○	●	○	●
Reduction of company risk	○	○	◑	◑	●	○	●	●
Improvement of corporate image on the market	○	○	◑	●	●	●	●	◑

Key: ○ = low importance; ◑ = medium importance; ● = high importance

Table 3: Importance of drivers influencing the adoption of green initiatives

External funding is seen as an important driver by UK2 and UK4, while UK1 and UK3 judge this driver as not important since they're able to internally invest for cost reduction. Regulations are seen as important by UK2 and UK3 while requests coming from the top management are seen as relevant only by UK1, which judges relevant also the actions undertaken by 3PL partners.

Barriers preventing the adoption of green logistics initiatives

For IT1 the most important barriers were both internal and external to the company. The high level of green investment and uncertainty about their payback period are considered the main constraints limiting the development of green measures by this company. A further barrier is the lack of well-defined regulatory framework, customers' environmental awareness and financial incentives are the most influential external barriers. IT2 indicated the lack of a well defined regulatory framework, financial incentives and insufficient human resources as the most influential barriers causing the slow down of green initiatives. IT3 and IT4 emphasised the lack of well defined environmental regulations. These companies see the lack of human resources and ICT skills as the two elements that may hinder the adoption of green measures.

The companies belonging to the UK's sub-sample provided further insights on the factors hindering the adoption of green logistics initiatives. Interestingly, all of them are recognising the high investment costs, lack of financial resources and the doubtful payback about green investment as the main barriers. Medium/low importance is given to the lack of human and ICT skills, as well as to the lack of customers' and 3PL partners' environmental awareness. UK2 is the only company recognising the lack of customers' environmental awareness as an important barrier: the company is in fact currently working in collaboration with key customers to improve the environmental sustainability of the supply chain. However, the company is willing to further foster the adoption of green logistics initiatives in the extended supply chain. The UK's sub-sample recognise the lack of funding and economic incentives as a main barrier, while different views are provided regarding the lack of well-defined regulations.

Barriers	***IT1***	***IT2***	***IT3***	***IT4***	***UK1***	***UK2***	***UK3***	***UK4***
High investment costs and lack of financial resources	●	○	◑	◑	●	●	●	●
Doubtful payback about green investment	●	○	◑	○	●	◑	●	◑
Lack of human resources in green initiatives	◑	○	●	●	●	○	○	○
Lack of ICT skills for managing green initiatives	○	○	●	●	●	○	○	○
Lack of customers environmental awareness	●	◑	◑	○	○	●	○	○
Lack of 3PL partner environmental awareness	●	◑	◑	●	○	◑	○	◑
Lack of funding/economic incentives	●	●	◑	◑	●	●	●	○
Lack of well-defined regulations	●	●	●	●	●	●	○	○

Key: ○ = low importance; ◑ = medium importance; ● = high importance

Table 4: Importance of barriers preventing the adoption of green initiatives

DISCUSSIONS AND CONCLUSIONS

The explorative comparison of the adopted green logistics activities and of the perception related to the drivers and barriers by the Italian and UK's sub-samples allowed to provide an answer to the research questions of the study. Additionally, it unfolded interesting insights on similarities and differences between the investigated sub-samples. While global trends on green logistics seem to be confirmed by our investigation, some divergences clearly emerge.

The majority of the companies in both countries implement a range of environmental initiatives especially in the area of operational efficiency of transport and distribution activities, including transport planning and employee training. These initiatives are implemented within the focal company rather than the entire supply chain. The adoption of supply chain collaboration initiatives, in fact, is still underdeveloped in both countries. An important driver common to both sub-samples is represented by national and international regulations. Regarding the barriers, it appears that all companies perceive the lack of funding and economic incentives and of well-defined regulations as major factors.

With reference to the divergences, our investigation found that the UK's companies are more active in changing vehicle specifications and in adopting warehousing and green building initiatives. As per the drivers, compared to the Italian sub-sample, the UK's companies seem to be more focused on cost reduction to achieve increased profitability and improve the corporate image through the adoption of green initiatives. On a similar note, the UK's companies perceive green initiatives as leverages for mitigating company risk, related to the potential changes in the competitive environment or in the regulatory framework. On the other hand the Italian companies perceive more the pressure coming from the actions undertaken by competitors with reference to green initiatives.

As per the barriers, UK's companies stress the importance of cost and required investments for making a step change for a greener supply chain, being focused on punctual cost compression initiatives. The Italian companies seem to be more hindered by lack of human resources and ICT skills for going green.

Consistently with the literature, from our results it emerges the key role potentially played by customers in driving the implementation of green logistics initiatives: when customers have a full environmental awareness, they can drive solutions to increase the environmental sustainability of supply chains. On the other hand, they represent a barrier when they do not require or expect the development of green logistics actions by 3PLs.

The described results can be connected to the national competitive environment where companies operate and to the specific companies' cultures. Further investigation on the role of customers in driving the green development of supply chains and on factors underpinning different choices and attitudes in different countries would be beneficial to academia and business practice.

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DETERMINANTS OF ENVIRONMENT MANAGEMENT PRACTICES ADOPTION FOR LOGISTICS COMPANIES IN MALAYSIA

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Abstract
There is an increasing growth of customers and regulators requesting enterprises to adopt the environmental management practices (EMP) over the last 15 years and this matter becoming an interest for researchers and practitioners. This paper will propose an integrated model that combines the theory of planned behavior (TPB) and Technology-Organization-Environment Model (TOE), the two theories that are most often used in environment and innovation studies. In this paper, a model is erected to indicate the relationship between TOE model, TPB theory and EMP implementation.

Keyword : technological, organizational, environmental, behavioral attitude, subjective norms, perceived behavioral control

1. Introduction

The foundation of several previous new technology and innovation adoption studies was based on the theoretical frameworks derived from Fishbein and Ajzen's (1975) Theory of Reasoned Action (TRA), Ajzen's (1985) Theory of Planned Behaviors (TPB), Theory of Acceptence Model (TAM); Rogers's (1983,1995), Diffusion of Innovations (DOI) theory and Tornatzky and Fleischer's (1990) Technological-Organizational-Environmental (TOE) model. Some of these theories are able to explain the organization level of innovation adoption, while others focused on the individual acceptance of new technology. This article proposes the integration of TOE model and TPB model for the framework of EMP adoption.

2. Background

2.1. Environment Management Practices (EMP)

An EMP or Environment Management Practices is a tool for an organization's managing their impacts activities toward the environment. It provides a structured approach to plan and implement environment protection measures. An EMP monitors environmental performance; similar to the way a financial management system monitors expenditure and income and enables for an organization to checks regularly company's financial performance. An EMP integrates environmental management into a company's daily operations, long-term planning and other quality management systems (Chavan, 2005; Marimon Viadiu, Casadesús Fa, & Heras Saizarbitoria, 2006; Zutshi, Sohal, & Adams, 2008). An EMP is one of the tools an organization can use to implement an environmental policy (Ann, Zailani, & Wahid, 2006; Chan & Wong, 2006; Fuong, 2010; Harangzó, Kerekes, & Zsóka, 2010). An EMP illustrates an extension of the core principles of total quality programs to managing the environment (Florida and Davison, 2001). In other words EMP can be described as the systematic application of business management to environmental issues (Florida and Davison, 2001).

2.2. Technology-Organization-Environment (T-O-E)

Technology-Organization-Environment (TOE) framework of Tornatzky and Fleischer (1990) undertakes a generic set of factors to predict the likelihood of innovations adoption. The theory suggests that innovations adoption is influenced by technology development (Kauffman & Walden, 2001), organizational conditions, business and organizational restructuring (Chatterjee, Grewal, & Sambamurthy, 2002), and industrial environment (Kowtha & Choon, 2001).

Technological context defines that adoption depends on the collection of technologies inside and outside the firm as well as the application's noticed relative advantage (gains), compatibility (both technical and organizational), complexity (learning curve), trialability (pilot test/experimentation), and observability (visibility/imagination).

Organizational context apprehends firm's business scope, top management support, organizational culture, complexity of managerial structure measured in terms of centralization, formalization, and vertical differentiation and the quality of human resource (Jeyaraj, Rottman, & Lacity, 2006; Tornatzky & Fleischer, 1990).

Environmental context conveys to facilitate and inhibited the factors in areas of operations. Substantial among them are competitive pressure, trading partners' readiness, socio-cultural issues, government encouragement, and technology support infrastructures (Al-Qirim, 2007; Jeyaraj et al., 2006; Scupola, 2003a, 2003b; Zhu & Kramer, 2005).

The major problem of the T-O-E is that the theory is lack of the influences of behavioral, attitudes, awareness and benefits construct on technological and innovation adoption decision (Awa, Emecheta, & Ojiabo, 2012). However, integrating the T-O-E with other models such as the TPB, with each theory offering larger number of constructs than the original, provides finer theoretical lenses to the understanding of technological and innovation adoption behavior.

2.3. Theory of Planned Behavior (TPB)

The TPB is an established general theory of social psychology, which emphasizes that specific significant beliefs influence behavioral intentions and subsequent behavior (Ajzen & Fishbein, 1975; Ajzen, 1985; T. C. Lin, Hsu, Kuo, & Sun, 1999; Netemeyer, Ryn, & Ajzen, 1991). The TPB extends the theory of reasoned action (TRA) (Ajzen & Fishbein, 1975) to explain for conditions where individuals do not have control over the situation (Kaiser, Wolfing Kast, & Fuhrer, 1999; Pavlou & Chai, 2002). The Theory of Planned Behavior has been used in several studies for examining the intention behavior to adopt innovation towards environment (Kumar, 2012). The theory of planned behavior would enables to complete the framework for exploring the factors which influence the decision to engage in behavior related to environmental issues and understanding different factors affecting the purchase behavior for environmentally sustainable products (Kumar, 2012).

2.4. Integration of The Technology-Organizational-Environment Framework (TOE Framework) and The Theory of Planned Behavior Model (TPB Model)

Innovation involves of any practices that is new to organizations, including installment or upgrading new equipment, products, services, processes, policies, and projects (Ho & Lin, 2012; C. Lin, Ho, & Chiang, 2009; C. Lin & Ho, 2011; C. Lin, 2011). It is important to understand the organizations' adoption behavior and identifying the determinants of innovation by distinguishing the types of innovation (Ho & Lin, 2012). As adopting environment management practices involves implementing new or modified processes, techniques, or systems to reduce environment damages, the adoption behavior can be regarded as a technical innovation process (Henriques & Sadorsky, 2008). Various researchers have analyzed environment management practice adoption from the perspective of technical innovation; however, little empirical research analyzes the influences of technological, organizational, and environmental factors simultaneously (Damanpour, 1991; Dou, 1999; Hoffman, Parejo, Bessant, & Perren, 1998; Worthington & Patton, 2005).

Although the TOE framework is applied to several innovation implementation research, the framework is better to be intregrated with other models preferably the Theory of Planned Behaviour (TPB), with several reasons.

Firstly, the the constructs in the adoption predictors in TOE framework is only apply to large organizations (Angeles, 2013; Awa et al., 2012; Tornatzky & Fleischer, 1990). With the integration of TOE and TPB, the propose framework is suitable to be apply for indivual level (Martins & Oliveira, 2008; Oliveira & Martins, 2011).

Secondly, TOE framework is not aiming to offer a concrete model describing the factors that influence the adoption process; it is rather for classifying factors in their respective context (Ven & Verelst, 2011). With the integration framework from the TPB model, contruct of TPB will further the studies examining the intention behavior to adopt innovation towards environment (Kumar, 2012).

Thirdly, Henderson (2102) suggest that future researchers would reflect whether the significance of technological, organizational, and environmental variables change based on internally or inter-organizationally adoption (Henderson, Sheetz, & Trinkle, 2012).

Fourthly, Although the TOE framework covers the technological aspects and also explores their organizational and environmental contexts, its does not cover the perception and attitudes aspects on adopting the new technology (Wan Nur Syahida & Azwadi, 2013). With the construct from TPB, the variables covers the perception and attitudes aspect.

Fifthly, the TOE framework has consistent empirical supports in the study of supply chain related to new IT technologies. Nevertheless, management information systems researchers have often stated that due to different technologies' characteristics, the TOE models often need to be extended to incorporate different variable beyond the TOE framework (Chong & Chan, 2012). Since EMP is a new technology or innovation, the proposed framework will cover the variables on innovation adoption.

Sixthly, researcher describe that the TOE framework as a generic theory, thus they have seen little need to adjust or refine the theory itself (Baker, 2011; Zhu & Kramer, 2005). With the proposed framework, the integration of TOE and TPB will offers more alternatives for researchers to research on technology adoption (Chong & Chan, 2012).

Seventhly, the TOE framework may have seen relatively little evolution because it has been viewed as aligned with other explanations of innovation adoption rather than offering a competing explanation to them (Baker, 2011). Since every technologies and innovations have different characteristics, the construct of both framework would cover the need of the studies on technology adoptions (Chong & Chan, 2012).

Finally integrating TOE with other models offering larger number of constructs than the original and provides richer theoretical lenses to the understanding of adoption behavior (Awa et al., 2011)

Accordingly, it has been suggested that a integration can be accomplished when the strength of some of the most widely used theories in adoption research for explaining individual behaviour {e.g., Theory of Technology Acceptance Model (TAM), Theory of Technology Acceptance Model 2 (TAM2), Theory of Planned Behavior (TPB), and Unified Theory of Acceptance and Use of Technology (UTAUT)} could be combined with the strength of a TOE framework to describe organizational behaviour (Baker, 2011).

The Theory of Planned Behavior (TPB) is a suitable model to be integrated with TOE framework in this research because for several reasons. The reasons are, the literature on technology adoption by businesses suggests that most research are based on the Theory of Planned Behaviour (TPB) (Netemeyer et al., 1991; Wan Nur Syahida & Azwadi, 2013). Although the TPB theory on focuses on percepttion and attitudes, the TPB theory are highly applicable in predicting adoption behaviour of the firm in considering new technology (Wan Nur Syahida & Azwadi, 2013). The TPB theory will focus on technological perspective which based on perceptions and attitudes, and have commonly been used as groundwork for new technology implentation at the individual level (Oliveira & Martins, 2011). Additionally, the TPB is a well-researched intention model that has been proved successful in predicting and explaining behavior across a wide variety of domains (T. C. Lin et al., 1999). Nevertheless there is scarce research concerning adopting any environment management practices or environment management system that use the TPB as a base theory to explain the behavioral intention of individuals (C. Lin & Ho, 2011).

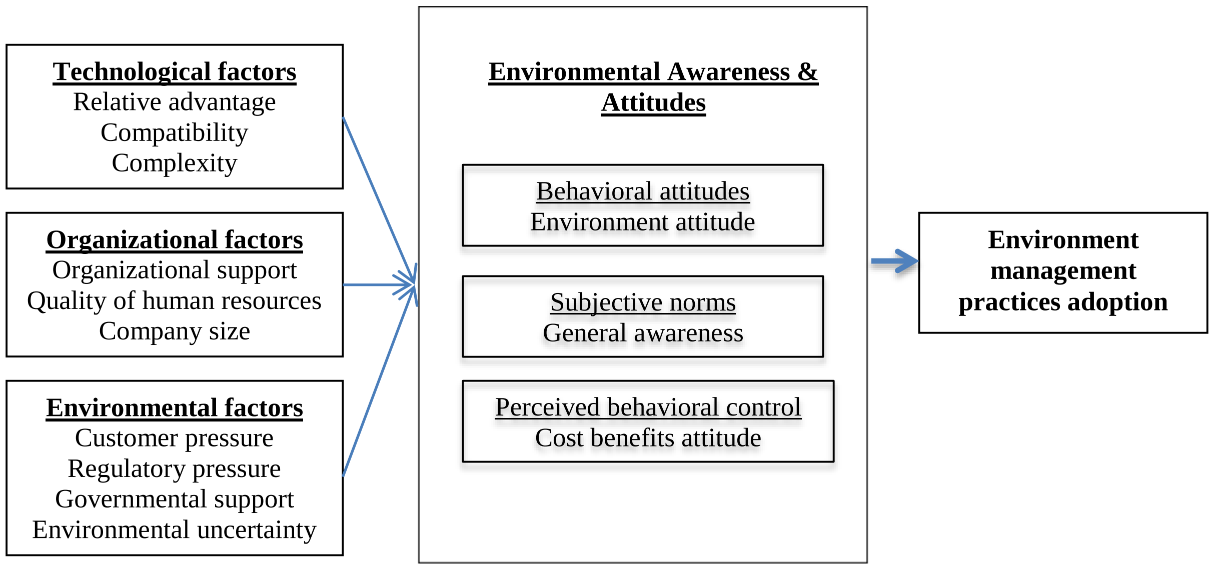
2.5. Proposed model of environmental management practices adoption.

In this research, a modified version of the Technology-Organizational-Environmental Framework (TOE) (Tornatzky & Fleischer, 1990) and the Theory of Planned Behaviour (TPB) (Ajzen, 1985) have been developed for researching the adoption of environment management practices. Based on the TOE framework, it covers the aspects of an enterprise's context that influence the process by which it adopts and implements a technological innovation or new technology system (Tornatzky & Fleischer, 1990). While in TPB, the intention to use a "system" is explained by attitudes toward certain behavior, subjective norm and perceived behavioral control (Ajzen, 1985). TOE or TPB have both been widely used among researchers and found to be very useful in explaining consumers' attitudes and intentions toward a given behavior (Awa et al., 2012; Min, 2008; Oliveira & Martins, 2010; Pavlou & Chai, 2002; Yoon, 2011). TPB is a general theory of human behavior while TOE is specific to innovation adoption. Studies on acceptance of new technology indicate that traditional adoption models need to be extended and modified to better explain the adoption of the innovations (Ervasti & Helaakoski, 2008).

This study modifies TOE by integrate the construct from TPB. Therefore, this research will explore the influences of technological, organizational, and environmental factors and the mediating factors of environment and awareness attitudes on the adoption of environment management practices in Malaysia logistics industry.

Figure 1 below illustrates the research framework of the study. The technological factors include the relative advantage, compatibility, and complexity of green practices; the organizational factors include organizational support, quality of human resources, and company size; and environmental factors include customer pressure, regulatory pressure, governmental support, and environmental support. For the mediating factors include environment attitude, general awareness and cost benefits awareness. As this article aims to analyze the influences of technological, organizational, environmental, and environment awareness and attitudes factors on environment management practices adoption, the potential relationships between the proposed determinant factors will not be considered in the current study.

Figure 1 : Proposed Model for Adoption of Environment Management Practices



3. Hypothesis development

Based on the foregoing review of the literature, it is hypothesized that the factors of technological, organizational and environmental factors have impact on environmental awareness and attitudes, which in turn are associated with the environment management practices adoption. The diagram in Figure 1 illustrates the relationships between the theoretical constructs and variables under analysis in this research. Figure 1 shows the fourteen theoretical constructs representing by five main factors of technological factors, organizational factors, environmental factors, environmental awareness and attitudes factors and environment management practices adoption factors. Technological factors include relative advantages, compatibility and complexity factors. Organizational factors include organizational support, quality of human resources and company sizes. Environmental factors include customer pressure, regulatory pressure, governmental support and environmental uncertainty. Environmental awareness and attitudes support includes environmental attitudes that represent behavioral attitudes, general awareness that represent subjective norms and cost benefits attitude represent perceived behavioral control. Based on the proposed research model, the following hypotheses were formulated:

- H1: The environment management practice's technological factors have a positive influence on environment attitude for Malaysian logistics companies.
- H2: The environment management practice's technological factors have a positive influence on general awareness for Malaysian logistics companies.
- H3: The environment management practice's technological factors have a positive influence on cost benefit attitude for Malaysian logistics companies.
- H4: The organizational factors have a positive influence on environment attitude for Malaysian logistics companies.
- H5: The organizational factors have a positive influence on general awareness for Malaysian logistics companies.
- H6: The organizational factors have a positive influence on cost benefit attitude for Malaysian logistics companies.
- H7: The environment factors have a positive influence on environment attitude for Malaysian logistics companies.
- H8: The environment factors have a positive influence on general awareness for Malaysian logistics companies.
- H9: The environment factors have a positive influence on cost benefit attitude for Malaysian logistics companies.
- H10: The greater level environment attitudes of a firms to be, the more positive the firms attitudes toward adopting EMP
- H11: The greater level general awareness of a firms to be, the more positive the firms attitudes toward adopting EMP
- H12: The greater level cost benefits attitudes of a firms to be, the more positive the firms attitudes toward adopting EMP

4. Discussion and Conclusion

In this article, we have proposed a new conceptual adoption model based on the TOE theoretical framework and the Theory of Planned Behavior framework. Through conducting an in-depth literature review, the researcher uncovered initial concepts, constructs, and a set of preliminary detriments that may influence knowledge map adoption. The proposed conceptual model for the adoption of EMP was founded by integrating two theories, the TOE framework and the TPB framework. The factors covering six broad contexts (technological, organizational, environmental, behavioral attitude, subjective norms, and perceived behavioral control) that could potentially influence EMP adoption. As stated above the literature argues that the majority of the current research of EMP and innovation adoption generally focuses on the technical aspects of adoptions with a particular lack of discussion on the factors that influencing the adoption of EMP. Therefore, we believe this model can offer a valuable tool for managers to understand the factors that influencing the adoption of EMP in order that they could proactively design further strategy to improve their employee’s attitudes to adopt EMP. So far, the initial research model is still untested. Thus, developing an instrument for survey and testing of the research model is crucial for future research.

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DEVELOPING SUSTAINABLE SUPPLY CHAINS IN GREECE, ITALY, POLAND AND UNITED KINGDOM – RESEARCH RESULTS

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Abstract

Purpose of this paper: The main purpose of this paper is to present the range of green practices required for developing sustainable supply chain in SME sector. It gives contribution to environmental aspects disused in relation to the sustainability concept. The article also presents the results from research conducted in an international project - PrESS (http://pressproject.eu/) aimed at promoting green thinking and transferring a decision support tool to the business practice.

Design/methodology/approach: A two-phase methodology design based on literature review and survey was used. The literature is a source of the knowledge about supply chain sustainability whereas the research provides findings based on 227 surveyed companies.

Findings: The findings of the research cover the range of green practices used by chosen companies in Poland, United Kingdom, Greece and Italy.

Value: The paper presents unique project and unique research results on companies which face the challenge of environmental protection improvements and developing supply chain sustainability.

Research limitations/implications (if applicable): The presented research includes a preliminary sample of the companies.

Practical implications (if applicable): The article shows the scope of environmental practices that are being implemented by companies. This can support supply chain managers during taking decisions on directions of product and process improvement.

INTRODUCTION

The most recognized definition of sustainable development describe it as a "development that meets the needs of the present without compromising the ability of future generations to meet their needs." [WCED 1987]. The different aspects of sustainable development may be considered: social, environmental and economic like in TBL concept [Elkington, 1997] Moreover the shift from macro (political concept) to micro level (organizational point of view) is observed [e.g Rudawska, Renko, Bilan 2013; Klettner et al 2014]. One of many examples how sustainability is translated into organizational level shows e.g Shrivastava who describes it as "the potential for reducing long-term risks associated with resource depletion, fluctuations in energy costs, product liabilities, and pollution and waste management" and underlines its environmental dimension [Shrivastava 1995]. Taking into account that the final products and services are the result of actions taken in the whole supply chain discover a new path of research exploration. The need to check how and if the sustainability appears in supply chains reveals the space for research and practical cases [Beske, Seuring 2014; Carter, Rogers 2008; Hall et al 2012, Ashby et al 2012; Seuring and Müller 2008; Fabbe-Costes et al 2011; Svensson 2007]. There are different definitions that try to show the whole spectrum of the concept of sustainability within supply chains. Sustainable supply chains are defined as "the management of environmental, social and economic impacts, and the encouragement of good governance

practices, throughout the lifecycles of goods and services[Sisco et al 2010] or as "the strategic, transparent integration and achievement of an organization's social, environmental, and economic goals in the systemic coordination of key inter-organizational business processes for improving the long-term economic performance of the individual company and its supply chains. [Carter and Rogers 2008]. It could be also treated as: "the management of material, information and capital flows as well as cooperation among companies along the supply chain while taking goals from all three dimensions of sustainable development, i.e. economic, environmental and social, into account which are derived from customer and stakeholder requirements"[Seuring and Müller 2008]. Sustainability in supply chain is an challenge which enterprises try to face by the wide range of strategies, tools and practices identified in literature and practice [[Abbasi and Nilsson 2012; Fabbe-Costes et al 2014; Faisal 2010; Svensson 2007].
The paper presents results from international research conducted in Poland, United Kingdom, Greece and Italy on 227 surveyed companies aimed at environmental aspects regarding green practices in their supply chains.

GREEN PRACTICES IN THE LITERATURE

Companies can perform many different green practices in their supply chains. The publications present the review of the literature [Diabat, Khodaverdi and Olfat 2013; Genovese, Koh, Bruno, Esposito 2013], survey research results [Zhu, Sarkis and Geng 2005; Vachon, Klassen 2006; Vachon 2007; Zhu, Sarkis, Laic 2012; Kenneth et al 2012], case studies [Lee and Cheong 2011, Khairani, Rajamanoharan, Thirumanickam 2012] and comparative studies on the green supply chain practices [Vijayvargy and Agarwal 2013].
Green practices can be divided into internal and external one. The former refers to the single company and the latter to the scope of supply chain [Zhu, Sarkis and Geng 2005]. Two types of green supply chain practices can be defined. First type is the environmental cooperation. It means involving partners in planning and development of environmental activities (e.g. sharing knowledge during seminars and workshops) and environmental solutions (pollution and control) to reduce environmental impact more effectively [Vachon 2007]. Environmental monitoring refers to the supplier environmental assessment, using e.g. questionnaires and audits [Min and Galle 2001]. It involves evaluation and control of suppliers in arm's length transaction [Vijayvargy and Agarwal 2013].
There are many different green supply chain practices [Zhu, Sarkis, Laic 2012; Diabat, Khodaverdi and Olfat 2013]. In general, they refer to relationships with suppliers (both procurement and collaboration with suppliers on product and processes improvement), relationships with customers (mainly product development and collaboration in the field of distribution logistics) and internal logistics in the single company.
Many researches take into account following areas of green practices: internal proactive environmental management, green purchasing, supplier managed inventories and services, environmentally conscious design (eco-design) [Xianbing et al 2012, Xiangmeng et al 2012]. Green practices can also be pointed for three areas of the supply chain: upstream, focal company and downstream. Upstream green practices refer to the cooperation with suppliers, whereas downstream – buyers [Azevedo, Carvalho and Cruz Machado 2011].
Green practices influence value creation in supply chain [Rania 2012]. In turn, implementation of green innovations effectively requires the involvement of many links like suppliers and clients [Jensen et al 2013]. Supply chain integration is one of the green practice. It can be expressed as a logistical and technological integration. It was proven that technological integration with key clients and suppliers positively influences environmental collaboration and monitoring, whereas logistical integration only has impact when involves key suppliers [Zhu, Sarkis and Geng 2005].
In order to reach environmentally preferable procurement, companies can use green assessment criteria for supplier selection. The literature suggest using criteria focused on green design capability, environmental staff training, energy efficiency, resource consumption, environmental management system and waste management [Genovese et al 2013].

Research results show that green supply chain practices are strictly connected with supply chain performance and determine:

- environmental performance (i.e. reduction of air emission, waste water, solid wastes, decrease of consumption for hazardous/harmful/toxic materials, decrease of frequency for environmental accidents);
- operational performance (on the one hand: decrease of cost for energy consumption, decrease of environmental fees, fines but on the other hand: increase of investment, operational cost, green purchasing costs);
- economic performance (i.e. better punctuality of deliveries, less inventory, improved product quality) [Zhu, Sarkis and Geng 2005; Zhu, Sarkis, Lai 2007; Green, Zelbst, Meacham, Bhadauria 2012].

Green supply chain practices are determined by different internal and external drivers e.g. legal regulations, competition, environmental attitude [Zhu, Sarkis and Geng 2005, Lee 2008, Holt and Ghobadian 2009; Xianbing et al 2012] and barriers e.g. lack of environmental awareness, knowledge, transparency in supplier-buyer relationships [Mathiyazhagan et al 2013; Drohomeretski, Gouvea da Costa and Pinheiro de Lima 2014; Rauer and Kaufmann 2015].

METHODOLOGY, RESEARCH RESULTS AND FINDINGS

The research was conducted within an EU funded project – Press – Promoting environmentally sustainable SMEs. The aim of PrESS is to develop an online decision support system (DSS) that will allow European companies monitor and assess their current decision-making strategies in relation to environmental concerns, adopt low carbon decision-making patterns, and develop a long-term plan for low carbon management and environmental sustainability of their supply chains. One of the projects' tasks aimed at conducting a survey in Poland, United kingdom, Italy, and Greece aiming at identifying green practices performed by SMEs in the selected countries. Other research targets focused on identifying "green" Key Performance Indicators, drivers and barriers to the adoption of green practices as well as decision making variables with relation to improving the supply chain management towards sustainability. This article aims at presenting the results of green practices, that are in use among the surveyed SMEs.

The questionnaire used in the research within the project was based on Zhu and Sarkis et al approach as it have been widely tested internationally. The study was conducted from April 2014 to February 2015. A total number of 227 valid responses was obtained with the following distribution among the participating countries: Poland – 98 questionnaires, United Kingdom – 44 questionnaires, Italy – 41 questionnaires and Greece – 44 questionnaires. The questionnaires were addressed to managers (owners /co-owners, senior managers and middle managers) and staff responsible for environmental issues in the companies. The surveyed companies represented following business sectors: manufacturing, construction, food and winery, hospitality, retail/commerce, healthcare services, transportation/spedition/logistics. A following 5 point Likert scale was used for the assessment of the green practices use among the surveyed SMEs – 1 = Not considering it, 2 = Planning to consider it, 3 = Considering it currently, 4 =, 5 = Implementing successfully.

The table below shows shares of companies on different implementation stages of the green practices in Poland, United Kingdom, Italy and Greece.

Table 1. Shares of SMEs at different implementation stages of the green practices

Share of companies	Poland	United Kingdom	Italy	Greece
Not considering to implement the practices	23%	29%	17%	14%
Planning to consider or considering to implement the practices	53%	49%	48%	59%
Initiating implementation of the practices	16%	13%	18%	13%
Implementing the practices successfully	7%	9%	16%	14%

Source: PrESS Project research results

The percentage of companies not considering to implement any of the green practices was the largest in the United Kingdom (29%) and Poland (23%) whereas the smallest in Greece (14%) and Italy (17%). The largest number of SMEs planning to consider or considering to implement the practices was identified in Greece (almost 60%). In terms of actual implementation the largest share of SMEs was identified in Italy (total of 34%) – 18% could be described as companies iinitiating implementation and further 16% as those that are implementing the green practices successfully. In the rest of the countries a share of about 25% of SMEs initiating implementation or implementing the practices successfully was observed.

With regard to green practices implementation, Polish SMEs mainly focus on changes of processes to improve energy efficiency, reduce air and/or odour pollution and reduce consumption of hazardous/toxic/harmful materials. Sustainability aspects are taken into consideration at the product design stage (designs of products for reduced consumption of material/energy) and during energy/environmental audits. The environmental awareness is being built both externally - in the whole supply chain (as Polish SMEs redesign supply chain/logistics components for greater environmental efficiency and provide design specifications to suppliers that include environmental requirements) and internally (as Polish SMEs provide environmental training and education for employees, as well as senior management commits to implementing environmental measures).

Table 2. Current use of selected green practices of SMEs in Poland

Green practices performed by the surveyed SMEs	Mean	SD
Changes of processes to improve energy efficiency	3,11	1,26
Designs of products for reduced consumption of material/energy	2,90	1,18
Redesign supply chain/logistics components for greater environmental efficiency	2,87	1,25
Changes of processes to reduce air and/or odour pollution	2,78	1,29
Energy/environmental audits	2,75	1,15
Changes of processes to reduce consumption of hazardous/toxic/harmful materials	2,73	1,37
Provides environmental training and education for employees	2,70	1,31
Provides design specifications to suppliers that include environmental requirements	2,69	1,32
Senior management commitment to implementing environmental measures	2,69	1,32
Improving environmental performance usually improves profit gains	2,68	0,85

Source: PrESS Project research results

In the United Kingdom the most frequently implemented green practices focus on sustainable product development (designs of products for reduced consumption of material/energy, designs of products for reuse, recycle, recovery of material, component parts, designs of products to avoid or reduce use of hazardous products). Furthermore the SMEs in united Kingdom aim at implementing changes in process to improve energy efficiency, reduce consumption of hazardous/toxic/harmful materials and reduce water and/or solid waste. Another highlighted aspect is the senior and middle management commitment and awareness in the area of environmental issues as well as energy/environmental audits.

Table 3. Current use of selected green practices of SMEs in United Kingdom

Green practices performed by the surveyed SMEs	Mean	SD
Designs of products for reduced consumption of material/energy	3,13	1,41
Changes of processes to improve energy efficiency	3,08	1,38
Senior management commitment to implementing environmental measures	3,04	1,31
Energy/environmental audits	3,00	1,47
Changes of processes to reduce consumption of hazardous/toxic/harmful materials	3,00	1,37
Mid-level management support for the implementation of environmental measures	2,96	1,27
Designs of products for reuse, recycle, recovery of material, component parts	2,94	1,39
Designs of products to avoid or reduce use of hazardous products	2,94	1,48
Changes of processes to reduce water and/or solid waste	2,89	1,37
Senior and middle managers awareness of the importance of environmental issues	2,75	0,80

Source: PrESS Project research results

Changes of process are also crucial in terms of green practice implementation for Italian SMEs. More important (comparing to Poland and United Kingdom) is raising the environmental awareness of the employees. Another specific issue that arise in case of companies in Italy is systemic approach and wide implementation of green practices such as: “Subscription to ISO14001 certification”, “Total quality environmental management”, “Environmental Management System (e.g., ISO14001)”. Similarly as in the United Kingdom the awareness and commitment of senior and middle management to implementing environmental measures. Less important comparing to other countries is the sustainable approach at the design stage of products.

Table 4. Current use of selected green practices of SMEs in Italy

Green practices performed by the surveyed SMEs	**Mean**	**SD**
Changes of processes to reduce air and/or odour pollution	3,41	1,37
Senior management commitment to implementing environmental measures	3,40	1,50
Provides environmental training and education for employees	3,27	1,53
Changes of processes to reduce consumption of hazardous/toxic/harmful materials	3,25	1,32
Subscription to ISO14001 certification	3,21	1,42
Designs of products to avoid or reduce use of hazardous products	3,17	1,42
Senior and middle managers awareness of the importance of environmental issues	3,13	0,90
Total quality environmental management	3,13	1,26
Provides design specifications to suppliers that include environmental requirements	3,11	1,42
Environmental Management System (e.g., ISO14001)	3,10	1,40

Source: PrESS Project research results

The Greek SMEs mainly focus on two areas regarding green parties implementation, that are designs of products and changes to process are most frequently implemented. Furthermore implemented green practices cover energy/environmental audits (similarly to Poland and United Kingdom), systemic aspects - Environmental Management System - e.g., ISO14001 (similarly to Italy) and middle level support for implementation of environmental measures.

Table 5. Current use of selected green practices of SMEs in Greece

Green practices performed by the surveyed SMEs	**Mean**	**SD**
Designs of products to avoid or reduce use of hazardous products	4,00	1,18
Changes of processes to reduce water and/or solid waste	3,88	1,13
Changes of processes to reduce consumption of hazardous/toxic/harmful materials	3,75	1,28
Designs of products for reduced consumption of material/energy	3,69	1,38
Changes of processes to improve energy efficiency	3,53	1,30
Designs of products for reuse, recycle, recovery of material, component parts	3,42	1,56
Changes of processes to reduce air and/or odour pollution	3,25	1,39
Energy/environmental audits	3,17	1,47
Environmental Management System (e.g., ISO14001)	3,13	1,59
Mid-level management support for the implementation of environmental measures	2,94	1,29

Source: PrESS Project research results

SUMMARY

During last decades the topic of optimization of supply chains was enriched by the notion of the sustainability. It suggests that besides typical economic issues also social and environmental concerns should be taken into account. One of the crucial aspects in sustainable supply management is its environmental context.

The presented paper shows research results conducted on SMEs regarding their approach to green practices. The study shows that the topic of environmental aspects is important in all countries. It gives the reflection that the challenge of making supply chains more sustainable seems to be essential. Companies declare that they are planning and considering the implementation of green solutions. The main directions in which companies improve their environmental performance are similar, however the differences appear when taking about the subject of possible actions and initiatives. The research revealed a space for further research to explore reason of these differences taking into account such factors like: cultural context and law regulations.

DISCLAIMER

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DEVELOPING EVALUATION SYSTEM OF GREEN SUPPLY CHAIN USING "SELF-ASSESSMENT SYSTEM" (INTERNAL AUDIT)[1]

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Abstract

Purpose of this paper:

Considerations have based on the attempt to find answers to the question, whether it is need a evaluating system for green supply chain. If so, what kind of tools and methods should be used for such an evaluation. It has not yet developed a unified evaluation system, which could be used for different types of supply chains.
The subject of green and sustainable supply chain is described in the literature for over 25 years. Also it is showing interest in business practice and implement various elements and principles of green supply chain. During the implementation of processes paid attention to environmental aspects and sustainable development. Therefore, it should consider what tools to use to evaluate such a chain. Analysis of the literature and practical implementations indicates, that the most commonly are used in the supply chain single tools, there is no collective assessment instruments. It turns out, however, that the use of the individual components, such as: ISO 1400X or ecological audit may be insufficient for a full assessment of the chain.

Given the above aspects puts itself to the following hypotheses:

H2: Properly selected components and parameters of audit for green supply chain may indicate how and which parts of the chain should be assessed, at what angle and how often

Design/methodology/approach:

To achieve the objective of the research will be conducted review and study of literature, reports and case studies. Deductive method will be used.

Findings:

The presented considerations are one of the stages of research. Indicated features and components of audit for green supply chain, as one of the elements of the assessment, are to be used as a contribution to the discussion and create a full assessment instruments for green supply chain.

Value:

Originality of considerations lies in the presentation of new, author`s solutions (components) included in the frame widely understood audit for green supply chain.
On the basis of available and already often used tools, methods, you can create an assessment tool (form will audit), which will serve as a benchmark and enable comparison of their position (and the degree of greenness of chain) to other organizations operating in the market. The proposed tool with the indicated, examples of elements of the assessment can be widely used in business practice as well as in the scientific field. On the one hand, it will give the opportunity to evaluate the chain and on the other to compare their position in the market.

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1. Introduction

The considerations in this paper are based on a sample of finding an answer to the question, how do evaluate green supply chain, and if broad understanding of the evaluation system is appropriate and helpful. Itis interesting to find the answer whether the self-assessment system providing the possibility of comparisons with competitors using computer tools which will be an effective instrument for this type of evaluation. Until now, there is developed a uniform evaluation system that could serve as a model. This does not mean that supply chains are not assessed. In assessing of chains (including their efficiency) will economic, legal, social, environmental or management tools used. In the context of the discussion, it is important to note how extensive should be the evaluation model. It seems to be interesting to indicate, if the currently recommended and used instruments and standards (including ISO) as well as tools (ecological balances, balanced scorecard, audit) ensure efficient and reliable assessment of supply chain.

2. The aims and hypotheses

The aim of the discussion is to present selected tools for the assessment of the supply chain and the characteristics of the basic issues related to the use of audit and internal control in the area of green supply chain. Given the above aspects presents the following research hypothesis: An useful element for the assessment of greening the supply chain can be a green supply chain audit (self-assessment system based on IT tool).

3. State of arts

Issues related to internal audit constantly evolve and include more and more new areas. Citing a Savcuk can be demonstrated that [Savcuk, 2007] "internal auditing is an independent, objective assurance and consulting activity designed to add value and improve a company's operations. It helps an organization accomplish its objectives by bringing a systematic, disciplined approach to evaluate and improve the effectiveness of risk management, control and governance processes". Recalling the definitions of strategic documents published primarily in the US, please indicate of the element of evaluation, such as the expansion of both: the role and scope of internal audit. And so in 1997. IIA Inc. [IIA Inc., 1997] specifies the functions of internal audit as: an independent appraisal function established within an organisation to examine and evaluate its activities as a service to the organisation. The objective of internal auditing is to assist members of the organisation, including that in management and on the board, in the effective discharge of their responsibilities. To this end, internal auditing furnishes them with analysis, appraisals, recommendations, counsel, and information concerning the activities reviewed. The audit objective includes promoting effective control at a reasonable cost". The expanding research on this topic, as well as drawing on the experience of other countries the next document IIA Inc [IIA Inc. 1999] it indicates, the redefinition and extension of information on internal audit, among other things with for the role of risk management. The activities can take place in different areas and fields of surveyed of enterprise or supply chain. "The internal audit activity must have the professionalism, profile and independence to fulfil its role effectively. It must be able to provide an environment of challenge, transparency and candid reporting to the highest level without fear and retribution. Internal audit must provide the focus on risk for the organisation. It must demonstrate a good understanding of the organisation's business operations together with communication and persuasion skills to get its message across". [IIA, 2000]. The international standards could be the benchmark, which give a chance to measure and comparative analysis different companies. Internal audit must be independent to evaluate as a service, processes in the organisation. By measuring and evaluating the effectiveness of organizational controls, with internal audit, get very important managerial control device [Carmichael et al., 1996]. This is directly linked to the organizational structure and the general rules of the business [Cai, 1997]. Presented definitions are fairly general. Searching for specific and dedicated of definition can are presented by Sawyer [Sawyer, 2003], which states that the internal audit is: "a systematic, objective appraisal by internal auditors of the diverse operations and controls within an organization to determine whether (1) financial and operating information is accurate and reliable, (2) risks to the enterprise are identified and minimized, (3) external regulations and acceptable internal policies and procedures are followed, (4) satisfactory operating criteria are met, (5) resources are used efficiently and economically and (6) the organization`s objectives are effectively achieved – all for the purpose of consulting with management and for assisting members of the organization in the effective discharge of their governance responsibilities". The result of audit and its utility is dependent on the measurement method, but also on the subjectivity of the selected criteria, and developed algorithms which are used for measurement. The success and usefulness is determined by activities, their complexity, the specialization of staff and the will of administration. [Papastathis, P., 2003,]. The very important elements are: conceptual framework, internal audit quality, management support, organizational setting, and audit attributes to describe audit effectiveness, and revealed the way the interaction of these factors improves audit effectivenessMihret D. G. and Yismaw A. W., 2007] In the year 2002 in the literature has been show the new definition of internal auditing. It was designed to accommodate the profession's expanding role and responsibilities [Standards for the professional practice]: "Internal auditing is an independent, objective assurance and consulting activity designed to add value and improve an organization's operations. It helps an organization accomplish its objectives by bringing a systematic, disciplined approach to evaluate and improve the effectiveness of risk management, control, and governance processes." Based on the literature, it should be noted, that the tool, which will be cited in the following parts of this paper, is not a typical audit. It is a self-assessment tool, and its scope of the study includes the creation accordance with the audit procedures -checklist and on this basis allows for self-assessment and comparison of the test position this supply chain of other companies in the industry. This means in part the presence of some kind of benchmark, as well as identification its position in reference to the standard, which specifies the greening of the chain. The generated report provides guidance on strengths and weaknesses, as well as tips for taking corrective action, but it does not require the presence of an auditor for the examination.

4. Internal audit at the level of the supply chain

The internal audit of supply chain management include: policies, organizational risks, process risks, major processes, cost-control and performance measures. In this case could be one part of audit focused on green processing and green supply chain. The audit tools could include areas of: safety, performance, environmental, social responsibility, ethics, risk and hazard analysis, resource capabilities, capacity, technical competency, new product development capabilities, financial stability and more. The internal auditing must be efficiency. The effectiveness of audit can be confirmed by using the following five interrelated criteria, components and areas: [Rezaee, 1995; Yang and Guan, 2004]: (1) Control Environment, (2) Risk Assessment, (3) Control Activities, (4) Information and Communication and (5) Monitoring. To use the audit to be carried out appropriate process and to implement this tool adapting them to the needs, in this case - the green supply chain. The control environment can be evaluated based on the following factors: Integrity and Ethical Values, Board and Audit Committee, Management Philosophy and Organizational Structure. The risk assessment component of control can be evaluated based upon the following factors: Process-Level Objectives and Risk Identification. The control activities component of control the following factors are used: Policies and Procedures and Control Activities in Place. The information and communication component the following factors are used: Quality of Information and Effectiveness of Communication. The monitoring component of control is evaluated based upon the following factors: On-Going Monitoring and Separate Evaluations. [Karagiorgos, T., Giovanis, N., & Drogalas, G., 2011]. Internal audit should meet certain of standards. The internal audit is performed in different environment (cultural and legal), which have different objectives, size, complexity and structure of organisation or construction of supply chain. For this reason has been created common basic principles. The principles called Standards on Internal Auditing are being created and announced by the Institute of Internal Auditors. They include basic requirements for implementation of internal audit. More on this topic in: [Savčuk, O. (2007)., NCA Self-Study Committee. (2014)].

As part of the considerations of relating to attempts to create and perform the audit of green supply chain it is a need to focus on the elements compliance audit and performance audit. In this area, you must build a questionnaire that will allow drawing conclusions as it can be understandable of greening of the chain, but also make the positioning of chain of the background of other companies and supply chain. At the operational level operating principle is the same. Audit of green supply chain requires commitment and knowledge about the green aspects at the whole chain. A very important element is to obtain information regarding of the greening of processes by the business partners and participants in the chain. In this case, not only will by key suppliers (although their role is extremely important), but also transport companies (for example answer to the question: what choose the means of transport), warehousing, product planning, marketing, etc. A large role will be played here, which implemented standards at the level of the chain, relating to compliance with relevant ISO standards, carbon footprint study whether the implementation of eco-innovation. There is no doubt, that assessment if distinctions are made on the market of the chains, or individual companies, taking into account the ecological and environmental aspects. However, it should consider whether having the ISO 1400x is a sufficient element to pointing to the greening of the chain. It seems that this type of tools and marketing tools are insufficient.

5. Tools and methods of assessment the greening of supply chain

The basic purposes of GSCM in area of performance measurement (PM) are: external reporting (economic rent), internal control (managing the business better) and internal analysis (understanding the business better and continuous improvement). These are the fundamental issues that drive the development of frameworks for business performance measurement. It is important to consider both purpose, as well as the interrelationships of these various measurements [Hervani, A. A., et.al. 2005]. In the assessment of greening of supply chain is important: a number of environmentally conscious practices are evident throughout the supply chain ranging from green design (marketing and engineering), green procurement practices (e.g. certifying suppliers, purchasing environmentally sound materials/products), total quality environmental management (internal performance measurement, pollution prevention), environmentally friendly packaging and transportation, to the various product end-of-life practices defined by the "Re's" of reduction, reuse, remanufacturing, recycling [Hervani, A. A., et.al. 2005]. Depending of the number of relationships in the supply chain, customers, suppliers, you can create different systems of measurement and evaluation of the supply chain. In the case of the green supply chain, the indicated above elements will play the biggest role. On the basis of observation and analysis of implementations its show that pro-active approach to the environmental aspects of the company will play a big role in the creation, but also in the assessment of green supply chain [for example Drumwright, 1994; Cramer, 1996; Ellram and Ready, 1998].The assessment tools can be shared by different criteria. Relying on [Hervani A. A., et.al. 2005]. measurement can be considered as: internal and external issues and organizational factors. That means a big challenge for companies operating in the supply chain. They need to create or customize the appropriate organizational structures to implement eco-innovation, in order to achieve its goals related to the reduction of negative impact of the chain on the environment, including using less of resources and producing less of waste. [Clayton et al., 1999]. Motivator to take action (including in the field of environmental assessment) are economic factors. To succeed in the economy is not enough knowledge about the product, its characteristics, process and available technologies, and markets. Very important are the environmental aspects. And to get the succeed in this field requires the application of knowledge in this area too. Assessment of the supply chain from the point of view of environmental frequently for the most important factor considered is the environmental performance indicators in the area and the area of activities, processes, hardware and services. These indicators are described in ISO 14031 (environmental management-environmental performance evaluation of the ISO 14001 accreditation guidelines). ISO 14031 is designed for use in environmental performance evaluation with indicators in three key areas: (1) environmental condition indicators; (2) operational performance indicators; and (3) management performance indicators. In addition six subcategories identify inputs of materials, energy and services, the supply of inputs, the design installation, maintenance, and operation of the physical facilities and equipments, output of products, services, wastes, and emissions, and finally the delivery of outputs. The ISO standard is a good tool, but it may be not sufficient to assess of the greening of the supply chain. It should remember that these are only guidelines. Selected indicators and elements of assessment must be carried out in accordance with the strategic objectives of the chain, including to be consistent with its vision and mission. They can be implemented at every level of the (operational, tactical and strategic), and reflected in both areas: quantitative and qualitative. The number and scope of environmental indicators is huge. There is a difficulty in determining which ones to use, how and where to measure, in which companies the evaluation should be applied. Different individuals may interpret them differently, they can be calculated using various assumptions which ones and at what level should be investigated. To make such a measurement of supply chain must be resolve many issues and answer of many questions. It should be remember, that each link in the supply chain, is also a subject to different circumstances. The conducting of environmental audit (internal control) requires the identification and analysis of environmental areas covered by the legal regulations concerning: (1) general legal requirements; (2) waste management; (3) packing management, (4) water and sewage management, (5) air emissions, (6) the impact of acoustic (7) hazardous substances, (8) environmental policies and procedures, (9) other activities affecting the environment. The objective of the audit of green supply chain is not only to investigate what changes in financial indicators triggers examples of indicators and measures of logistics and whether these changes are beneficial for supply chains, but an indication of other elements, in addition to the financial performance, are important to the overall assessment of the green supply chain. Internal audit has to be only element supporting, as such for example carried out at the level of the whole chain of ecological balance sheets.

6. Construction of assessment model of green supply chain - examples of areas and the use of "self-assessment of green supply chain using the IT platform”

Frequently, relating to the construction of supply chain the assessment model is using performance measure. By developing a model of green supply chain assessment seems it reasonable, that in addition to the chain efficiency and economic-financial aspects are used in other elements. One of the additional elements (although largely covering performance measurement) may be green by internal audit, to other useful tools include: environmental analysis, balanced scorecard, life cycle analysis and AHP, ecological balance sheets as well as compliance with ISO14031 standard assumptions. Some of the tools can be directly used to assess and build of GSCM and others require adaptation, adjustments and extensions. In the literature are described examples of the use of environmental impact studies along the supply chain with, for example: EcoScan [Faruk, et. al., 2002] analysis tools to the model based on the life cycle of products and environmental aspects. Another way might be to use AHP method [i.a. Handfield et al. (2002), Pineda, Henson et al. (2002) and Sarkis (2003], as part of supporting to the decision process account the dimensions and environmental aspects. An important element is also balanced scorecard [Kaplan and Norton, 1992]. The balanced scorecard suggests organizational performance be viewed from four perspectives, and to develop metrics, collect data and analyze the organization relative to each of these perspectives: (1) the learning and growth perspective; (2) the business process perspective; (3) the customer perspective; and (4) the financial perspective. The paying of attention to environmental aspects and sustainability, and to extend the BSC was in the research papers [Epstein and Wisner, 2001].
Another element is the environmental balance which is a comprehensive systematic analysis to identify the complex impact of business on the environment. As a result, not only allows you to estimate the impact of production on the environment, but also provides an indication of remedies to address persistent minimize or eliminate the effects of these interactions. The requirements of ISO14031 standard will include among other things, elements related to environmental performance, economic performance, operational performance [Zhu, Q., et al., 2008]. The same authors also propose to the evaluation and practical implementation of GSCM use of 21 elements divided into 5 areas

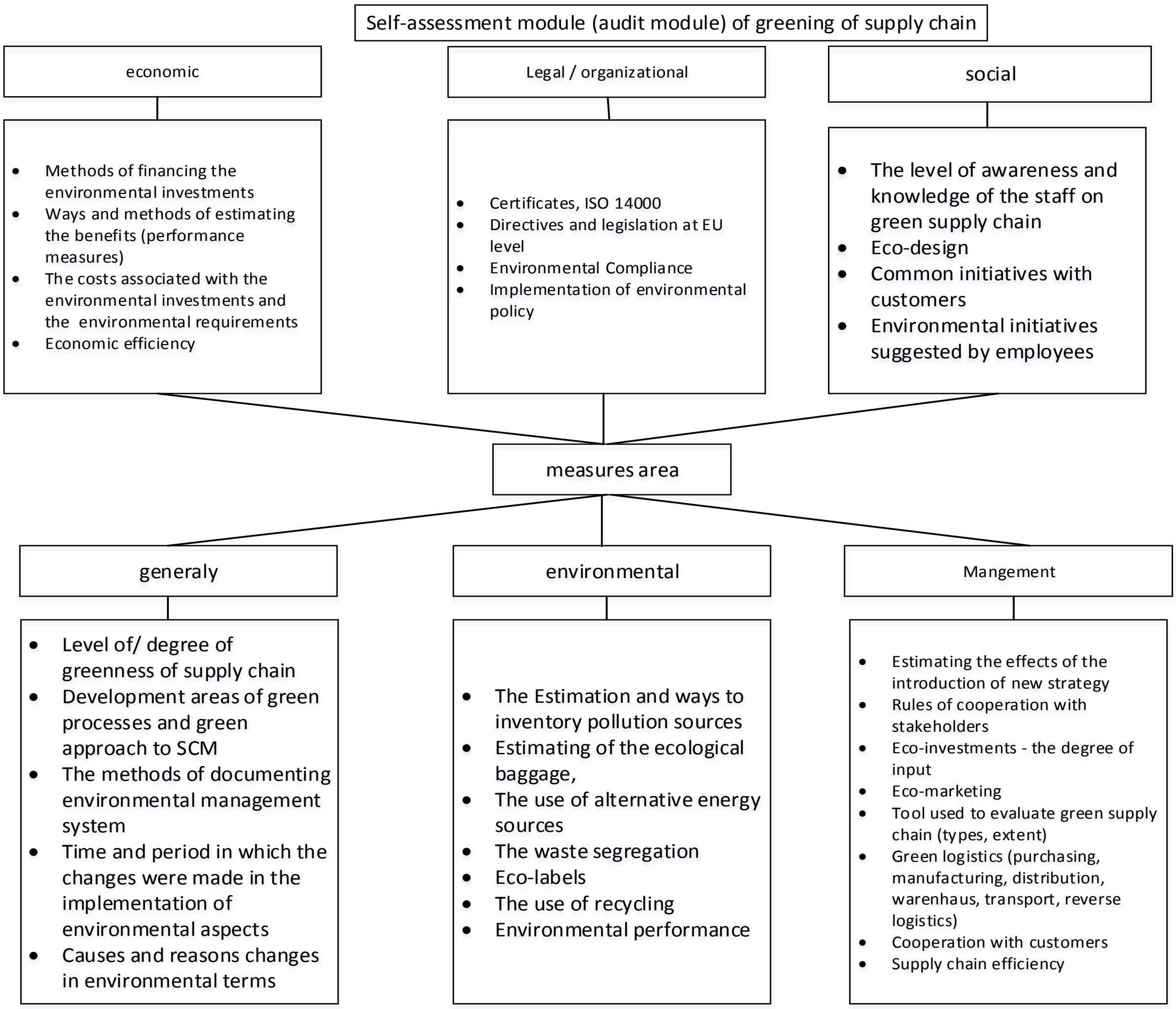
- Internal environmental Measurement items management: (1) Commitment of GSCM from senior managers, (2) Support for GSCM from mid-level managers, (3) Cross-functional cooperation for environmental improvements, (4) Total quality environmental management, (5) Environmental compliance and auditing programs, (6) ISO 14001 certification, (7) Environmental Management Systems exist;
- Green purchasing: (8) Eco-labelling of Products, (9) Cooperation with suppliers for environmental objectives, (10) Environmental audit for suppliers’ internal management, (11) Suppliers’ ISO14000 certification, (12) Second-tier supplier environmentally friendly practice evaluation;
- Cooperation with customers: (13) Cooperation with customers for eco-design, (14) Cooperation with customers for cleaner production, (15) Cooperation with customers for green packaging;
- Eco-design: (16) Design of products for reduced consumption of material/energy, (17) Design of products for reuse, recycle, recovery of material, component parts, (18) Design of products to avoid or reduce use of hazardous products and/or their manufacturing process;

- Investment recovery: (19) Investment recovery (sale) of excess inventories/materials, (20) Sale of scrap and used materials, (21) Sale of excess capital equipment.

The analysis of literature and practical implementation allowed to us and to create a catalogue of questions that can applied as a base to conduct an audit (self-assessment) green supply chain. The result of the research by using assessment tools presented green supply chain to indicate position of the supply chain and companies involved in the market as well as comparison with other chains and companies in the market. The construction of assessment model covers not only the financial aspects but also organizational, social and economic. Self-assessment tools are developed for the supply chains, which are made up of a directory of questions in different areas, whose design allows for subsequent evaluation and comparison of their situation and the degree of greenness with other entities (chains) active on the market. Figure 1 presents a catalog of areas and examples of issues relating to self-assessment in area of greening of the chain[2]. As can be seen, it is a combination of issues contained in ISO 14031, assumptions of BSC, environmental stewardship, economic, social and operational level and in terms of research productivity and ecological balance. Author's approach includes the use of the above described tool to build a full tool, to evaluate the environmental performance of the supply chain. Products including approximately 50 questions in each area and covers a broad spectrum of issues. An innovative element in this approach is to evaluate the use of the internet platform and a very broad approach to the subject. In the quick way supply chains could to test the situation and gets answers how its position in the market is. Based on an respectively algorithm and factor analysis obtained answer to the basic question - the overall greening in the supply chain, as well as specific questions relating to specific areas.

[2] List of questions served as the basis for research using IT audit tool. Self-evaluation will take place after the introduction of data by the internet platform. Interpretation and evaluation algorithm will point unit and compared with other organizations and point to its place and position in the market in this (greening) area.

Figure 1 Self-assessment model – degree of greening of supply chain



7. Conclusion

The model presented is in the testing phase. After testing answers are given , if so designed tool will be useful for a comprehensive assessment of green supply chain. It seems that his advantage is the wide spectrum of considerations and ease of use. The model will help to assess of greening of supply chains and individual companies. Although it does not entirely meets the requirements of the internal audit, ease of obtaining very relevant dates of greening process should be an asset of such an approach and development tools.

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A SUSTAINABLE ECONOMIC PRODUCTION QUANTITY MODEL

USING EXTENDED EXERGY ACCOUNTING

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ABSTRACT

Extended Exergy Accounting (EEA) has been proposed as a tool to attain environmental, social and economic sustainability in firms, societies and countries. This paper presents a sustainable Economic Production Quantity (EPQ) model based on EEA. We first modify the EPQ model to account for energy and greenhouse gases (GHG) emissions costs. Next, we perform the EEA analysis. Numerical examples illustrate the behaviour of the EOQ-EEA model. The results show that the exergetic cost of a system may better reflect the true amount of consumed resources.

INTRODUCTION

The Economic Production/Order Quantity (EPQ/EOQ) model has been widely used by academicians and practitioners as discussed and celebrated in a recent special issue of the International Journal of Production Economics (Andriolo et al., 2014; Glock et al., 2014). Despite its popularity, some studies have critiqued the EPQ/EOQ model on the basis that its basic assumptions are never met (e.g. Jaber et al., 2004). Environmental concerns and calls for sustainability have steered the inventory research in a new direction. Bonney and Jaber (2011) suggested that classical inventory models do not provide a meaningful basis for analyzing real and practical inventory problems. They were the first to argue that there is a need for new (non-classical) forms of inventory analyses to solve many of the environmental problems that relate to production, logistics, product use/reuse, logistic, etc. These non-classical models are reviewed in Andriolo et al. (2014) and Bushuev et al. (2015).

Sustainable development can be attained by being conscientious about the environment and the utilization of natural resources. Exergy analysis is a useful tool in that regard. Exergy is the useful amount of energy that can be obtained from a system. It analyses the inputs (material, energy, labour, capital, equipment) and outputs (products, by-products, heat and emissions, waste, losses) of a system including the destroyed and wasted exergy in order to improve the system's efficiency and its environmental and economic performance (e.g., Balomenos et al., 2011). Exergy measures the potential of material and energy to do work (Gutowski et al., 2006). Its advantage is that it allows input and outputs to be expressed in a single unit, joules. In this regard, EEA, introduced by Sciubba (2001), assigns equivalent exergetic values to a system's inputs and outputs.

Production and inventory activities and transport are among the activities responsible for producing GHG emissions across a supply chain. The amount of GHG (especially CO2) emitted is also used to evaluate the environmental performance of a business firm. Various schemes of pricing emitted carbon have been introduced in recent years to encourage businesses, enterprises and individuals to look for tools and strategies to reduce carbon pollution. One would be to determine a production and inventory policy that measures and possibly minimizes the costs and environmental implications of its activities and the related GHG emissions costs. Andriolo et al. (2014) and Bushuev et al. (2015) reported several works that investigated how to reduce GHG emissions in inventory and logistics systems. Energy costs have recently been considered in production and inventory systems (e.g., Zanoni et al., 2014). In this regard, EEA has been used to capture the exergetic cost of GHG resulting from energy generated from non-renewable resources (Dai et al., 2014).

Jawad et al. (in press) is the only available work that applies EEA to the classical EOQ model. The exergetic version of the EOQ model they developed was used to calculate and analyse the size of the EOQ and the total cost of the inventory systems for three firms located in the USA, Germany and China. Their results showed that using the classical EOQ, based on traditional costing approaches as a decision tool favours China over the USA, while the opposite was true when the decision was based on the exergetic model. They showed that in some circumstances the lowest cost solution could be the worst exergetic solution.

This paper derives an exergetic version of the EPQ model to compute the amount of exergy consumed when producing and storing an item. Before doing so, it adds two cost functions representing energy usage and GHG emissions, which Jawad et al. (in press) did not consider. The paper then applies the EEA concept to the modified EPQ model.

The rest of this paper consists of four sections. Section 2 presents a very brief background to the concept of exergy and exergy analysis. Section 3 introduces the concept of an exergetic EPQ model which it then uses to select the optimal EPQ that reduces the sum of the costs of production (including material and labour), inventory, energy, and GHG emissions. Section 4 presents a numerical analysis of the model, the results, and some discussion. Section 5 adds some concluding remarks.

A BRIEF BACKGROUND TO EXERGY

"Exergy" is a thermodynamic term representing the maximum amount of useful work a source or a system can produce/generate at a given state when interacting with a reference point (the environment) at a constant condition. In other words, exergy is the useful amount of energy that can be obtained from a system (Dincer and Rosen, 2004). Exergy analysis can be used to describe and examine energy, work and material flows entering and leaving a production system.

The cost of a commodity (c) is broadly expressed by a "production function", which is the sum of the costs paid to cover the material (M), energy (E), labour (L), capital (K), and environment remediation (O) if it is applicable; i.e., $c = f\,(M, E, L, K, O)$ (Sciubba, 2009). Sciubba (2004) provided specific exergy equivalent, ee, of one monetary unit for capital, ee_K, and labour, ee_L, measured in Joules per working hour, e.g., J/$. There is no equivalent ee needed for energy as it is already measured in joules, where its exergetic cost is Ex_{Eg}. Readers may refer to Jawad et al. (in press) for a brief discussion on how to compute the ee measures. The exergetic cost of the environment remediation, $Ex_{En} = C_{En}.ee_K$, where C_{En} is the annual cost of waste, recycling, recovery and any other process related to the environmental remediation. It can also be any carbon tax, penalty or other mechanism that pays for the protection of the environment. Other exergetic costs are material, $Ex_M = C_M.ee_K$, labour, $Ex_L = C_L.ee_L$, and capital, $Ex_K = V.ee_K$, where C_M, C_L and V are the annual material, labour and investment capital (if any), respectively. The annual exergetic cost of a system to produce and deliver a commodity can be obtained by adding the exergetic equivalents as:

$$EEA_{Commodity} = Ex_M + Ex_{Eg} + Ex_K + Ex_L + Ex_{En} \tag{1}$$

The values of ee vary from country to country as described in Sciubba (2004). The exergy lost (or destroyed) in the system is due to inefficiencies (entropy in thermodynamics). The exergy is not all translated into products, as part of it is destroyed; e.g., as a result of producing scrap, idle workers and machines, producing pollution and waste.

The next section applies the EEA concept to the EPQ model and shows that using the classical approach to analyze inventory systems may result in policies that are less sustainable.

THE EXERGETIC EPQ MODEL

The EPQ unit of time cost function is givens as:

$$TC(Q) = \frac{Ad}{Q} + h\frac{Q}{2}\left(1 - \frac{d}{p}\right) + c_M d + c_L\frac{d}{p} \tag{1a}$$

where A is the setup cost (\$), h is the unit holding cost (\$/unit/year), c_M is the unit material cost (\$/unit), c_L is the unit time labour cost (\$/year), d is demand rate (units/year), p is the production rate (units/year; where $p > d$), and Q is the economic production quantity and a decision variable (units); with $C_M = c_M d$ and $C_L = c_L\frac{d}{p}$. Narita (2012) and Jaber et al. (2013) reported that CO2 emissions are a convex function of the production (processing) rate; $E(p) = ap^2 - bp + c$ where a, b and c are positive parameters and $E(p)$ is measured in ton-CO2/unit, with minimum emissions when the production rate is $p^* = b/2a$. Gutowski et al. (2006) reported that the energy required to process a unit is expressed as $Eg(p) = k_0 + k/p$ where k is the power in kWh or mega-joules/year and k_0 is kWh or mega-joules/unit. If we include CO2 emissions cost and energy costs in Eq. (1a), it becomes:

$$TC(Q) = \frac{Ad}{Q} + h\frac{Q}{2}\left(1 - \frac{d}{p}\right) + c_M d + c_L\frac{d}{p} + c_{En}d(ap^2 - bp + c) + c_{Eg}d\left(\frac{k_0}{p} + k\right) \tag{1b}$$

Where $c_{En}$is the emission cost (\$/ton-CO2), and c_{Eg} is the unit energy cost (\$/kwh). Eqs. (1a) and (1b) are minimized when $Q = \sqrt{2Ad/h(1 - d/p)}$.

The exergetic form of Eq. (1b) is written as

$$\begin{aligned} TC_x(Q) = {} & \frac{A_x d}{Q} + h_x\frac{Q}{2}\left(1 - \frac{d}{p}\right) + c_M d ee_K + H\frac{d}{p}ee_L + c_{En}d(ap^2 - bp + c)ee_K + \\ & d\left(\frac{k_0}{p} + k\right) \end{aligned} \tag{2}$$

where H is the number of work hours per year (c_L/w where w is the hourly wage), A_x the exergetic setup cost and is estimated as $A_x = A_K ee_K + A_L ee_L/w + A_{En} ee_K$, where $A = A_K + A_L + A_{En}$ and A_i is the portion of A attributed to i = K, L and En. Similarly, $h_x = h_K ee_K + h_L ee_L/w +$

$h_{En}ee_K$. The economic exergetic order quantity, Q_x, that minimizes (2) is $Q_x = \sqrt{2A_x d/h_x(1-d/p)}$. Note that $Q_x/Q = \sqrt{A_x h/Ah_x}$, which is different from 1 because $ee_K \neq ee_L$.

If the firm operates according to its EPQ policy, then the inventory related costs, $C(Q) = \frac{Ad}{Q} + h\frac{Q}{2}\left(1-\frac{d}{p}\right)$ or $C = \sqrt{2dAh\left(1-\frac{d}{p}\right)}$, will be a minimum; however, its exergetic equivalent will not, and vice versa. Another important parameter is the production rate. Slower production rates (p values closer to d) reduce inventory related costs (classical and exergetic), but increases energy and emission costs, especially if the operational value if p is not optimal to reduce emissions; i.e., $p \neq p^* = \frac{b}{2a}$. The next section illustrates and compares the behavior of the classical and exergetic EPQ models.

NUMERICAL RESULTS

The following example relates to a production facility for which the following values of the input parameters with appropriate units are used (some of these values are taken from Jaber et al., 2013): d=1000 units/year, p =1250 unit/year, A = 1200 \$/order, h =10 \$/unit/year, c_M = 20 \$/unit, c_L = =24000 \$/year, w = \$24/WH, a = 3.00E-7 ton.year^2/unit^3, b=12.00E-04 ton.year/unit^2 and c=1.4 ton/unit. Assume that a production plant located in California, USA plans to price carbon with a value of c_{En} =18\$/ton-CO2. To determine the cost of energy consumed during the production process, the following parameters are used: k=50000 kWh/year and k_0=100 kWh/unit (1kWh = 3.6 MJ), with c_{Eg} = 0.1 \$/kWh. Waters (2003) noted that the holding cost per unit is 10-15% of the cost of money, 2-5% is storage space related, 4-6% is loss, 1-2% is handling, administration is 1-2%, and insurance is 1-2%. These percentages may translate, roughly, to at least 50% capital, 40% labour, and 10% environmental costs. That is, A_K = 0.5A, A_L = 0.4A, and A_{En} = 0.1A and similarly for h_K, h_L, and h_{En}. For a firm that is located in the USA, then ee_K = 3.18 MJ/\$ and ee_L = 72.8 MJ/WH (Jawad et al., in press).

The optimal solution for the classical model occurs when Q = 1095.45 units with a cost, TC, \$60,933.45 from Eq. (1b). The exergetic values of A and h, are A_x = 3745.6 MJ and h_x = 31.21 MJ/unit/year, which are calculated as explained earlier. The exergetic EPQ, Q_x, is the same as Q since $A_x/A = h_x/h$ and the exergetic cost, TC_x, is 653,785.75 MJ/year.

If the firm treats its production rate as a decision variable, then the production rate that minimizes (using Excel Solver) Eq. (1b), after replacing Q with p, is 2429.72 units/year corresponding to TC = \$48,414.62 where Q = Q_x = 638.64 units and TC_x= 553,993.68 MJ/year. This suggests that focusing on optimizing p reduces TC by about 21% (from \$60,933.45 to \$48,414.62) and TC_x by about 15% (from 653,785.75 MJ/year to 553,993.68 MJ/year). This suggests that minimizing the inventory costs may not be relevant in such situations as they are insensitive when Q deviates, within a range, from its optimal value. The production rate that minimizes TC_x in Eq. (2) is p = 2863.84 units/year where TC_x = 548471.21 MJ/year, Q = Q_x = 607.26 units, and TC = \$49735.20.

The above results suggest that if the firm minimizes TC, not TC_x, subject to p, it saves \$1320.58 (\$49735.20 – \$48,414.62) but pays an additional 5522.47 MJ/year (553,993.68 MJ/year – 548471.21 MJ/year), which is equivalent to \$1736.63 (5522.47 MJ ÷3.18 MJ/\$). If the firm saves \$1320.58, then \$1736.63 is paid by the society, suggesting a loss \$416.05

to all; whereas, if the firm minimizes TC_x, not TC, the firm and the society gain \$416.05. One can deduce that minimizing TC_x is more meaningful than minimizing TC.

Let us assume that the firm would like to focus on reducing its CO2 emissions only, then it has to operate at $p^* = b/2a$ = 2000 units/year, which reduces emissions to a minimum, where Q = 682.82 units, TC = \$49,834.55, and TC_x = 572260.62 MJ/year. This does not seem to be a good policy as the firm and the society will lose a total of \$7580.26 (\$49,834.55 − \$ 49,735.20 + (572,260.62 MJ/year − 548,471.21 MJ/year)÷3.18 MJ/\$). The numerical example considers a total annual labour cost of \$24,000 at w = \$24/hour, suggesting 1000 work hours. Intuitively, w = \$30/hour or 800 work-hours suggests a more productive workforce can accomplish the desired task with 800 instead of 1000. Then TC_x = 542401.76 MJ/year is minimum, and TC = \$49,555.30 when p = 2811.36 units/year. The savings to the firm and the society total \$516.20 (\$49735.20 − \$49,555.30 + (548471.21 MJ/year − 542401.76 MJ/year)/3.18). A less productive workforce, w = \$18/hour or 1333.33 hours, results in TC_x = 558473.30 MJ/year is minimum, and TC = \$ \$50,049.63 when p = 2913.71 units/year, where \$3459.74 (\$50,049.63 − \$49735.20 + (558,473.30 MJ/year − 548471.21 MJ/year)/3.18) is the joint loss of the firm and the society. These results suggest that a more productive workforce reduces the exergetic consumption of resources, or leads to a more sustainable alternative. We varied w over the range 10 to 40, while keeping the values of the other input parameters unchanged. The results showed that TC_x reduced by about 9% (from 589638.28 MJ/year to 536277.79 MJ/year) and TC by about 3.5% (from \$51149.13 to \$49383.01), which translates to savings of \$18,546.14 to the firm and society.

We investigated the model for changes in the primary inventory parameters, which are A and h and varied each of them while keeping the values of the other input parameters unchanged. Setup cost A was varied from \$100 to \$1200 and h from 4 to \$20/unit/year. This showed that TC_x reduced by about 1.6% (from 539690.2 MJ/year to 548471.2MJ/year). These results suggest once more that using the classical approach of determining the lot size policy may no longer be appropriate to make inventory management decisions in a non-classical era (Bonney and Jaber, 2011).

SUMMARY AND CONCLUSIONS

This paper extended the economic production quantity (EPQ) model to include energy and greenhouse gases emissions costs. Later, it presented an exergetic version of the suggested model by introducing concepts from extended exergy accounting; a mechanical engineering concept that measures resource consumption in a system. Its unit of measure is in joules.

The results showed that the classical approach of determining the EPQ that minimises total inventory costs may no longer be appropriate as this results in a significant exergy loss. They also showed that minimising the exergetic cost function, where the production rate is the decision variable, produced better results than the earlier approach, where the firm and society experience savings. This suggests that it is possible to perform the production and inventory activities consuming fewer resources, a sustainability improvement. The results further showed that having a more experienced/productive workforce (even when associated with higher wages) improves the exergetic performance of the system, and that lower setup and holding costs brought little improvements. The latter suggests that focusing on inventory related costs may produce minimal improvements to a system's performance.

Exergy destruction results from the system inefficiencies, which result from entropy generation. A challenge remains about how to disaggregate entropy to capture individual sources, i.e. the entropy that capital, machines, labour, material, energy, pollution, waste, etc., generate. Another extension is to see how productivity increases that improve workforce efficiency and which can arise from any source including learning, may improve the exergetic performance of a system.

The implications of the model are obviously data dependent and the data relates to the conditions under which production occurs. Countries that have invested in creating positive human systems e.g. that have clean, safe, efficient, better ambient conditions and treat the external environment including air, water, waste and use of resources, with care, are going to incur lower incremental exergy costs because they already have better systems in place. This suggests that producing in developed economies will incur lower exergy costs in many cases. It is clear that exergy analysis and EEA are important tools to use when assessing where to locate production. This is true even when the analysis excludes the exergy spent on transportation. Transportation raises a range of new questions because some of the transportation costs could be lower if production is closer to the market. Likewise, transportation costs may be less if production is closer to the source of material. Thirdly, the availability of suitable transportation systems is a critical factor. All of the above factors are dynamic. Therefore, concern about the environment suggests that many organisations should reappraise the locations where they produce items. Globalisation is not necessarily as clear-cut as its proponents believe.

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DIMENSIONS AND CONTINGENCIES OF CORPORATE SOCIAL RESPONSIBILITY IN SMES' SUPPLY CHAINS

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Abstract

Purpose of this paper:

This research aims to conceptualise the dimensions of CSR in supply chains and then demonstrates the degree of implementation of these CSR practices from SMEs perspectives. The objectives of this research are three-fold. The first is to conceptualise the dimensions of CSR in supply chains, highlighting which dimension is prioritised in the practice. The second is to demonstrate to what degree SMEs implement CSR practices. The third is to explore the contingencies that drive and enable SMEs' CSR practices based on the institutional theory and the stakeholder theory.

Design/methodology/approach:

A large-scale questionnaire survey was conducted with SMEs in South Korea. A total of 200 questionnaires were distributed via email to the SMEs based in the Gyeongbuk Province of South Kore, and 87 usable questionnaires were collected. The data were analysed by analytic hierarchy process (AHP), a 2X2 matrix and ANOVA to demonstrate the SCR implementation level and the contingencies behind it.

Findings:

SMEs tend to focus on explicit CSR practices that can be easily identified their customers. On the contrary, operational issues hidden to the customers are not considered in SMEs' practices. ANOVA analysis empirically showed that stakeholder and institutional pressures are valid in the performance of SCR practices. However, the level of pressures was largely biased to customers, government and regulatory pressures, which means that SMEs are more reactive rather than proactive to implement CSR practices.

Value:

This research investigated CSR practices within supply chains particularly from the SME perspectives, which have not been fully explored in the supply chain management discipline. In addition, it will empirically analyse the contingencies of CSR implementations using survey data.

Research limitations/implications:
This study has a limitation in conducting the survey with SMEs in one country, which may reduce the generalisability of this research.

Practical implications:
The conceptual model to evaluate the degree of SCR implementation can be used as an index to compare the CSR level of the SMEs.

INTRODUCTION

The integration of sustainability into supply chains has drawn much attention both from practitioners and researchers with the current emphases on the triple bottom line (TBL) of economic, environmental and social concerns of business operations, also known as corporate social responsibility (CSR) (Gimenez and Tachizawa, 2012). However, sustainable supply chain management (SSCM) research is largely biased to economic and environmental aspects, which highlights the importance of CSR research focusing on both environmental and social impacts of the business beyond economic concerns. Following an extensive literature review, the scope of extant research on CSR is limited to large companies and public authorities, neglecting small and medium-sized enterprises (SME) in the sustainability debates. Indeed, SMEs are in a weak position in supply chains and own less resources compared to large and brand-owning firms, which often leads to their passive reactions to sustainable supply chain management. Another research gap was that the desirability of SSCM in theory does not match the implementation in practice. Given these research gaps, this research aims to conceptualise the dimensions of CSR in supply chains and demonstrates the degree of implementation of these CSR practices from SMEs' perspectives. It also explores the drivers (factors which initiate and motivate firms to adopt CSR) and the enablers (factors which assist firms in achieving CSR practices) of CSR, based on the institutional theory (Kim, Amaeshi, Harris and Suh, 2013) and the stakeholder theory as overarching theoretical lenses (Park and Ghauri 2015). Under this idea, we advance the theoretical understanding of CSR in SMEs' supply chains and to provide a consolidated framework to investigate CSR-SMEs relationships. We employ the empirical findings of SMEs' supply chains to illustrate this theoretical development. The remainder of this paper is structured as follows. In the next section, we review the extant research and related theories that shed light on the dimensions and contingencies of CSR. Then, the methodological approach of the study is explained and the findings are outlined and discussed. Finally, conclusions are drawn including limitations of the study.

THEORETICAL DEVELOPMENT

Corporate social responsibility

The form and concept of CSR has become a prevalent subject in business research which led to various conceptualisations of CSR by scholars and to date, developing a widely-accepted conceptualisation of CSR is highly contested in the literature (Crane et al., 2008; McWilliams, Siegel and Wright, 2006; Mohr, Webb and Harris, 2001). Given the complexity of the concept of CSR, it is viewed mainly from four perspectives: as a social obligation, as a stakeholder obligation, as an ethics-driven process and as a strategic managerial process (Maignan and Ferrell, 2004; Oberseder, Schlegelmilch and Murphy, 2013). Within these CSR perspectives, CSR research and practice lies on a paradox between a notion of voluntary basis or behaviour of social concerns in companies' operations (Vilanova, Norazo and Arenas, 2008) and an opposing notion of social responsibilities that is typically mandated by law (Campbell et al., 2012). For the purpose of our paper, we take the view of CSR as a concept whereby companies go beyond and extend to the grounding CSR on a voluntary basis and integrate the greater notion of socially binding responsibilities in their business operation and in their interface with their stakeholders. Thus, our study adheres to the definition by McWilliams and Siegel (2001: 117) where they define CSR as "actions that appear to further some social good, beyond the interests of the firm and that which is required by law." This interpretation of CSR suggests the potential dimensions of CSR practices of business operations where CSR is firmly connected to institutions of stakeholder or government involvement.

Corporate social responsibility in supply chains

Extending the notion of CSR to not only being socially responsible internally within the organisation, CSR encompasses the idea of being responsible socially and environmentally throughout its supply chain (Pedersen and Andersen, 2006). Research on how to integrate CSR in supply chain management is rather limited but it is becoming a field of increasing interest, with research particularly concentrating on the CSR practices and activities of large corporations in their supply chain. Within CSR in supply chains, the implementation of environmental and social standards along the supply chains(e.g. Seuring and Muller, 2008) and the risks and challenges related to implementing and complying with these environmental and social standards (e.g. Lim and Philips, 2008) have been researched. Implementing CSR principles into the supply chain can be challenging and yet, despite the increasing awareness of implementing CSR into supply chains, many firms, specifically SMEs, struggle to see the real value of CSR practices in terms of business profits and performance. Due to the fact that the distribution of CSR complements the supply chains by linking buyers and suppliers, this research looks at SMEs both as buyers and suppliers in their role for implementing sustainability with their supply chains.

Corporate social responsibility in SMEs

With respect to the organisational size in CSR practices, the literature tends to focus commonly on large corporations and neglects SMEs in the current sustainability debates. There is a clear knowledge gap in the link between CSR-SMEs (Russo and Perrini, 2010) although SMEs make up over 90 percent of the global population of corporations and produce major contributions in social and economic related activities (Udayasankar, 2008). Given their importance, this gap needs to be addressed by focusing on CSR specifically putting emphasis on SMEs. Typically, SMEs often seem to possess intrinsic differences when compared with large corporations. These differences come in the form of legal structures, sector, strategic orientation toward profit and institutional forms (Perrini, 2006). Moreover, SMEs often possess passive reactions towards CSR and sustainability partly due to insufficient resources and competencies compared with large corporations which put them in the weak position (Park and Ghauri, 2015).

Stakeholder theory and institutional theory

In principle, both stakeholder theory and institutional theory are linked and contribute to CSR on various levels which provide a guide to the drivers that initiate and motivate SMEs to adopt CSR as well as the enablers that facilitate SMEs in achieving CSR activities in their business operations. Accordingly, we can suggest possible avenues to illustrate the dimensions of CSR in supply chains and demonstrate the degree of implementation of these CSR practices from SMEs' perspectives integrating stakeholder theory and institutional theory. Stakeholder theory specifies the extent to which corporations interact with their stakeholders appropriately (Laczniak and Murphy, 2006). It also illustrates the dimensionality of CSR practices or thinking which can be used as a guiding tool in the implementation and evaluation of CSR into business operations (Mishra and Suar, 2010). In the conceptualisation of CSR, the centrality of stakeholders has been emphasized by Campbell (2007). The primary stakeholders can include any individual, group, organisation, institution, community and the environment (Spiller, 2000) as well as internal managers and employees, customers, investors, government and suppliers (Panapanaanet al., 2003). They can even include any groups that may be required for long-term business survival and management (Mitchell, Agle, and Wood, 1997). Over the last twenty years, several SSCM literatures discuss wide-ranging forms of stakeholders which affect pressures to adopt sustainable thinking, practices or activities (Gonzalez-Benito and Gonzalez-Benito, 2006; Wolf, 2013).

Current research on CSR from stakeholder perspectives fails to include discussion of all or wider stakeholder mandates (Obersede et al., 2013). The omission of all or wider stakeholders is partly due to poor and different conceptualisation of CSR in the literature and practice which affects directly or indirectly the identification of accurate boundaries for whom corporations are responsible (Donaldson and Preston, 1995; Jones, 1995). The tensions between business-driven and stakeholder-driven systems and issues of CSR are closely inter-related. Within the stakeholder perspective, there are various ways in which stakeholders determine significant parts in supply chains as facilitators as well as hinderers. Thus, SMEs are required to take in all stakeholders "who can affect, or are affected by, the achievement of an organization's mission'' (Freeman, 1984, p. 54). Consequently, developing CSR for SMEs is complex and involves strategic decisions to formulate how they encounter CSR activities or sustainability goals into their operations at a corporate level (Polonsky and Jevons, 2009; Schneider and Wallenburg, 2012).
While the role of stakeholders has been widely researched, the role of institutions has been ignored in CSR research (Brammer, Jackson and Matten, 2012). Institutional theory determines companies are socially embedded within a set of formal institutions such as government regulation and informal institutions such as norms and shared beliefs (North, 1990). In this vein, it facilitates to identify the different boundaries between business associations and society. Within the dominant stands in institutional theory, there are two aspects of CSR: the diversity and the dynamics of CSR (Tempel and Walgenbach, 2007). Scott (1995) illustrates several social and cultural pressures that SMEs may face and be required to fulfil within their specific institutional environments and networks for social norms and rules. Given that the stakeholders' demands are linked to the institutional pressures (Reimann et al., 2012; Yang and Rivers, 2009), in complying with these institutional pressures, SMEs in supply chains may require adaptations of their values, processes, structures and business practices. In the course of institutionalisation, CSR takes a wider boundary of the market and government regulations. Thus, an institutional theory views CSR practices beyond the territory of voluntary action. This paper examines the contributions of stakeholder theory and institutional theory to understanding the CSR practices in SSCM and to investigating CSR-SMES relationships.

METHODOLOGY

The aim of this research is three-fold. The first is to conceptualise the dimensions of CSR in supply chains, highlighting which dimension is prioritised in the practice. The second is to demonstrate to what degree SMEs implement CSR practices. The third is to explore the contingencies that drive and enable SMEs' CSR practices based on the institutional theory and the stakeholder theory. A step-wise research process was adopted to address these objectives, as outlined below.
Step 1: Define the CSR dimensions in supply chains. This will generate a vital framework to be used in the questionnaire survey. Literature review, panel discussions and a pilot study will be applied to ensure their validity.
Step 2: Evaluate the relative importance of each CSR dimension and sub-dimension. This will show which factor is perceived most important in SMEs' CSR in the supply chain context. Also, the CSR framework combined with relative weights can be utilised for assessing a firm's overall CSR level in Step 4.
Step 3: Demonstrate the average implementation level of CSR dimensions by SMEs. This can generate a 2X2 matrix comprising of importance (Step 2) and performance (Step 3) on each axis.
Step 4: Evaluate the overall CSR level of participating firms using the results of the previous two steps. The respondents can be grouped into upper and lower groups in terms of CSR implementation.
Step 5: Validate the impacts of various contingencies on CSR implementation by comparing the upper and lower groups.

Data collection

A large-scale questionnaire survey was conducted with SMEs in South Korea. To investigate the CSR in supply chains, the survey sample was constrained to the manufacturing firms directly or indirectly involved in global supply chains so that supply chain contexts can be fully integrated into the responses. South Korea is a rapidly developing economy which has recently become quite concerned about the CSR issues in its international trade. Among many places in South Korea, Gyeongbuk province was selected because of its traditional and strong focus on manufacturing. A total of 200 questionnaires were distributed via email to SMEs based in the province of South Korea from February to March 2015. The list of these SMEs can be sought from Gyeongbuk Pride Product Support Center which supports the globalisation of SMEs in the region.

The questionnaire consists of four parts. Following the first part which asked general information about participating firms and respondents, the second part was designed to measure the relative priority of CSR dimensions and CSR practices by pair-wise comparisons. In the third part, respondents were asked to assess the implementation level of CSR practices in their organisations. The last part covered the evaluation of contingencies that may affect the level of CSR implementation, namely regulatory impact, normative impact, cognitive impact (institutional theory), customers, government, suppliers, competitors, local community and NGOs (stakeholder theory). The third and fourth parts were measured by 7-point scales. Before commencing the large-scale survey, this questionnaire was reviewed by CSR experts and then by a pilot study to examine the applicability and validity of measurement items.

A total of 87 questionnaires were collected, showing the response rate of 43.5% which is a relatively high response rate compared to that of other SCM research. No missing data and non-response biases were detected, thus all responses were used for the analysis.

Data analysis methods

The collected data was analysed by analytic hierarchy process (AHP) and analysis of variance (ANOVA) to demonstrate the CSR implementation level and the contingencies behind it. These two methods will be specifically applied to Step 2 and Step 5 respectively. For Step 3 and Step 4, descriptive statistics and simple numerical calculations will be used.

AHP can produce the relative weights of importance, pairwise comparisons of CSR dimensions and sub-dimensions. In the questionnaire survey, the respondents are asked the pair-wise comparisons between three CSR dimensions and between sub-dimensions in each CSR dimension. On the 9-point scale to each end, the respondents evaluate the extent to which they think one dimension is more important than the other. The results will be converted into 1/9 to 9 scales as suggested by Saaty (1980), and individual answers will be summarised as a representative perception using geometric means.

ANOVA is a statistical tool to test as to whether the means of two or more groups are equal or not. In this study, the overall CSR level of an individual firm will be assessed from 0 to 7 by the sum of weighted CSR implementation which multiplies relative weight of one CSR dimension with the implementation level of the dimension. In this way, the participating firms can be categorised into two groups according to the CSR level (Step 4). ANOVA analysis will be applied comparing the upper and lower groups in order to test their mean differences in contingencies based on the institutional theory and the stakeholder theory. If there exists a statistically significant mean difference in contingency A, its impact on CSR implementation can be confirmed.

FINDINGS

This research followed the aforementioned research steps to address research questions.

Dimensions of CSR in supply chains

In general, CSR consists of the environmental dimension and the social dimension. But most CSR literature dedicates its focus to the social dimension, dividing it into several sub-dimensions, such as labour, health and safety, human rights, community, society and etc. The environmental dimension, on the contrary, was captured by just one dimension although green logistics and/or SSCM literature described this dimension with details, including but not limited to material handling, waste management and packaging and transport (Rodrigue et al., 2009). Moreover, since the current CSR dimensions are developed from an individual firm's perspective, it is difficult to capture the CSR dimension applicable to the supply chain level. Therefore, it is pre-requisite to find appropriate CSR dimensions in supply chains.

For this purpose, the review of existing literature on CSR, green logistics and supply chain management was conducted. In particular, Global Reporting Initiative (2013)'s Sustainability Reporting Guidelines was quite useful because they suggested comprehensive criteria to be applied to a firm's CSR. At the supply chain level, some supply chain research focused on how to implement CSR across the supply chain, and suggested supplier assessment, collaboration (Gimenez and Tachizawa 2012), awareness building and training (Ciliberti et al., 2008) and evolution of governance (Alvarez et al., 2010).

After identifying various sub-dimensions of CSR in supply chains, five CSR experts in the SMEs sector were invited to review the sub-dimensions for a parsimonious model. There was an argument as to whether the ethical supply chain dimension should take the same hierarchy as the environmental and social dimensions, but they agreed that the dimension should be separated as a unique dimension when diffusion of CSR requirements in the supply chain is considered. As a result, the dimensions of CSR in supply chains can be drawn (see Table 1).

1. Environment	2. Society	3. Ethical Supply Chain
(1) Material Management	(1) Labour	(1) Supplier Assessment
(2) Environmental Sites	(2) Health & Safety	(2) Consumer Protection
(3) Environmental Products	(3) Local Community	(3) Ethical Collaboration

Table 1. Dimensions of CSR in Supply Chains

The CSR framework with relative weights

Based on the CSR framework shown in Table 2, the relative importance of each dimensions and practices were calculated by AHP. Four analyses were conducted using SuperDecisions software package to find out the relative weights of CSR dimensions and CSR practices within the three dimensions, whose results can be seen in Table 2. Consistency ratio of all these analyses was within the threshold of 0.1.

At the CSR dimension level, the society dimension was the most important dimension, closely followed by the environment dimension. Both of them have been emphasised in the general CSR, but society was more prioritised partly because CSR concept was originally associated with social issues. Although lagging behind other two dimensions, the ethical supply chain dimension also gained 20% of the overall weights. This demonstrates that ethical supply chains are gaining their status in CSR because they decide the final products which a firm must be responsible for.

Dimensions	Weight	Practices	Weight
Society	43.84%	Health & Safety	20.64%
Environment	36.11%	Environmental Products	15.00%
Ethical Supply Chain	20.05%	Environmental Sites	13.41%
		Local Community	11.72%
		Labour	11.48%
		Consumer Protection	8.01%
		Material Management	7.70%
		Supplier Assessment	7.27%
		Ethical Collaboration	4.77%
Total	**100%**	**Total**	**100%**

Table 2. The Weights of Dimensions

The level of CSR implementation

The level of CSR implementation was measured by the mean. The results show that consumer protection (5.3 out of 7) is the most implemented practice, which is followed by environmental products (5.01) and environmental sites (4.86). While local community (4.6), supplier assessment (4.6), health & safety (4.53) and ethical collaboration (4.52)

are located in the middle of the table, labour (4.47) and material management (4.37) were selected as the least implemented practices.
To analyse this results with the relative importance of each practice, a 2X2 matrix was generated as shown in Figure 1. Among the CSR practices, environmental products and sites were well recognised by SMEs, and at the same time, were embedded in their CSR practices well. Consumer protection, on the other hand, was heavily implemented in the practice, but its importance was relatively low. These practices are, in common, explicit to customers, which can easily build up good social reputation.

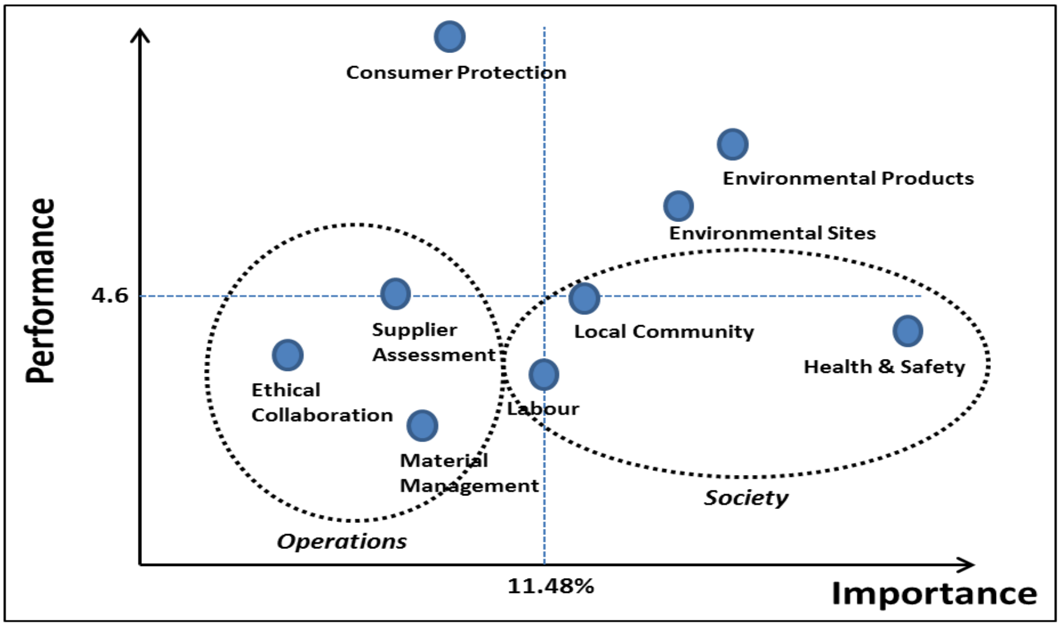

Figure 1. The importance and performance of CSR practices

Figure 1 illustrates the importance of practices in the society dimension which was highly regarded but the implementation level was less than expected. In particular, health and safety was not properly addressed by SMEs despite its highest importance. This can be explained by cost issues because these practices will require immediate spending which cannot be easily decided by SMEs under financial constraints. If SMEs seek their competitiveness from cost advantages, emphases on practices for the society can be just rhetoric.
As for the operational aspects, they are often implicit to customers which were not highly considered by SMEs. These include supplier assessment, ethical collaboration and material management, which commonly require a certain level of strategic decisions to implement the operations. In particular, these topics are one of the prolific research agendas in the SCM disciplines which have previously suggested many innovative ideas, but SMEs tend to be less interested in these practices.

The impacts of contingencies

Given the relative weights of CSR practices and the performance of participating companies, the overall CSR level of each SME can be calculated. The highest and lowest CSR levels were 5.8 and 3.15 out of 7, which indicated that there are clear discrepancies in CSR implementation across the SMEs. Also, it meant that there should be some contingencies which create this difference. This research thus tested the impacts of contingencies from the stakeholder theory and the institutional theory on SMEs' CSR level by comparing the means of the better group and the worse group. Six factors (customers, government, suppliers, competitors, NGO and local community) and three factors (regulatory, normative and cognitive pressures) were drawn from the theories respectively.
The ANOVA results showed that there are significant differences in CSR implementation given all these contingencies. This implies that the theories are effective even in the SMEs and the supply chain contexts. When the overall mean values are considered, customers

and government from the stakeholder theory and regulatory pressures from the institutional theory showed the highest mean values.

Contingencies	Mean	Upper Group		Lower Group		F-value	Sig.
		Mean	S.D	Mean	S.D		
Customers	5.38	5.85	0.65	4.86	0.75	41.446	***
Government	4.8	5.34	0.73	4.36	0.73	37.987	***
Suppliers	4.51	4.78	0.57	4.29	0.71	12.245	**
Competitors	4.51	4.80	0.68	4.07	0.60	27.209	***
NGO	4.46	4.98	0.79	4.00	0.54	43.259	***
Local Community	4.29	4.68	0.61	3.93	0.46	40.412	***
Regulatory Pressures	4.74	5.20	0.71	4.36	0.49	39.228	***
Normative Pressures	4.39	4.83	0.77	4.00	0.54	32.277	***
Cognitive Pressures	4.32	4.54	0.74	4.14	0.65	6.622	*

Table 3. The ANOVA results

CONCLUSION

This research explored the dimensions of CSR in SMEs' supply chains, and then found out how SMEs considered CSR practices by analysing their importance and performance. Also, it investigated the impacts of various contingencies, based on the stakeholder theory and the institutional theory, on CSR implementation. Although more discussion will be needed for the initial results of this research, it can be concluded that SMEs tend to focus on explicit CSR practices that can be easily identified their customers. On the contrary, operational issues hidden to the customers are not considered in SMEs' practices. Such characteristics of SMEs being as resource constraints, imbalanced power within their relationships with customers, deficiencies in CSR strategies and lack of supply chain innovation may explain this trait in SMEs' CSR. ANOVA analysis empirically showed that stakeholder and institutional pressures are valid in the performance of CSR practices. However, the level of pressures was largely biased to customers, government and regulatory pressures, which means that SMEs are more reactive rather than proactive to implement CSR practices.
In this sense, this research has its value in investigating CSR practices within supply chains specifically taking the SME perspectives, which have not been fully explored in the supply chain management discipline. Also, it empirically analysed the practices and contingencies of CSR implementations using survey data and various statistical techniques. In addition, the CSR framework to evaluate the degree of CSR implementation can be used as an index to compare the CSR level of the SMEs. However, this research has a clear limitation in conducting the survey with SMEs in one country, which may reduce the generalisability of this research. A comparative analysis with larger firms can highlight the unique features of SMEs' CSR practices in supply chains.

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GREEN PROCUREMENT CHALLENGES IN PUBLIC HOSPITALS: A CASE OF QUEENSLAND STATE

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Abstract

This study investigates challenges of implementing green procurement in Australian public hospitals. We develop a framework of green procurement that incorporates five major challenge-categories and 19 challenges, and structure the problem as an analytic hierarchy process (AHP) model. Under AHP set-up we interview health-procurement executives to prioritize critical challenges of the problem. The research identifies that the key challenge-categories of green health procurement are related to government initiatives and organisational support. Identified critical challenges are lack of legislation on green procurement, senior management support, lack of financial support, clear strategic goals on green, and government incentives for green purchase. The identification of critical challenges will help policy makers to develop sustainable hospital purchasing strategies for practice, and create a model for other public sector organisations to follow.

Key words: Analytic hierarchy process, Australia, Queensland, Green procurement challenges, Public hospitals.

Paper category: Research paper

1. INTRODUCTION

Under green, many organisations emphasise purchase of products made from recycled materials, inclusion of environmental criteria in green supplier selection (Igarashi et al., 2013, Zhu et al., 2013), or practices in green logistic activities such as using less energy and resources and more environmentally friendly packaging and transport (Otsuki, 2011), or monitoring and auditing suppliers with ISO 14001 certification and actual green performance records (Seuring and Müller, 2008).

Incentives for practicing green procurement are often limited (Zhu et al., 2013). Tensions may exists between green procurement and efficiency agenda (Thomson and Jackson, 2007). In cases where green procurement represents cost savings then the choice of green procurement is clear. However, in many instances there is no obvious or clear decision and there is substantial sentiment that green procurement results in the purchase of inferior products, that places additional burdens on procurement officials who must develop green procurement policies, and procedures and graft them on to existing procurement systems (Coggburn, 2004).

Public hospitals need to purchase a wide variety of supplies (equipments, goods and services), which involve different suppliers, and a complex supply network from original source to end customer (Harland, 1996). A public health facility can boost green procurement initiatives by reducing the environmental impacts of the products and services it uses or procures before regulatory problems arise or waste disposal costs increase (Kaiser et al., 2001). However, there are challenges to implement green procurement. Walker and Brammer (2009) investigate challenges and perceived facilitators of sustainable procurement in the UK public sector and find financial issues, lack of resources, conflicting priories, and lack of budget as the major green procurement challenges. Literature review suggests that Research has tended to examine green procurement issues within particular countries including the UK (Hall and Purchase, 2006), Sweden (Faith-Ell et al., 2006), the US (Coggburn, 2004), Germany (Günther and Scheibe, 2006), France (Oruezabala and Rico, 2012), and Canada (Hartshorn et al., 2005). To our knowledge research on green procurement challenges in Australia has not been conducted; and associated research from the private sector or from other countries is difficult to transfer directly to the Australian healthcare sector. The objective of this research is to focus on the Australian public health purchasing and identify potential challenges of implementing green procurement in public hospitals in the State of Queensland, Australia.

2. BACKGROUND OF THE RESEARCH

In Australian every state has their own procurement policies and state health systems issue specific environmental procurement guidelines under value for money or environmental protection criteria (AELA, 2014). Hence, the Australian government has potential to play the role of a leading model purchaser and encourage and incorporate green considerations into procurement decisions. The Queensland procurement policy aims to deliver excellence in procurement and covers six principles: value for money, working together across different government agencies, understand need, the market and deliver better outcomes, procurement to support sustainability, focus of stakeholders and community in procurement, and ensure accountability for outcomes (DHPW, June 2013). Health Services Purchasing and Logistics is the major governing body of Queensland health that provides services to 17 hospitals and health services and the Department of health (DHPW, June 2013). The major purchasing roles of HSPL are to oversee cross-organisation procurement contracts management, planning purchasing process improvement and staff development, and eco-efficiency & carbon management plan (HSPL, 2011). The carbon management unit of HSPL plays an important role through increasing green awareness in Queensland health with development and implementation of a statewide eco-efficiency program to introduce energy and water conservation measures into health facilities.

3. GREEN PROCUREMENT CHALLENGES

We develop a green procurement challenge structure based on previous research on public and sustainable procurement. The proposed framework adopts the main categories of public procurement outlined by Gelderman and Ghijsen (2006), and green procurement challenges suggested by Coggburn (2004) and Günther and Scheibe (2006). Our proposed framework is consisted of five green procurement challenge categories for public health sector which are: (i) familiarity with the green issues, (ii) organisational issues, (iii) perceived cost/benefits, (iv) government and NGO issues, and (v) supplier issues. Based on procurement literature, we further breakdown the five major challenge categories into 19 challenges. The proposed framework is unique, as no previous study has considered green procurement challenges at the micro level. An outline and brief discussion of each of these main challenge-categories and challenges are discussed in following subsections, and are shown Figure 1 and summarised in Table 1-5.

3.1 Familiarity with green issues

To effectively implement green procurement it is important for the purchasing authority to be familiar and understand the concept of green, to have knowledge on the impact of procured goods and services on the environment, and related government and organisational policy, rules, and procedures to implement the green (Gelderman et al., 2006). Details of the familiarity related challenges are shown in Table 1.

Table 1: Brief explanation of the aspects of 'familiarities with green issues'

Terms	Brief explanation	Source
Understanding of green policy	Purchasing professionals of respective organisation need to have clear understanding of existing green procurement policy for setting up tender requirements and identify best offer for sustainable value for money.	Testa et al. (2012)
Familiarity with environmental impacts of products	Familiarity and knowledge on impact of procured goods and services on environment helps organisations to set up green preference.	(Mosgaard et al., 2013)
Green preferences in purchasing	During purchasing, green products and suppliers should be given priority.	(Walker and Brammer, 2009)
Management information systems (MIS) support for green	Management information systems (MIS) help green purchasing through hardware, software, people, procedures, and tasks.	(Sarkis, 2012)

3.2 Organisational issues

Organisational issues are considered as internal problems of green procurement (Hoejmose and Adrien-Kirby, 2012). Organizational culture and resources usually prevent firms from implementing green procurement (Hoejmose and Adrien-Kirby, 2012). Organisational issues cover the degree to which organisational attitudes and incentives are supportive of green procurement (Walker and Brammer, 2009). Challenges on organisational issues are shown in Table 2.

Table 2: Brief explanation of the aspect of 'organisational issues'

Terms	Brief explanation	Source
Senior management support	Senior or mid-level managers are key in mobilising organisational resources in development and implementation of green procurement strategy.	Hoejmose and Adrien-Kirby (2012)
Clear strategic goals on green	Organizations should clearly convey strategic goals and intangible benefits of green procurement to employees.	(Walker and Brammer, 2009)
Competent procurement professionals	Competent procurement professionals know green procurement policy and related purchasing processes, and have ability to carry out procurement tasks efficiently.	(Tassabehji and Moorhouse, 2008)
Adopting environmental management system (EMS)	EMS involves the formal system and database which integrates procedures and processes for the training of personnel, and monitoring, and reporting of green performance information to stakeholders.	(Melnyk, 2003)

3.3 Perceived cost/benefit

Though cost and sustainability are aligned in a win-win situation, there is a perception that cost is a big barrier in green procurement (Zhu et al., 2013). Given the tight budget constraints and countervailing objectives faced by most public sector organisations, perceptions regarding the cost-effectiveness of sustainable procurement are expected to play an important role in green public procurement (Walker and Brammer, 2009, Brammer and Walker, 2011). The summary of the cost/benefit related challenges under the perceived cost and benefit categories is shown in Table 3.

Table 3: Brief explanation of the aspects of 'perceived cost/benefit'

Terms	Brief explanation	Reference
Lack of financial support	Lack of financial support means a lack of resources or sufficient budget that prevents firms from implementing green procurement.	(Hoejmose and Adrien-Kirby, 2012)
High cost of sourcing	It is a costly process to identify the sustainable sources of green product supply and procure them from available sources.	Brammer and Walker (2011)
Green product not worth	Firm's perceive that environmentally friendly products are more expensive than conventional alternatives, and thereby represent an unfavorable deal.	Walker and Brammer (2009), (Mosgaard et al., 2013)

3.4 Government and NGO Issues

There are three different types of external stakeholders in a public procurement decision: government or state, market, and citizens (Günther and Scheibe, 2006). Government and non-government organisations create pressure and may work as motivating factors in adopting various green practices in public procurement (Wu et al., 2012). Government issues relate to legislation, creation of financial pressure, incentives and power on implementing green procurement issues (Günther and Scheibe, 2006). Non-government organisation (NGO) issues are related to public and activist pressure on green agenda (Hervani et al., 2005). Further details of government and NGO related challenges are outlined in Table 4.

Table 4: Brief explanation of the aspects of 'government and NGO issues'

Terms	Brief explanation	Reference
Government legislation	Local or federal Government pass regulations in procuring non-green goods and services.	Günther and Scheibe (2006)
Organisational incentives	Organisations encourage green procurement by providing incentives (through price subsidies or tax benefits etc.) in procuring green goods or securing contract with green suppliers.	Walker and Brammer (2009)
Public/citizen pressure	General public or citizens are stakeholders and have strong influence in favour of green product use in the public sector.	Günther and Scheibe (2006)
NGO or activists	Non-government volunteer organisation or activists are external stakeholders, and they pressure hospital authorities to procure green products.	Zhu et al. (2013), Hervani et al. (2005)

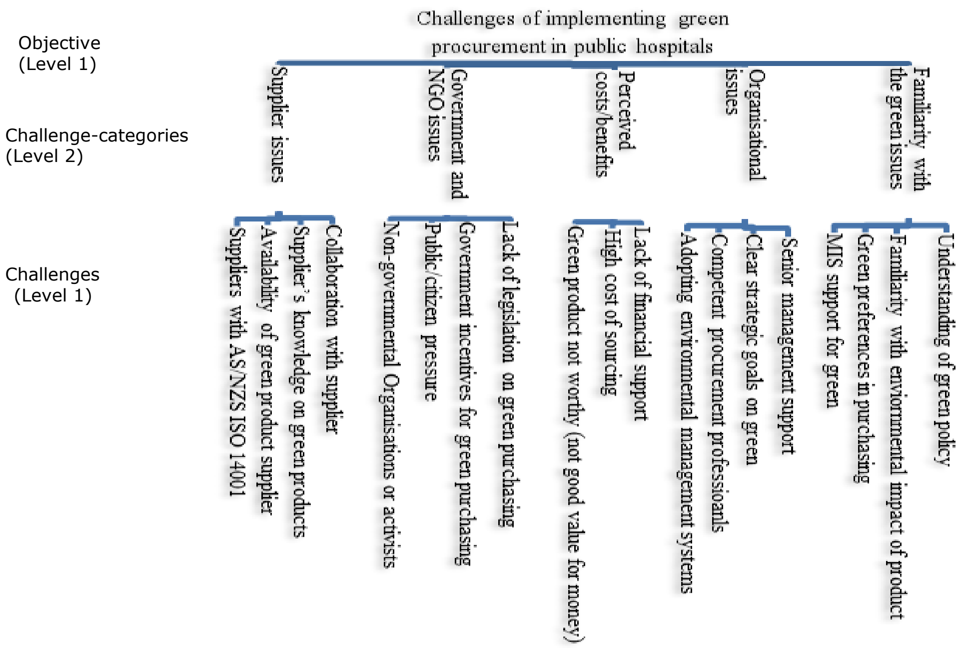

Figure 1: Green procurement challenge-categories and challenges in public health system

3.5 Supplier issues

A firm is only as green (sustainable) as its suppliers (Krause et al., 2009). Suppliers are the primary stakeholders, and without participation and support of suppliers green procurement will be incomplete. Unlike the purchasing authorities, green purchasing also requires suppliers to make efforts to reduce environmental impacts in their products or services (Zhu et al., 2013, Carter and Dresner, 2001). Green purchasing challenges related to suppliers are availability of green products, poor supplier commitment and unwillingness or ability to exchange information (Table 5).

Table 5: Brief explanation of the aspects of 'supplier issues'

Terms	Brief explanation	Reference
Collaboration with suppliers	Supplier collaboration consists of activities such as joint development efforts of greener product, reducing logistical waste, sharing sustainable information, and management of environmental risks.	(Gualandris and Kalchschmidt, 2014, Walker et al., 2012)
Supplier's knowledge of green products	Supplier knowledge on green products ensures supplier is knowledgeable on green or environmental performance of product across the whole product lifecycle.	Sarkar and Mohapatra (2006)

Availability of green product supplier	Many of the goods and services procured by the public sector are specialist, and identifying availability of suppliers who can provide green products and services may be challenging.	Walker and Brammer (2009)
Suppliers with AS/NZS ISO 14000 certification	Having AS/NZS ISO 14000 ensures that a supplier or an organisation is competent in providing green products or services.	Sarkis (2012)

4. IDENTIFICATION OF CRITICAL CHALLENGES

4.1 The Analytic Hierarchy Process (AHP) Model

This study employs the analytic hierarchy process (AHP) methodology for analysis. AHP is a multi-criteria decision making approach that helps in breaking down a complex, unstructured situation into components in hierarchical structure (Saaty, 1990). There are three main construction steps of AHP: hierarchy construction of criteria, compilation of decision-makers' opinions, and synthesis of normalized priority weights and consistency verification (Saaty, 1990). Considering the features of the AHP approach and nature of our research problem, we find AHP an appropriate method for identifying critical challenges of green procurement in Australian public health sector.

4.2 Respondents Selection

We interviewed health care procurement professionals from Queensland, Australia. Participants were selected non-randomly through the use of purposeful sampling and snowballing techniques. Selection of respondents were based on their position, current role in procurement, work experience and background knowledge. We visited websites of public organisations related to health procurement, identified key professionals and approached them though telephone, email and LinkedIn. Upon confirmation of their participation, prior to the structured interview we sent the AHP questionaries to participants to give a prior idea of the interview questions. After approaching 10 potential participants from Queensland, we confirmed interviews with three participants from Queensland. Respondents are mid-level executives and procurement managers who requested to keep their identity anonymous. The work experience of these executives varies between 6-15 years in the field of public procurement. A summary of the respondents experience and their roles are provided in Table 6.

Table 6: Background of the respondents

Respondent 1 (Resp #1)	Purchasing project officer; eight years' experience in procurement, policy analysis, stakeholder management. Current role is to look after consumables related to green products and to record and ensure the utility consumption for the whole of the state health facilities including electricity, gas and water.
Respondent 2 (Resp #2)	Holding a senior executive position in health care procurement & supply chain, 15 years' experience in procurement. Currently dealing with developing and implementing strategic procurement programs, practices and guidelines for improving the efficiency of procurement processes, managing and building effective and strategic relationships with suppliers.
Respondent 3 (Resp #3)	Senior procurement project officer with six years' experience in public procurement projects, currently working in environmental sustainability area and oversee tender, monitor and work to reduce energy consumption and Co_2 emissions in health care environments.

We developed a two-part questionnaire for data collection. Part-1 is related to respondent's opinion on relative importance of weights amongst different challenge-categories and challenges, and part 2 consists of open-ended questions about green procurement challenges and respondents' background information. The data collection procedure using the AHP methodology lasted approximately 75 minutes for each respondent.

4.2.1 AHP application for critical green procurement challenges

The process of AHP involves three steps:

Step 1- Identification of key challenges and AHP structuring: The first step involves identification of key challenges for green procurement in the public health sector in Queensland. We considered five major challenge-categories and 19 challenges for green procurement in public health sector (shown in Figure 1). The structuring consists of breaking down the complex multi-criteria decision-making problem into a set of integrated levels. In this study, the problem was structured as objective, challenge-category, and challenge at three hierarchical levels (see Figure 1).

Step 2- Pair-wise comparison of decision criteria: In this step, criteria in each level are compared pair-wise in terms of their importance to a criterion in the next higher level. The scale used for pair-wise comparisons in AHP is called a one-to-nine scale and is based on five attributes equal, moderate, strong, very strong, and extremely strong. We asked participants to judge the relative importance of the five major challenge-categories, and challenges under each category. In total six matrices were generated: one for challenge-categories at level 2 and five for challenges at level 3 of the problem hierarchy.

Step 3- Determination of critical challenges and consistency of judgements: In the third and final step of AHP, the overall weights of the challenges are determined by aggregating the weights throughout the hierarchy. The AHP analysis also provides a direct measure of consistency of judgment elicited by the decision-makers. Saaty (1990) demonstrated inconsistency ratio (**CR)** as the degree to which decision-makers adhere to the rank order specified and measures the extent to which an established preference is kept. A **CR**≤0.1 is considered acceptable (Saaty and Kearns, 1985). Based on AHP principles and using the Expert Choice® Software we calculate the overall CR of the model for each respondent's judgement, CR with respect to the goal, and CR for challenge for each challenge-category. Details of respondent's judgment CR, local and global priority weights of different challenge-categories and individual challenges are presented in Table 7. For example, in Table 4 calculated overall CR for respondent-1 (in column under Resp # 1) is 0.08 (where CR ≤ 0.1 and is within the acceptable limit).

Table 7: Local and global weights and consistency ration of judgements

Respondents		**Resp #1**	**Resp #2**	**Resp #3**	**Overall**
		Local	**Local**	**Local**	**Global**
Overall CR of judgement		**0.08**	**0.08**	**0.09**	**0.03**
Challenge categories	**Challenges**			weights	
Familiarity with green issues		0.04	0.06	0.08	0.06
Organisational issues		0.46	0.37	0.26	0.31
Perceived costs/benefits		0.16	0.18	0.13	0.21
Govt. and NGO issues		0.25	0.35	0.45	0.34
Supplier issues		0.09	0.04	0.07	0.07
Familiarity with green issues				weights	
CR of judgements with respect to 'familiarity with green issues'		**0.07**	**0.005**	**0.08**	
	Understanding of green policy	0.25	0.45	0.59	0.038
	Familiarity with environmental impact of products	0.25	0.41	0.21	0.026
	Green preferences in purchasing	0.25	0.06	0.14	0.013
	MIS support for green	0.25	0.07	0.05	0.009
Organisational issues					
CR of judgement with respect to 'organisational issues'		**0.09**	**0.02**	**0.04**	
	Senior management support	0.48	0.62	0.526	0.186
	Clear strategic goals on green	0.28	0.15	0.11	0.062
	Competent procurement professionals	0.09	0.15	0.16	0.043
	Adopting environmental management systems	0.15	0.09	0.21	0.046
Perceived costs/benefits					
CR of judgement with respect to 'perceived costs/benefits'		**0.05**	**0.0**	**0.06**	
	Lack of financial support	0.70	0.78	0.73	0.113
	High cost of sourcing	0.09	0.11	0.19	0.02
	Green product not worthy	0.20	0.11	0.08	0.02

Govt. and NGO issues					
CR of judgement with respect to 'Govt. and NGO issues'		**0.1**	**0.02**	**0.06**	
	Lack of legislation on green purchasing	0.66	0.75	0.63	0.209
	Govt. incentives for green purchasing	0.16	0.07	0.18	0.050
	Public/citizen pressure	0.06	0.07	0.13	0.025
	NGO or activists	0.11	0.12	0.06	0.025
Supplier issues					
CR of judgement with respect to ' supplier issues'		**0.02**	**0.10**	**0.08**	
	Collaboration with supplier	0.13	0.096	0.21	0.026
	Supplier's knowledge on green products	0.56	0.30	0.08	0.041
	Availability of green product supplier	0.15	0.03	0.61	0.024
	Suppliers with AS/NZS ISO 14001	0.15	0.57	0.11	0.037

Priorities of challenges under each challenge-category are determined by considering only level 2 and corresponding 3 challenges. Details of local priority weights for respondents are shown in Table 7. For each respondent, we also determine the overall (global priority) weight of challenges (Figure 2) and the overall consistency ratio of judgement. Global priority weights are calculated with respect to goal (level 1) by synthesizing all the weights and relative priorities of level 2 and 3. This is done by following a path from the top of the hierarchy to each challenge at the lowest level, and multiplying the weights along each segments of the path. For example, in case of Resp #1, top green procurement challenge is identified as 'senior management support' (weight = 0.228), and the lowest rank challenge is 'understanding of green policy (weight = 0.011). Details of challenges and priorities are presented in Figure 2.

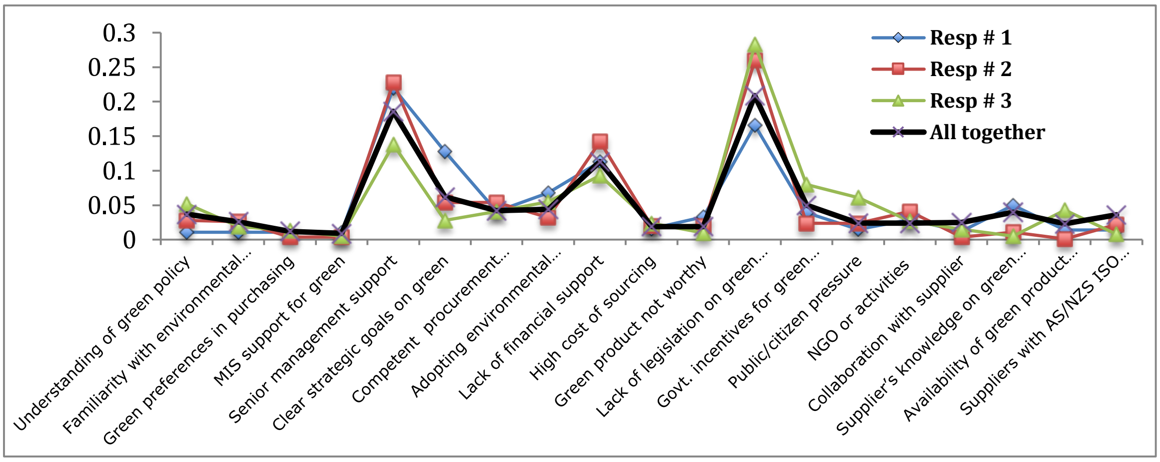

Figure 2: Global priority weights of challenges for each respondent

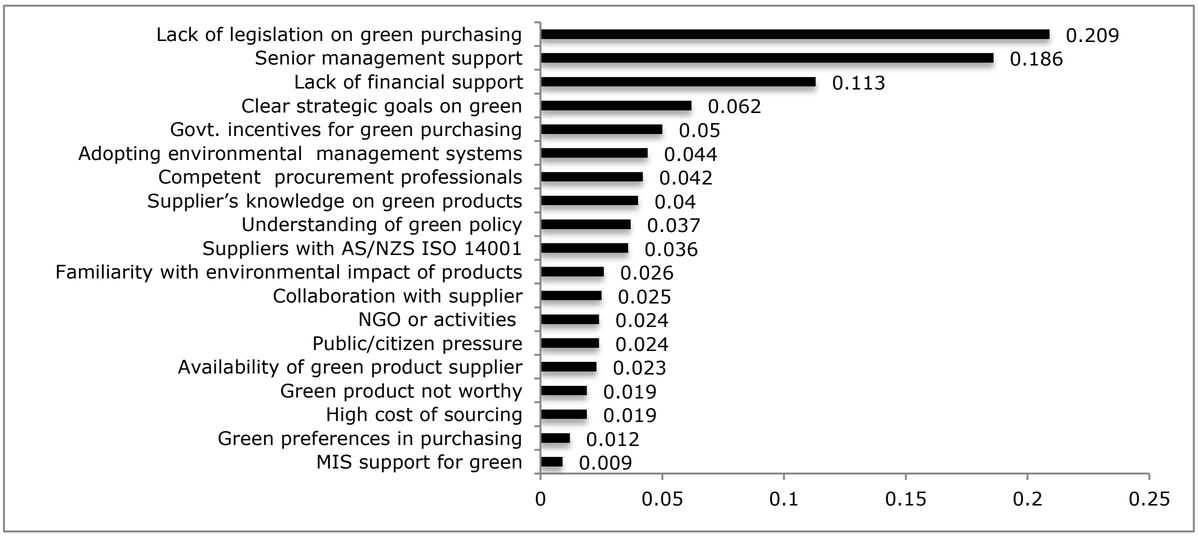

Figure 3: Overall priority ranking of the challenges (CR=0.03)

We further synthesize the model to determine overall weights of the critical challenges for all the respondents for Queensland by aggregating the weights throughout the hierarchy. Synthesising the relative priority weights of all three respondents with respect to the goal, an overall ranking of five major challenge-categories and 19 challenges (Table 7, Figure 3) are obtained. The two main green procurement challenge-categories identified are: government and NGO issues (weight = 0.34), and organisation issues (weight = 0.31). With respect to goal we obtain an overall rank order of 19 critical challenges (Figure 3). The top five critical challenges identified are lack of legislation on green purchasing (weight = 0.209), senior management support (weight = 0.186), lack of financial support (weight = 0.113), clear strategic goal on green (weight = 0.062), and government incentives for green purchasing (weight =0.05). Results of the AHP analysis also show that the respondents' opinions are consistent to determine critical green procurement challenges (CR = 0.03).

5. RESULTS OF SENSITIVITY ANALYSIS

Sensitivity analysis is one way of analysing the robustness of priority ranking (Saaty and Vargas, 2012). It is performed to investigate whether small variations in the priorities would change the ranking of the challenges initially determined in this study. Thus, sensitivity analysis is useful in providing insights due to the dynamics of green procurement challenges perceptions and importance over time (Yakovleva et al., 2012).

We conduct sensitivity analyses with two major challenge-categories (government and NGO issues, and organisational issues) taking one at a time based on their calculated priority weights. Through sensitivity analysis we observe that changes of priority weights of 'government and NGO issues' and 'organisational issues' have impact on overall rank of top five critical challenges. For example, with the decrease of the priority weight of 'government and NGO' issues or with the increase of priority of 'organisational issues' challenge-category, 'senior management support' moves to rank 1 from rank 2. The changes of priority weights of other three major challenge-categories have little impact on the overall ranking of top critical challenges. It means that the identified critical challenges are robust to change of priority weights of challenge-categories such as 'perceived cost/benefit', 'supplier issues', and 'familiarity with green issues'.

6. DISCUSSION

From the AHP analysis we find that the main challenge-categories of green procurement challenges are 'government and NGO issues', and 'organisational issues'. Analysis also shows that the majority of identified green procurement challenges in Queensland public hospitals are related to policy and organisational commitment. The top five critical challenges are 'lack of legislation on green purchasing', 'senior management support', 'lack of financial support', 'clear strategic goal on green', and 'government incentives for green purchasing'. If we classify the challenges as external and internal to the public hospital, amongst the top five challenges four are external to the purchasing organisation. Hence, support through legislation, government incentives, and top-level management care is required to effectively initiate the green procurement process in Australian public hospitals.

6.2.1 Importance of government initiatives for green procurement

Currently, in Australia there is no mandatory government legislation to support green procurement in the health sector. European Union experience shows that existing regulations support public authorities in developing green public procurement strategies (Testa et al., 2012). The results of this study also indicate that the hospital procurement executives are in favour of green procurement implementation through legislation. A survey undertaken by the Buy Recycled Business Alliance found that 43% of Australian businesses considered the state government had a responsibility to encourage the purchase of green and recycled products (CES, 2006). The Australian Federal and State governments should make a clear policy on greener procurement of goods and services. The government can exert pressure on organisations through regulation and legislation to accelerate initiatives of green procurement (Beamon, 1999, Green et al., 1996, Zhu et al., 2005, Walton et al., 1998, Handfield et al., 1997).

Governments around the world have developed green procurement programs through different jurisdictions. For example, the UK government has set up a public procurement task force, Japan has developed the Green Purchasing Network to spread the concept and practice of green procurement, the US government has set up environmental preferable purchasing, and the Norwegian government has established GRIP, a foundation for sustainable consumption and production.

Governments are typically one of the largest purchasers around the world (CES, 2006, Audet, 2002)). Green procurement practices are being viewed as an indicator of a government commitment to sustainability (OGC, 2004). Green procurement in the Australian public health sector is still in the early stages. In Queensland, aspects of green procurement has not yet been spelled out appropriately at the strategic level. Health Services Purchasing and Logistics unit of Queensland Health support green procurement activities through eco-efficiency and carbon management leadership role to identify, plan, implement and measure strategies to reduce energy, water usage and greenhouse gas emissions in procurement of goods and services (medical equipment, medical consumables, facilities maintenances, specialist health services etc.).

6.2.2 Importance of senior management support for green procurement

A perceived lack of senior management support for greener procurement was identified as one of the top two challenges of green procurement in public hospitals. This finding is similar to the finding in the UK public sector, where the main barrier to green procurement is lack of priority and support at senior level (Thomson and Jackson, 2007, Walker and Brammer, 2009). Through senior management support, organisations can set target, operational direction on green procurement. Senior management support helps mobilise organisational resources in the development and implementation of procurement strategy for an organisation (Hoejmose and Adrien-Kirby, 2012). Senior management can support organisational strategy to buy green products, giving more priority to green product suppliers in the tender evaluation process. Support could also be in terms of providing training to employees on green procurement strategy and process, and providing support to implement environmental management systems.

7. CONCLUSIONS AND FUTURE RESEARCH

The objective of this research is to focus on Australian public health purchasing and identify potential challenges of implementing green procurement in hospitals. Considering Queensland an emerging state for green procurement, we identify the major categories of green procurement challenges as government and organisational support, and the least important category as familiarity with green issues. The top five critical challenges are lack of legislation on green purchasing, senior management support, government incentives for green purchasing, lack of financial support, and clear strategic goal on green. The top five critical challenges as more strategic issues, which fall under both external challenge-category such as government incentives and legislation, and internal challenge-category such as organisational strategy and support and commitment. The challenge 'lack of legislation on green purchasing' which falls under the government challenge-category is found to be the most critical challenge of green procurement in public hospitals in Australia. At present there is no clear government legislation or regulatory measure available for green procurement. Through legislation, the government can exert pressure on organizations to undertake green procurement initiative. By legislating and adopting appropriate green procurement policies in the public health sector, the Australian state governments can play a leading role as a model purchaser and encourage other firms to follow. Lack of support for green procurement from organisation has also been identified as a major challenge. Support from top management is essential to operationalize any new policy or plan on green procurement. Furthermore, the green procurement process is new, and financial support is required to implement green procurement processes through training procuring staff for sourcing the green product, and/or to develop the product with the help of suppliers.

In conclusion, our research shows that green procurement in the public hospital sector faces many challenges. Major challenges are strategic in nature and are both external and internal to organisations. Green procurement in hospitals started in isolation (for some product or in a section of the hospitals) and currently lacks legislation for countrywide implementation. This research will open up new policy dialogue for green procurement in health care in Australia.

This study uses AHP for identifying critical green procurement challenges. We interview three-health procurement respondents based on their current role in hospital procurement and work experience. The number of respondents used in this research is justifiable for AHP. Previous research investigated the sample adequacy issue and concluded that AHP is a subjective method that focuses on specific issue where a large sample is not mandatory (Wong and Li, 2008). However, AHP does have certain disadvantages. For example consideration of relationships amongst the major challenge-categories and challenges can provide a more realistic assessment of the situation (Yakovleva et al., 2012). Perhaps, as an extension of this research a more complex tool such as Analytic Network Process can be used for further investigation.

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A THREE-DIMENSIONAL EMERGENCY SYSTEM FOR OIL SPILLS DURING OCEAN TRANSPORTATION

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ABSTRACT

With frequent occurrence of oil spills in the marine environment, emergency system for these accidents has received increasing attention. In this study, we propose a three-dimensional visualization system for the management of emergency disposal of marine oil spills, including the scheduling of emergency resources, real-time monitoring of vessels, and simulation exercises. The proposed system integrates multiple techniques, such as Web GIS, vessel positioning, and vessel track generation. It can serve as a great support for decision makers and contribute considerably to the management of emergency disposal of marine oil spills in China.

Keyword: marine oil spill, 3D visualization, Web GIS.

1. INTRODUCTION

With the rapid development of economy, offshore oil drilling and transportation has become increasingly frequent. However, oil spills during transportation have become a recurring threat to the marine environment. A lot of studies have investigated the emergency disposal of oil spills in recent years. The development and application of Geographic Information System (GIS), Global Positioning System (GPS), and web-based digital mapping has provided a good technical basis for the visualized emergency system for marine oil spills. Some studies applied Web GIS technology to the emergency disposal of oil spills. Oil film sensor system, emergency resource scheduling system, and disposal decision support system have been developed in previous research [1-3]. However, among the studies on the management information system of marine oil spills, neither visualized simulation on the whole process of emergency disposal nor visualized real-time monitoring and scheduling of emergency resources has been presented. Therefore, the previous proposed emergency systems cannot provide sufficient decision support for the emergency disposal. In this paper, a three-dimensional emergency system is proposed with the integration of multiple techniques, which can provide an enhanced support for decision makers during the management of emergency disposal of marine oil spills in China.

2. KEY TECHNOLOGIES

It has been demonstrated that an integrated information system can provide an effective assistance to the emergency disposal of marine oil spills [4]. Such system can display the oil spills and emergency resources, and monitor the implementation

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of emergency plans. Accordingly, the emergency system developed in this study has integrated several key technologies; positioning technology was applied for the real-time monitoring and tracking of rescue vessels, and digital mapping technology was applied for the three-dimensional visualization to improve the interactivity of the system.

2.1. Vessel positioning technology

GPS was utilized to monitor and track the location of vessels in the proposed system. In the maritime sector, GPS technology has become the standard vessel auxiliary equipment, and has formed a comprehensive system for information gathering and controlling. Automatic Identification System (AIS) for vessels, which consists of wireless transmission equipment, digital mapping data, and integrated information processing equipment [5], can gather the real-time information of vessels through the accurate positioning. Therefore, AIS provides a great convenience for the real-time monitoring of vessels and the display of vessel tracks.

2.2. Digital mapping technology

In order to perform three-dimensional visualization and simulation on the emergency treatment process, web-based digital mapping technology is required. Google Earth is an Internet digital mapping program that comprises terrain, administrative divisions, traffic information and business information. Compared with other digital maps, Google Earth has the following advantages:

1) The geographic information and data is very completed and covers worldwide;
2) The three-dimensional visualization can display the terrains all over the world;
3) Information can be transformed and displayed conveniently on Google Earth with Keyhole Markup Language (KML).

Besides, a rich source of geographic data can be obtained through the API of Google Earth, which greatly reduces the development cost. Consequently, the three-dimensional emergency system for marine oil spills proposed in this study is based on Google Earth.

2.3. Track generation for vessels

During the simulation exercises and real-time monitoring of marine oil spills, the system is expected to generate the tracks of rescue vessels and display the tracks on Google Earth. KML was applied to display such information. In KML, the Placemark label was used to display the geographic information of ports, e.g., the name, description, and coordinates. The Model label was used to visualize the three-dimensional model of vessels, including the coordinates, elevation, and scale ratio. For the visualization of vessels tracks, the LineString label was used to display the connection between points. Then the three-dimensional model and the vessel tracks were integrated into MultiGeometry. Finally, the TimeStamp label was used to display the time of a point. With these labels, a point with corresponding coordinates, model, and time can be displayed on Google Earth.

3. SYSTEM DESIGN

The aim of this study was to develop a three-dimensional visualization system for the emergency disposal of oil spills, so the three-dimensional modeling and integration of emergency resources and sensitive areas are required. In order to perform real-time monitoring and control on the emergency treatment process, it is necessary to implement the remote data transmission to local database and the real-time updates of digital maps. Besides, the design of database model and object-oriented classes is also needed for data storage and processing.

3.1. Three-dimensional modeling and scene integration

Three-dimensional modeling technology was adopted for the three-dimensional display of vessels, aircrafts, spill containment booms, emergency resource warehouses, ports, and airfields. Based on that, scene integration was conducted on the three-dimensional scenes in the marine environment, including coastal geography, sea surface, coastline, etc.

In the integrated three-dimensional scene, emergency plans can be simulated and evaluated. Decision makers can select the optimal emergency plan and monitor the implementation process in real time.

3.2. System architecture

The emergency system proposed in this study consists of four modules. The first one is the management and scheduling of emergency resources. The second one is the simulation of marine oil spills. The third one is the decision support module that generates and evaluates the emergency plans. And the last one is the real-time monitoring module. The relations among these modules are shown in Figure 1.

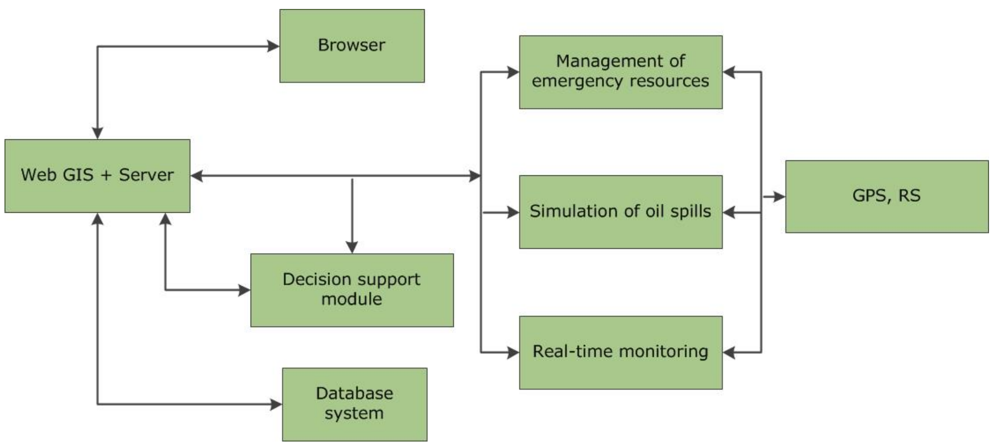

Figure 1. Functional modules of the proposed system

The proposed system adopted the Browser/Server (B/S) structure in consideration of the low development cost and good portability. The architecture is shown in Figure 2. In the local server, Navicat was used for database management, and

Hibernate was used for the object-relational mapping from database tables to Java classes. KML files were generated by Java. In the browser, Google Earth API was utilized to import the KML files and produce the visualization. In addition, the interaction with digital map was realized through URL transmission. Remote servers gather the data (e.g., spill information and GPS signals) dynamically and transmit the encoded data to the local database. After decoding, the data will be used for display.

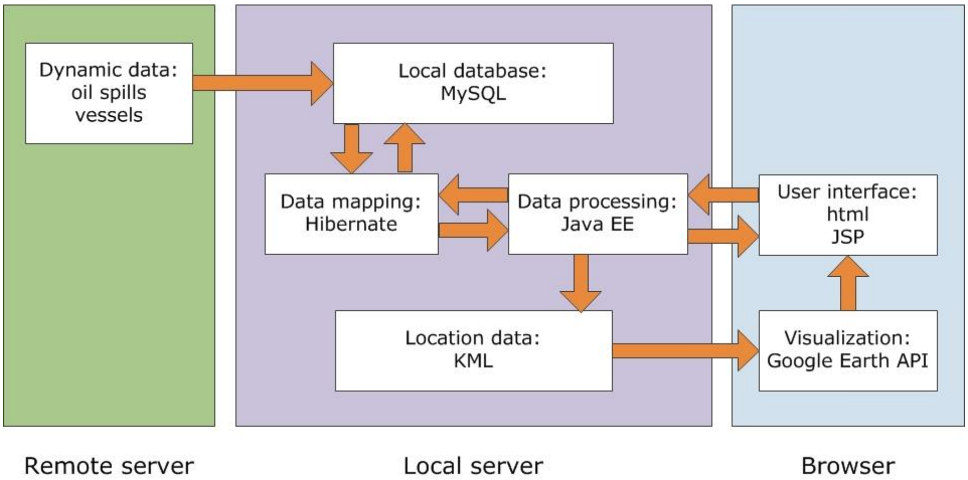

Figure 2. System architecture

3.3. Database and Java classes

Corresponding to the scheduling of emergency resources, the updates of vessel tracks, and the positioning of vessels, the database model of the proposed system has three entities, namely emergency plans, vessels, and vessel tracks. Another two tables are needed for the relations among entities.

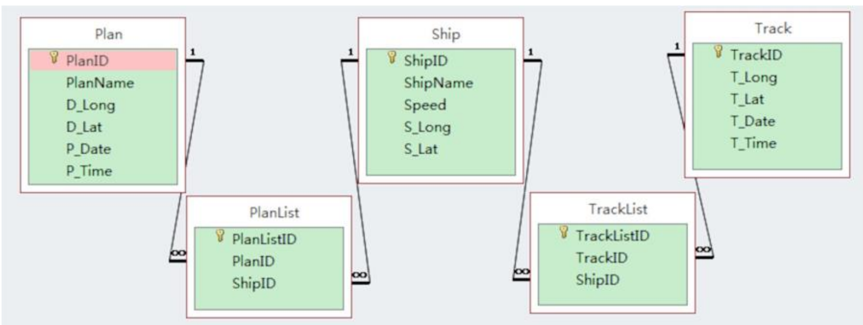

Figure 3. E-R model of the database

Given that the generation of KML files and the implementation of algorithms were based on Java program, the data in the database need to be transformed into the objects applicable to Java. Hibernate plugin was utilized to build a Java class for each database table, which can avoid the frequent use of SQL queries and enhance the efficiency of the system.

4. SYSTEM IMPLEMENTATION

For the proposed three-dimensional emergency system, algorithms that compute vessel's voyage and time are needed for the generation of vessel tracks. And a user-friendly interface is also required for the display and monitoring of simulation exercises. Accordingly, Java was adopted for the computation of vessel tracks and the generation of KML files, and JSP was adopted for the development of interface.

4.1. Vessel track computation

In order to perform simulation exercises and real-time monitoring, the system is required to generate the routes or tracks of the rescue vessels and display them on Google Earth. Given that the system focuses on the coastal areas of China, the following hypotheses were made:

1) The disposal to marine oil spills is conducted by proximity. Due to the small latitude and longitude span along the coast of China, the nearest ports will be chosen to send the rescue vessels.
2) Straight route is selected for the disposal. Because the coastline of China is smooth and usually convex, straight line can always provide the shortest route.

Based on the two hypotheses above, the distance and time of the vessel track can be computed according to the start and the destination. In the system, the route was pre-evaluated based on the longitudes and latitudes of the starting point and the destination. Real-time monitoring was based on the coordinates and time information decoded from the real-time GPS signals. Then the vessel tracks can be simulated and visualized with these data.

4.2. KML files generation

In simulation exercises, information of vessels and vessel tracks are needed. In real-time monitoring, only the vessel information is concerned. And the information of ports is regarded basic and will be displayed all the time. The proposed system displays these information through KML files. KML files were automatically generated by Java programs. An example of the KML file is shown in Figure 4.

```
<Model>
        <altitudeMode>absolute</altitudeMode>
        <Location>
                <longitude>121.95</longitude>
                <latitude>31.0</latitude>
                <altitude>0</altitude>
        </Location>
        <Orientation>
                <heading>-18.152705886651013</heading>
                <tilt>0</tilt>
                <roll>0</roll>
        </Orientation>
        <Scale>
                <x>10</x>
                <y>10</y>
                <z>10</z>
        </Scale>
        <Link>
                <href>files/ship.dae</href>
        </Link>
</Model>
```

Figure 4. An example of the KML file for the display of a vessel

4.3. Interface implementation

The interface on the webpage mainly consists of a menu and a map. The digital map needs frequent updates according to the user’s operation, while other areas in the webpage have no need for frequent refreshing. Therefore, two individual frameworks were utilized in the interface design for better user experience. An example of the system interface is presented in Figure 5.

Figure 5. Interface for the simulation exercises and real-time monitoring

In Figure 5, the left side is the control menu, and the right side is for display. In real-time monitoring, the right side of the webpage requires periodic refresh to display the real-time position of the vessels. The refresh interval can be set in the JSP file in Google Earth.

5. CONCLUSION

The proposed three-dimensional emergency system for marine oil spills has the following key contributions:

1) The three-dimensional visualization for the scheduling of emergency resources was implemented;
2) Simulation and evaluation on emergency plans were implemented. A number of emergency plans can be generated and simulated, and the optimal one can be determined by decision makers through the comparisons among those plans;
3) Real-time monitoring on rescue vessels was achieved on the basis of Google Earth API and GPS techniques;
4) The actual effect of an emergency plan can be comprehensively evaluated according to the simulation and real-time monitoring.

Consequently, the proposed system can serve as a great support for decision makers and contribute considerably to the management of emergency disposals of marine oil spills in China.

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Section 5: Transport and distribution

MULTI-CHANNEL MANAGEMENT FACED WITH THE CHALLENGE OF INTEGRATION: A DOUBLE MARKETING AND LOGISTICAL PERSPECTIVE

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ABSTRACT
When a company simultaneously manages several distribution channels, a question arises concerning a pooling of marketing, informational and logistical resources between them. This policy, in particular, aims at making important economies of scale regarding transport, order management and storage. One of the main issues is that the sales force and information about product availability in a channel (for example, in shop sales) is rarely faced with a distribution failure encountered in another channel (for example, Internet sales). This paper discusses the influence of an integration of sales staff, communication and logistical operations in the organisation of supply chains to improve the service delivered to multi-channel consumers.

INTRODUCTION
When a company simultaneously manages several distribution channels, a question arises concerning a pooling of logistical resources between them. This policy, in particular, aims at making important economies of scale regarding transport, order management and storage. One of the main issues is that the sales force of a channel (for example, in shop sales) is rarely trained to face a logistical failure encountered in another channel (for example, Internet sales). More generally, multi-channel management still seems confronted with a lack of integration at two levels: logistical and marketing. The aim of the paper is to show that an active integration strategy could improve the service delivered and the level of satisfaction of multi-channel consumers. The contribution is based on a literature review regarding multi-channel management, marketing strategies and logistical pooling in order to build a conceptual framework. This conceptual framework is confronted with the French multi-channel distribution field using three illustrations: King Jouet, Fnac and Darty. The information emerges from an analysis of secondary data resulting from interviews given by top managers, presenting the keys to success in multi-channel management.

MULTI-CHANNEL MANAGEMENT
Multi-channel distribution enables the consumer to use different channels (Internet, brochure, physical store) during the purchasing process. This system has now become a rule, rather than an exception (Frazier, 1999). Large retailers have not always considered changes and modifications implied by this system. Two research streams should be distinguished: the first stream focuses on the analysis of consumer behaviour and the second stream focuses on the management of companies developing a multi-channel strategy.

Analysis of consumer behaviour
In a multi-channel context, the consumer benefits from the complementarity and synergies existing between traditional and digital channels. In a multi-channel distribution context, consumers can thus alternatively or simultaneously use both channel types depending on the advantages sought, in particular in terms of availability or gratifying experience, or the type of needs. Increasingly, as pointed out by Huré & Cliquet (2011), we notice that a consumer no longer limits itself to a multi-channel behaviour through multiple interactions with each channel but has a *cross-channel* behaviour through crossed and multiple interactions between the channels. This mechanically intensifies the integration requirement as a strategic approach aiming at offering a similar and smooth experience to consumers through all the channels used (Montoya-Weiss *et al.*, 2003). In the opposite case, a dissonance experience could become an issue for customer loyalty; the perceived congruity of stores and websites clearly constitutes an essential element of customer loyalty given the evolution of cognitive scheme of multi-channel consumers.

According to Cassab & MacLachlan (2009), the consumer's perception of integration can result in a coherent answer to a question asked *via* different channels, or to an interaction through a channel that takes into account past interactions *via* other channels. Moreover, multi-channel integration, by enabling the consumer's complete tracking along the different channels, provides a better understanding of its multi-channel behaviour. This enables companies to provide offers that are more adapted to the needs, or even to anticipate them. The importance of integration in multi-channel consumer experience led Seck & Philippe (2013) to introduce in their conceptualisation of service quality and multi-channel satisfaction, the perceived quality of integration, referring to the "*capacity to provide the client with a similar experience through all the channels used*". It is the case for Sephora in France, by scanning its loyalty card with a smartphone with the MySephora application, the salesperson accesses the consumer's complete sales record (on Internet as well as in store), and a software automatically suggests products that are consistent with this record and the consumer's profile.

It is clear that the multiplication of channels available to cosnumers change their purchasing behaviours. Studies analyse the channel selection process (Balasubramanian *et al.*, 2005), the use of channels during the purchasing process (Piercy, 2012), the consumer migration from a channel to another (Gensler *et al.*, 2012) as well as the research for elements determining multi-channel adoption and its influence on consumer profitability (Venkatesan *et al.*, 2007). Vanheems (2012) highlights the changes in the consumer's profile who, thanks to the multiplication of information sources, becomes a genuine expert. Bouzid & Vanheems (2014) shows that the cross-channel path of a consumer changes its purchasing behaviour in store. This new consumer is less receptive to business offers and to the shop's staging; the consumer develops a control of the situation (temporal and financial resources) and self-control. Existing relationships between the sales force in store and consumers are therefore changed: the dominating position in terms of knowledge, detained by the salesperson up until then, is questioned (Vanheems, 2009). This change can lead to a distrustful behaviour from the consumers towards the sales personnel (Vanheems, 2012).

Analysis of multi-channel strategies

A second stream of research focuses on the management of multi-channel systems. Indeed, the risks of conflict associated to the cannibalisation risks are substantial (Coelho & Easingwood, 2003; Jeanpert, 2010). Research has highlighted the importance of multi-channel coordination to benefit from synergies associated to multi-channel (Neslin *et al.*, 2006), others focused on management channel conflict (Webb & Lamb, 2007). The analysis of studies on multi-channel system management shows two possible strategies: integration strategies and separation strategies. This choice is not dichotomous (Gulati & Garino, 2000; Zhang *et al*., 2010). Mixed strategies also exist; they are based on a mix of integration and separation strategies. Gulati & Garino (2000) define the elements (brand, management, operations and capital) on which companies can define their level of integration or separation. With a separation strategy, the company shows a different product mix, prices are not homogeneous between the channels. This strategy can lead to numerous conflicts, however, it enables to keep a great flexibility to face competitive situations; it also enables a better adaptability of the mix depending on the segments targeted (Zhang *et al*., 2010). Then again, an integration strategy assumes the blending into a unique system (Stone *et al.*, 2002). Integration is based on the will to create "links" between channels (Vanheems, 2009). Each channel must complement the others, as indicated in Box 1.

Box 1: Interview of the cross-channel manager for the company King Jouet

King Jouet is a French chain of stores specialised in games and toys for children, it has a network of over 180 stores. It possesses three types of stores: (1) the stores named King Jouet, located in periphery of large cities with a store space of over 750 m²; (2) the stores named King Jouet City, located in medium sized cities with store spaces from 300 to 750 m²; (3) the shops named King Jouet, located in city centres with medium sized store space of 300 m². This results in a substantial national coverage.

How do you plan your web and retail activities?

The aim of the drive-to-store is to decompartmentalise e-commerce and retail, in order to avoid internal competition between sales made online and sales made in store. Internet must position itself as a business provider for stores. In our company, it only represents 10% of the group's turnover. The KPIs implemented are not linked to e-commerce but to cross-channel activities. We are ahead of our *competitors regarding this aspect and we started by changing our website. Indeed, developing the necessary tools in store is a good improvement, but our website had to have a ROPO approach (research online purchase offline). We have developed practices such as the click & collect, the e-reservation and the mutualised cart (reserve or purchase online, then collect from the store or be delivered). We now give the possibility to choose a favourite store (giving access to its stock), with the aim to improve the consumer's purchasing process.*

What were the effects?

This modification enabled us to offer five times more products, corresponding to the entire range contained in over 200 stores, while keeping the same volumes of supply. We had to upgrade our stores by placing devices to ease the consumer's choice. Indeed, as toys are intended for children, the choice becomes very technical and very involving. We need our sales personnel to be on equal footing, for example, by equipping them with tablets providing the consumer's sales record. Technology is not the only tool that is why they will be trained in different sales techniques. Web-to-store consumers are not low-end consumers; they must be treated equally, by showing our stores' collection points more clearly for example.

Source: http://ledrivetostore.com/ [retrieved March 11, 2015].

Recent studies have highlighted that a large majority of multi-channel companies are managed as independent systems (in silos), where marketing or communication operations are not done in common (Cunnane, 2011). For Neslin & Shankar (2009), a multi-channel company must coordinate its channels rather that manage them in an independent way. Vignon (2013) reminds us that cross-channel management gives priority to consumers rather than to channels. Multi-channel retailers must modify their functioning, go over their organisational founding principles, their business processes and their customer knowledge (Cunnane, 2011). This integrated management questions a certain number of elements, such as marketing, stock management, range of products, product orders and returned products. Logistical and operational decisions must be rationalised (Oh *et al.*, 2012). Van Baal (2014) notices two levels of integration: coordination of channels and harmonisation of marketing variables.

The coordination of channels covers activities that are invisible to consumers like purchasing, logistics and customer data management. Organisational coordination must be done through the considering of potential economies of scale (Neslin *et al.*, 2006; Pentina & Hasty, 2009; Zhang *et al.*, 2010). From the analysis framework established by Gulati & Garino (2000), Pentina & Hasty (2009) identified sources of coordination. Marketing and communication functions can be coordinated: the use of the same brand name in all channels enables to benefit from the brand reputation, its perceived quality, its fame, etc. The trust and credibility associated to the brand reduces the perceived risk (Pentina & Hasty, 2009). The use of online communication tools (e-mailing, viral marketing, site search) benefits all channels. For example, the company sends its consumers an e-mailing to communicate on its new collection by adding links to the stores where the products can be found, as well as their availability. Marketing coordination also allows the implementation of cross-channel promotions and cross-selling (Neslin et *al*, 2006). Pentina & Hasty (2009) also consider the coordination of logistical operations and information management. The creation and development of a cross-channel database uniting customer information would enable to create genuine multi-channel shopping experiences. CRM operations and logistical functions would be synchronised.

The compensation system should also be changed (Zhang *et al*., 2010). Fournier (2009) underlines the importance of entirely rethinking compensation systems in a multi-channel context. He suggests to reconsider the payment structure by, for example, increasing the fixed part of the total remuneration, developing qualitative objectives (integrate qualitative indicators such as customer satisfaction or product knowledge), setting team objectives. The payment system must minimise conflict in particular those linked to the allocation of sales and encourage collaboration between channels (Jeanpert, 2009; Jeanpert & Salerno, 2013). Jeanpert & Salerno (2013) highlight the impact of the compensation system regarding the personnel's consent to multi-channel. Marketing variables unite the elements that are visible to the consumers: it may be the shop image, prices or product mix (length and depth of the range). Baal (2014) shows that the harmonisation of these marketing variables lead to advantages (increase in quantities sold, customer loyalty, customer retention) as well as inconvenients (such as risks of cannibalisation, in the short run). The decision to harmonise is not trivial (Müller-Lankenau *et al.*, 2005; Pentina & Harsty, 2009; Zhang *et al*., 2010).

CHALLENGES RELATED TO INTEGRATION

Within a single generation, multi-channel distribution has become a management model that raises major technological and organisational concerns. In the extensive literature dedicated to this theme, the emphasis is placed in an increasingly systematic way on the necessity of a global and combined management of all the channels offered to the consumers in reference to their coordination or even to their integration. The management of logistical operations, linked to the sales on Internet, is often paired with a purchasing system developed for stores. This is a major approach as, without it, the risk for the companies to simply add a new channel is significant (examples: Internet or a call centre) to an existing channel (example: sales in stores).

Risks linked to the absence of integration

As said by the France CRM manager of Accenture, in an interview given in 2002 to the magazine *Marketing Direct*, *"the adoption of multi-channel was done by many companies through the successive addition of channels without a genuine global integration".* We cannot deny that, today, companies should opt for a true multi-channel strategy based on precise objectives to achieve, a rigorous implantation approach and a subsequent evaluation of policies used (Verhoef, 2012). Indeed, the fact that too few companies work on globalising schemes of multi-channel distribution, by developing an ago-antagonist view of different channels, can end up with numerous malfunctions:

- Risks of conflicts between channels, resulting from a lack of role convergence between the channels (Stone *et al.*, 2002; Payne & Frow, 2004);
- A lack of potential synergies between channels (Coelho & Easingwood, 2003), leading to additional costs in lieu of economies of scale and economies of scope;
- A relatively long and costly learning period for the company (Vanheems, 2009), synonymous of a potential loss of competitive advantage.

Therefore, it is normal for numerous companies to raise questions regarding the way to effectively integrate their channels according to a holistic perspective (Stone *et al.*, 2002; Montoya-Weiss *et al.*, 2003). Coelho & Easingwood (2003) present cross-channel management as the degree according to which the distribution activities are placed under the direction and the control of a unique entity. Multi-channel integration leads us to consider a company's channels as being part of a coherent value creating system, rather than as parallel or isolated elements. Concerning logistics, multi-channel integration consists in coordinating supply chains associated to different channels in order to place common "knots" (warehouses, platforms), with the aim to make economies of scale, as well as differentiate operations, in particular final delivery, when the advantages sought by the clientele are specific.

The opening to a multi-channel distribution corresponds to the companies' desire to optimise their profitability. The choice of a click & mortar strategy, by adding an Internet channel to the traditional channels, will give them the opportunity to succeed. Now, they can make their products, and the information related to it, available at any time, in any place and at a lower cost, with, for example, a decrease in distribution and transaction costs (through the decrease of intermediaries). However, the use of multiple channels leads companies to organise and manage each channel, to establish marketing strategies, to invest in technologies and logistics process and to create a customer database. For the companies, this constitutes a heavy investment and forces them to think about the means to make this multi-channel distribution system as efficient and effective as possible, in particular by associating the sales personnel to it, as Fnac did (see Box 2). Working on globalising schemes becomes essential; multi-channel integration constitutes a mean to reach this objective (Payne & Frow, 2004).

Box 2: Interview of the managing director (France) of Fnac

Fnac covers a large number of sectors, on which it is positioned as a leader: distribution of technical and cultural products, gift boxes, shows and travel tickets. The company is in line with a cross-channel where all the products are offered and accessible to consumers both in store (80) and on Internet. The strategy articulates around three main areas: (1) Develop Internet; (2) Develop store network in periphery of *urban areas; (3) Anticipate market evolutions by working in particular on the dematerialisation of cultural products.*

What is the place occupied by multi-channel in the strategy of Fnac?
Multi-channel is essential for us. Fnac.com is a powerful tool that enables us to manage our product and customer references. We have a strong added value content and we are capable of understanding the needs and behaviour of consumers in store as well as on Internet. The value is created from the capacity to cross this information and use it in all our marketing channels. We have deeply modified the organisation regarding customer activation by entrusting this management to Internet teams in order to have a unique customer management policy. These teams have developed a set of tools enabling to understand and analyse the path used by the consumer on the website. We provide these quality management tools and methods and put them at the disposal of the stores.

What is the place still occupied by the stores and sales personnel?
Stores remain at the heart of our strategy and the objective of the new organisation is to develop the turnover in store. We will therefore enable the consumer to be more autonomous, and help the salesperson to better understand the consumer: the consumer can access its My Fnac page and customise the advice needed. We wish to develop the "everything, all the time, everywhere": a store's salesperson should be able to offer products located in other stores or on Internet, and get them delivered at the consumer's home or in store. This is a real innovation in support of customers.

Source: http://lumens-consultants.com/ [retrieved January 27, 2015].

Impact in terms of performance

Through the sharing of logistical process, technologies, marketing and communication policies, cross-channel management helps to enable the benefits of synergies and complementarities between the channels. For example, some large retailers, having developed sales through Internet, use their physical stores like a logistical base to prepare orders made online. They make *store picking* operations (Tesco model) before delivery to the consumer's home, or they may ask the latter to come to a *drive*, sometimes annexed to a physical store, from which the consumer will collect its orders (Auchan model). In both cases, the physical and the digital store (website) are integrated in a global strategy in terms of management of product mix and policy of product availability for customers (Durand & Senkel, 2007; Agnihotri, 2015).

Besides, cross-channel, through a more coordinated management and a more cross-functional vision of all channels, enables a better perception of the real performance of each channel in terms of turnover, costs of customer contact, profitability, etc. (Seck & Philippe, 2013). It makes possible a more efficient and effective allocation of resources and logistical skills within, as well as between the channels and, as a result, a more rapid return on investment. Furthermore, a direct relationship has been established between integration and performance. Hence, the studies led by Fabbe-Costes & Jahre (2008) underline the existence of a positive impact of integration on five types of performance: logistical, sales, financial, strategic and linked to sustainable development.

Besides the cost savings and the improved profitability that a cross-channel can bring, significant challenges lie ahead. Given that consumer-oriented logistics is clearly a key to success for online retailing (Colla & Lapoule, 2012), it is important to question the articulation between physical stores and digital stores regarding the effective management of flows. This is an issue that Darty has been trying to solution for the past ten years, and that is at the root of numerous innovations (see Box 3). As underlined by Stone *et al.* (2002), a certain number of issues should be resolved, such as:

- *Unification of different systems*, based on operating modes that are very different from one another;
- *Assembly and standardisation of data*, resulting from multi-channel interactions with the client;
- *Heavy investment in technologies and strategies*, the consequences of which are difficult to evaluate;
- *Decrease or suppression of some organisational obstacles*, linked for example to the personnel's adoption of new technologies.

Box 3: Interview of the managing director of Darty.com

Darty stores offer a wide selection of home appliances products, TV, video, hi-fi, telephony, multimedia and Internet. The company has over 230 stores and is positioned as the leading distributor of home appliances and consumer electronics in Europe. In 1999, the company created its website Darty.com. It is seen as complementary to physical stores, with a significant level of visits (over 120 million visitors per year).

How can the success of your company's cross-channel strategy be explained?
The key element of our success is the relationship with customers that is not specific to a type of point of sale. We consider that the customer may prepare its visit on our website, continue within a store and finish through its mobile. This complementarity of points of sale is what makes the value and effectiveness of the system. Of course, prices are uniform according to the channels. And we offer all usual delivery systems. You can buy your products online and then pick them up an hour later in the store. We also offer the Darty delivery, which includes the installation and recovery of the old equipment.

How have you reached interoperability of channels?
Interconnection and synchronisation of points of sale are very complex to achieve. To do so, a real-time vision of the stock in stores from the website is necessary, this requires a high level of IT. As well as successfully synchronised marketing and supply. We constantly work on making our positioning uniform, by multiplying the points of contact between the services.

How can we create a dynamic between Internet and the stores?
One of the keys for a successful cross-channel development is to avoid working in silos, and to consider that, ultimately, what matters are the sales to customers. In our company, each Internet sale is assigned to a store. The channel analysis is not very important. The physical point of sale prevails and the store manager responsible for the point of sale with an annual turnover for physical and virtual activities, corresponding to the Internet sales to which it is assigned. This prevents contrasting the channels and helps build many projects, such as customer information and store news via the website.

Source: http://www.ecommercemag.fr/ [retrieved April 16, 2015].

DISCUSSION AND CONCLUSION

The pursuing of a cross-channel strategy in a double approach, logistics and marketing, highlights major benefits in terms of profitability and differentiation, provided that globalising schemes, based on a holistic vision of channels at the disposal of customers, are initiated. The latter should not be seen as compartmentalised and unconnected entities, but as a single entity whose mission is to create value for both the company and the customer. From this point of view, cross-channel management could be driven in various ways and requires a number of changes at strategic, logistical, financial, organisational and informational levels, including regarding the design of channels. Cross-channel management is not an end in itself but it can be a manner to significantly improve the company's performance, helping it to benefit from synergy and complementarity between channels, resulting in economies of scale and greater profitability. In addition, it creates value for the customer who will have a coherent, uniform and continuous vision of its experience across all channels. For this purpose, two tracks should be favoured:

(1) *The necessity to strengthen links between the Internet channel and physical channels.* The advantages and potentials that a website can provide to a business are well established. If, for many companies, the addition of this channel to traditional channels initially responded to "a fad" (Monnoyer-Longé & Lapassouse-Madrid, 2007), now the trend is to promote links between the website and traditional existing channels. Consequently, it becomes important for businesses, especially in the retailing industry, to favour a cross-channel management through a combined vision of traditional and digital channels. The website has become, especially in the trade sector, an essential media for the customer relationship management, rather than just a marketing channel in its own right, in support of traditional channels. The integration of the website to the company's overall offer, through its interactivity, is likely to create value and sustainably capture customers. However, a deliberate strategy on the matter should be pursued, which is far from being the case, for example in banking. The challenge is to *harmonise* the different components of multi-channel, rather than *homogenise* the offer (Zhang *et al.*, 2010).

(2) *A more cross-functional multi-channel organisation.* For companies, cross-channel management becomes a key challenge, beyond the technological questions, to the extent that

it requires a set of changes at the strategic and organisational levels (Stone *et al.*, 2002). Yet, there is a high risk to see a vertical management continue, without an involvement and a true interaction of all channels in any questions linked to it. For example, a large retailer implementing a *drive* logistical system, based on the picking of products in stores, needs to make sure that the store will not be completely disorganised by the orders made on Internet. A cross-functional work needs to be done to coordinate actions, beyond the famous functional silos of Fordist companies. For any action led, it is essential that the key functions concerned, and the managers of marketing channels, work together. The aim is to lead each of the actors to develop a "multi-channel reflex" that will homogenise the consumer's vision of its global experience across the various channels.

The latter element seems essential. Indeed, when facing all the channels at its disposal, customer assistance, improving the use of the wide range of channels, is capital; the company cannot limit itself to the simple action of raising awareness regarding the existence of the channels, it should prove how it can meet the needs and advantages sought in the most efficient manner (Vanheems, 2012). Only a consumer perception based on the multi-channel coherence (congruence), stemming from the powerful integrative processes, can achieve this. The sales personnel should be considered as a component of these integrative processes. The coherence depends on the degree to which the consumer perceives the uniformity of information received through various channels of the company. The consumer's awareness of channels at its disposal, and their functionalities, is likely to help guide its choice, which will positively impact its satisfaction.

It remains to be seen whether the sales force should be placed at the centre of the cross-channel management measure. This seems to be the case for Fnac and, to a lesser extent, for King Jouet. As the sales force holds an increasingly important role in the service recovery, to do so it must have real time data available regarding flows passing in logistical networks. This data enables the seller to be quick to react in case of problems by offering an acceptable replacement solution to the consumer (for example, a defective product after an Internet order replaced by a product available in a warehouse and delivered at home within 24 hours). Companies must therefore facilitate the access to logistical information for sales forces, which implies an organisational *decompartmentalisation* between the marketing and the supply chain activities. The usual analysis of the sales force is done based on marketing and HRM studies, in particular to study the implication of sales staff and role conflicts (role of consumer's representative, role of defence of the company's interests). There is a need to widen this narrow vision. Indeed, when it has logistical data available regarding product flows, the sales force can increase customer satisfaction, for each of the distribution channels and for all channels. This is a major challenge for large retailers in the coming years.

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THE IMPACT OF THE SHORTAGE OF TRUCK DRIVERS ON LOGISTICS: CASE STUDY OF JAPAN

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ABSTRACT
Truck transport has fulfilled a crucial role in contemporary logistics. However, a major change has occurred recently in truck transport logistics, especially in Japan. There has been a severe, ongoing, shortage of truck drivers which has had a serious impact on the logistics as a whole. This has made the supply of truck transport in the market more unstable and unreliable for the logistics needs of companies. Under these circumstances, it is strongly recommended that companies' whose logistics depend heavily on truck transport, should adopt new measures to secure their stable transport needs. Three measures were introduced by companies in Japan on the whole: a modal shift that changes from trucks to railroad and marine transport; the implementation of cooperative delivery systems that increase loading efficiency and decrease the number of trucks needed on a daily basis; and finally, an improvement of problematic, common, practices that have deteriorated the efficiency of transport.

INTRODUCTION
Truck transport has fulfilled a crucial role in contemporary logistics. It provides a fast and relatively low cost service which has contributed greatly to the implementation of efficient logistics. However, a major change has recently occurred in truck transport logistics, especially in Japan. There has been a severe shortage of truck drivers. This has made the transport of products by truck unstable and brought uncertainty into a once very reliable mode of delivery.

This situation poses a severe challenge for a great many of the companies which use trucking as their primary means of transport. The truck driver shortage has in essence lowered the utility of trucking since it is no longer able to guarantee a fast and low cost service. This is very serious development which has had a wide impact on the logistics needs of companies. New measures have to be seriously considered to maintain the high standard of service clients' demand from their cargo transport. The new measures being introduced have already started to improve the unreliable transport situation.

This is a case study of the recent changes seen in Japan. The purpose of this paper is to show how logistics has been impacted by the truck driver shortage and to analyze the new measures adopted to overcome it. This paper will make clear what these new measures are and how they will change logistics. There is a good possibility the new logistics methods being introduced will be able to overcome the truck driver labor shortage.

The situation being seen in trucking mirrors the inevitable labor shortage being experienced in varying degrees throughout the developed world where the working age population is decreasing. This labor shortage is having a direct effect on the labor-intensive truck transport area and logistics will have to change to cope with this new factor. What is happening in the logistics of Japan is widely expected to happen in other developed countries in the future. Thus, it is valuable to clarify how the logistics responded to this labor shortage.

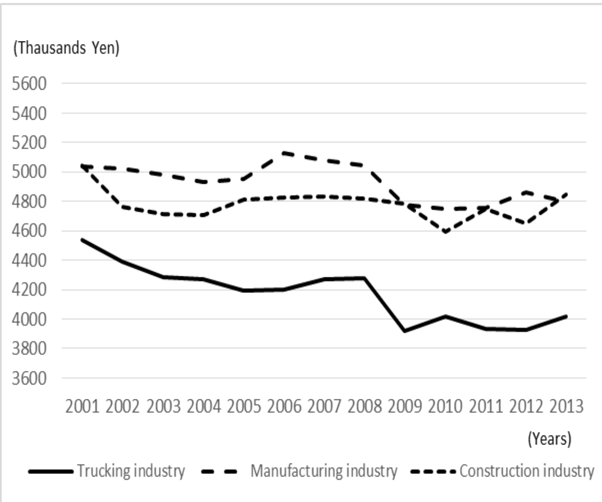
This research paper looks into the various measures companies have taken in response to the truck driver shortage. Interviews with manufactures, retailers, and logistics service providers have been conducted in order to facilitate this process.

THE SHORTAGE OF TRUCK DRIVERS AND ITS IMPACT ON LOGISTICS

Truck transport plays an important role in Japan. It accounts for more than 91.4 % of the total cargo volume in ton and more than 51.3% in ton-kilometers in 2012. There are two types of trucks: commercial–use trucks and private-use trucks. Commercial-use trucks operated by trucking companies account for 69.0 % of the total cargo volume of trucks in ton and 85.9% in ton-kilometers. Commercial-use trucks transport much more cargo than private-use trucks. This means the trucking industry with its use of commercial trucks, plays the most important role in cargo transport. This industry, however, is now facing a severe truck driver shortage.

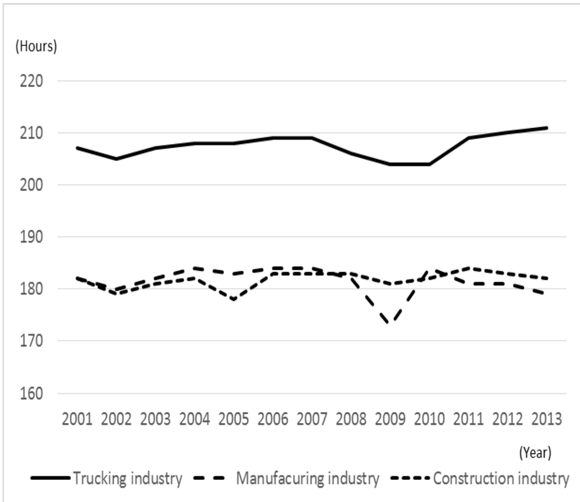
Since the deregulation of the trucking industry in 1990, many small companies have aggressively entered the truck transport market. The number of trucking companies has increased by 20,000 since deregulation. This large amount of new entry into the market has caused excessive-competition. Under these circumstances, trucking companies had to offer cheaper truck freight rates to shippers. The truck freight rate eventually dropped rapidly and trucking companies had to reduce their costs in order to survive. As a result, trucking companies had to both lower their driver's wages and make them work longer hours.

As indicated in Figure 1, the difference in wages between the trucking industry and other industries can be seen to have gradually spread since deregulation took place. In Figure 2, you can see the working hours for truck drivers has gradually increased and there is a big difference between the working hours of the trucking industry and other industries. Given this situation, the trucking industry has slowly become less and less attractive for workers.



Data: Ministry of Ministry of Health, Labor and Welfare

Figure 1: Annual Earnings by Industry



Data: Ministry of Ministry of Health, Labor and Welfare

Figure 2: Monthly Working Hours

As the Japanese economy is slowly recovering from the recession and the working age population has decreased, the shortage of truck drivers has become a severe problem. Many truck drivers have moved to other industries that offered more attractive wages and labor conditions. It has become more difficult for trucking companies to recruit new employees. Although the truck driver shortage was initially acute only in the long distance transport sector because of their extremely long working hours, this situation has recently expanded into both the medium and short distance transport sectors as well. Almost all trucking companies now face a severe shortage of drivers and this is common throughout the trucking industry. This shortage of drivers has become one of the most important problems for the logistics industry in Japan.

The impact of the truck driver shortage on logistics

The severe driver shortage has had a great impact on cargo transport costs in companies. The driver shortage caused wages to increase at first, this, in-turn, increased truck freight rates. Transport costs began to increase. Companies used to have relatively low transport costs, this is why they selected trucks as their main method of transport. However, contrary to what they experienced in the past, companies are now experiencing the opposite trend and transport costs are increasing.

Secondly, it was inevitable the quick and flexible high level of service seen in the transport service sector would deteriorate. Trucking companies provided a just-in-time transport service and shippers could maintain logistics operations without having large amounts of warehouse stocks. Shippers could specify the time of delivery and were given many options. However, the labor shortage decreased the supply of truck transport and has made it harder for just-in time transport to be offered as widely as before.

Thirdly, the driver shortage has brought about the risk of a physical inability to transport cargo, especially during the peak times such as at the end of the calendar and fiscal year. During those peak times, it has become difficult for shippers to find trucks, even if they offer high freight rates. Trucking companies might be unable to ship their cargo and this means that manufacturers may have to stop production and retailers may be unable to stock their shelves. Both situations would be ~~a~~ critical for shippers.

THE IMPLIMENTATION OF A MODAL SHIFT

In response to the severe truck driver shortage many companies have changed their primary means of transport from trucks to both railroads and marine vessels. Railroads provide container services, while shipping companies provide maritime services which can include ferryboats, container ships and roll-on /roll off ships.

When the prevalent means of transport changes from, in this case, trucks to railroads and marine vessels, this is called a "modal shift". Since the end of the 1980s, the Japanese government recommended this modal shift to companies that depended heavily on trucks in order to help reduce CO2 emissions. Some big companies took the governments' advice and took steps to alleviate the burden on the environment under the rubric of their CSR (corporate social responsibility) duties, but many did not.

Despite the expectation for a change to greener logistics, the modal shift the government was trying to introduce didn't make substantial progress until recently. It didn't happen for two reasons. First, the costs were higher; and second, the lead times were longer. Trucking was surprisingly both cheaper and faster than using either railroad or marine vessels. It was difficult for companies to change when trucks were less expensive and provided a faster transport service. Most companies selected cost and speed over being environmentally friendly, and fulfilling 'unrewarded' CSR plans.

However, the severe driver shortage has now become too unstable, and companies are starting to focus on alternative means of transport which is rapidly pushing forward the modal shift. The driver shortage has forced companies to start utilizing railroads and marine vessels, in order to secure a stable, long distance cargo transport service.

The case of a model shift in a food manufacturer

One of the major food manufacturing companies in Japan, Ajinomoto, has moved forward positively with this modal shift. Although the company is already transporting a lot of its cargo by railroad, it has taken steps to accelerate both the use of railroads as well as marine vessels against its earlier heavy use of trucks in its long distance transport needs of more than 500 km.

Ajinomoto clearly shows the modal shift taking place in 2014, when approximately 87% of its long distance transport of more than 500 km had already shifted away from trucking. Railroads account for 54% of this total shipping volume and marine vessels account for the remainder of 33%. The company plans to completely ban the use of trucks by 2016. This means the modal shift rate will soon hit 100% and all of its long distant cargo needs will have shifted away from trucking.

Railway containers of 12-feet are commonly used in Japan. But it is difficult to use pallets in containers of this size, even though they are very important for the efficient handling of cargo. If pallets are used in these 12-feet railway containers, not only does the loading efficiency of the containers go down, as both the loading and unloading have to be done by hand which uses more manpower, but it takes a lot more time. In response to this problem, Ajinomoto has pioneered the introduction of 31-feet railway containers that not only have the same carrying capacity as large trucks, but make it possible to use pallets efficiently. The introduction of these new 31-feet containers has revolutionized railway modal transport by making it more efficient and a suitable alternative to trucking.

This company is also using roll on/roll off ships in marine transport. The merit of marine transport is that it is not only punctual, but cargo damage is minimized due to the shaking of ships even in rough weather. This mode of transport is also proving to be an excellent means of transport.

The case of a modal shift in a retailer

One of the biggest retailers in Japan, Aeon, has started to use railroads for the cargo transport of its store brand items. This retailer has aggressively developed a variety of its' own store brand items. The manufacturers which make its brands used to ship items by truck to its distribution centers.

But in response to the severe truck driver shortage, Aeon suggested to some food manufacturing companies to try transporting their finished brand items to Aeon by railroad. Three food manufacturers participated in this project and Aeon placed an order for the appropriate number of cargo trains to be made available during the peak time at the end of the year.

The company decided to use railroads to secure the stable and timely transport of its goods because of the truck driver shortage. Aeon says it can enjoy a cost benefit in using rail transport if the distance is more than 700 km. In other words, despite the rapid increases in the freight rates for long distance trucking, railroads are still not as cost efficient as trucking under 700 km. Aeon is clearly worried about the delivery of its goods, especially at the busy times of year.

THE INTRODUCTION OF COOPERATIVE DELIVERY

One of the new methods to achieve a cost saving in trucking is called cooperative delivery. Cooperative delivery makes it possible to use less trucks which is crucial when truck transport becomes unstable due to a truck driver shortage. Some companies have started to introduce the cooperative delivery system in response to the severe truck driver shortage.

Companies in the same industry compete with each other in the sales of products or services. Under these circumstances, each company transports their cargo individually, despite having the same customers at the same destination. However, if it is possible to carry each company's cargo together to the same customers, the loading efficiency of trucks will improve and the number of necessary trucks will decrease. This is the cooperative delivery system that improves the loading efficiency of trucks and decreases the number of trucks at the same time (see Figure 3).

Although companies continue to compete against their rivals in the sale of products, they have decided it is in their best interests to form an alliance and do joint logistics with each other. The cooperative delivery system is an attempt to go beyond the normal framework of competition between companies and cooperate with one another in the logistics field to reach a goal which is beneficial for all parties.

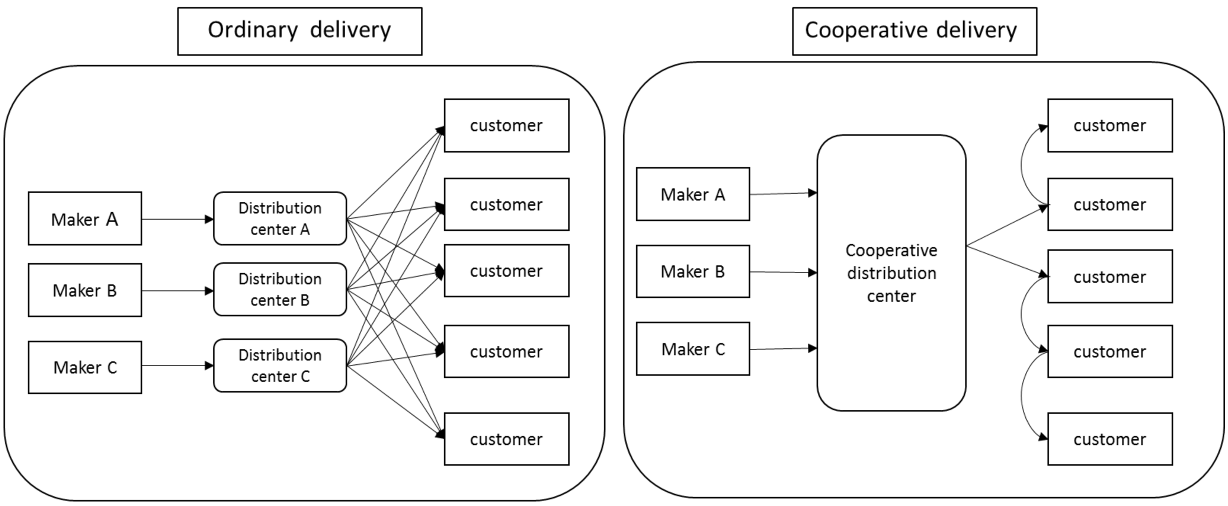


Figure 3: Cooperative Delivery System

The Case of Cooperative Delivery by Six Major Food Manufacturers
In response to the unstable transport supply situation brought on by the severe truck driver shortage, six major food manufacturers will start a new cooperative delivery effort in the transport of their shelf-stable foods. This new joint cooperative delivery service was decided by the presidents of these companies in a top-down fashion. This indicates how serious and concerned top management is about the driver shortage problem.

Cooperative delivery is not an entirely new concept, some companies in the food industry have practiced a loose form of cooperative delivery in the past, but since six major food companies have joined together to help one another, the scope of cooperative delivery has expanded greatly. It will become necessary to form an entirely ~~a~~ new company as the new cooperative delivery joint venture becomes more widely used and more important to the companies involved. The plan itself is called a "logistics platform of food manufacturing companies".

This platform will select new cooperative distribution centers that will be able to handle both sorting and stock functions. It will eventually consolidate all its' member's products and deliver (bundle) them at one time to their wholesalers and retailers. This new cooperative delivery platform, which will consolidate the products of six major food manufacturing companies, is expected to both greatly increase the loading efficiency of trucks and greatly reduce the number of trucks needed for delivery.

The Case of Cooperative Delivery by Logistics Service Providers
Logistics service providers also offer cooperative delivery systems to companies within the same industry. Marubeni Logistics, itself ~~a~~ logistics subsidiary of a major trading company, provides cooperative delivery systems for two categories of products respectively: confectionary and pet food. .

Marubeni Logistics bundles the same category items together and delivers them at one time to the same customers. It can do this delivery using less trucks with a much higher loading efficiency compared with the case of each company delivering its' products individually. Manufacturing companies that participate in a cooperative delivery system can take advantage of lower transportation costs without being anxious about the unstable supply of truck transport. Cooperative delivery will greatly contribute to both the efficiency of trucks and help to decrease their number.

IMPROVING PROBLEMATIC PRACTICES IN LOGISTICS

There have been a number of problematic practices in logistics which cause the industry to operate many more trucks than necessary. Improving upon these problematic practices will definitely decrease the number of trucks needed for delivery. There are mainly three problematic practices in logistics: small order amounts, delivery at a designated times, and long waiting time at distribution centers (see chart 1). These practices are widely done in logistics in Japan because companies have placed a priority on their customers' benefits in logistics.

	Small order amounts	**Designated delivery times**	**Long waiting time**
problems	• Frequent delivery • Low loading efficiency of truck	• Many trucks to meet customer demands	• Waste of time of truck operation
improvement	• Increase of minimum order size • Confinement of delivery days	• Request to make the designated time more flexible	• scheduled loading and unloading at distribution centers
effects	• Increase of loading efficiency of truck • Decrease of trucks needed	• Round trip to many places by one truck • Decrease of trucks needed	• More round trips per trucks • Decrease of trucks needed

Table 1: Problematic Practices in Logistics

There has been a trend in logistics for companies to order goods frequently and in small quantities in order to avoid carrying an inventory of products. The wide prevalence of just-in-time delivery has led to the more frequent delivery of smaller quantities of goods. In order to provide this service, it was necessary to operate a large number of trucks which resulted in a corresponding low loading efficiency ratio.

While companies were seeking the delivery of smaller quantities of goods, they also required logistic providers to deliver cargo at the same designated time throughout the day. This also helped to continue the theme of keeping inventory as low as possible. The designated delivery time is usually fixed at the same hours of the day. Vendors must preserve the designated time to keep the business. This practice of giving good service and meeting the demands of customers has increased the number of trucks needed for delivery.

It is an inevitable consequence of common practices seen today in logistics, such as the frequent order of smaller lots of products and the prevalent use of a set, designated time for delivery by customers, that there will be a reduction in the loading efficacy of trucks along with a correspondent increase in the number of trucks being needed. In the situation of severe driver shortage, these practices have become ~~a~~ big problems for the logistic industry.

It is also quite common for trucks to wait a long time for loading and unloading cargo at distribution centers. Many trucks concentrate in distribution centers during certain times of the day and there are no systematic loading and unloading process. Under these disorderly conditions, truck drivers have lost time in distribution centers without anything to do, greatly lower their efficiency.

Some companies have started to improve these problematic practices by trying to negotiate with their customers to make the size of the minimum lot order bigger and to make the designated time for delivery more flexible. There is also the attempt to make loading and unloading at distribution centers more on a scheduled basis. Making lot orders bigger increases the loading efficiency and making the designated time more flexible makes it possible for trucks to deliver goods to more customers in one trip, both of these contribute to a reduction in the number of trucks needed for delivery. If distribution centers can prepare for the scheduled loading and unloading of trucks, this will also allow trucks to make one more round trip to their customers, further improving their efficiency.

A Case of the Improvement of the Practices in Logistics

As you can see, concrete steps are being taken in response to the severe truck driver shortage. In review, six major food manufacturing companies are starting the cooperative delivery of their products and problematic, widespread practices in logistics such as small lot, designated time deliveries, along with unscheduled, loading and unloading times at distribution centers are being dealt with, but do pose a significant challenge to the industry.

Food wholesalers and various retailers have had such a strong power in the direct sales to consumers that they have been able to force food manufacturing companies to use the commonly followed, uneconomic practices seen in logistics. It has been very difficult for a single food manufacturing company to persuade their clients the situation must change and be improved, even if it is a major company.

However, the power to negotiate against unwilling customers has strengthened as a result of both the new cooperative delivery project the six major food manufacturing companies are participating in together, and the situation of the severe shortage of truck drivers within the marketplace. One of the main purposes to organize cooperative delivery is to improve problematic practices through a collective approach and to increase the efficiency of truck transport accordingly.

The negotiations are tough, but if they can change commonly held practices in the industry, it is a step in the right direction towards increasing both the load efficiency and decreasing the number of trucks necessary for the delivery needs of society.

CONCLUSION

The shortage of truck drivers has had serious impact on logistics in Japan. In the perspective that the working population will decrease further in the future, it is clear that the unstable supply of truck transport will continue to be one of the biggest problems for the foreseeable future. Under these circumstances, it is strongly recommended that the companies' logistics which depend heavily on truck transport take steps to adopt new measures to secure stable transport. Some new measures have been introduced and are already being practiced by companies facing the severe truck driver shortage.

A measure which could be taken is to change transport means. This is when a modal shift which changes the transport means from trucks to railroads and marine vessels takes place. Implementing a modal shift makes it possible for companies to decrease their dependence on the increasingly unreliable method of truck transport. Although the modal shift has not proceeded quickly in the past, it has attracted the attention of companies facing a severe driver shortage. Some companies have started towards this modal shift positively even though there is still a disadvantage in the cost and the lead times in both railroad and marine transport.

Another measure which could be taken is to reduce the number of trucks. This important measure is the introduction of the cooperative delivery system. This goes beyond the competitive relations of rivalry between companies in the same industry, as they put aside their differences and build new alliances in logistics through cooperation with one another through cooperative delivery. This cooperation would improve both the loading efficiency of trucks and reduce the number of trucks necessary. The formation of new alliances in logistics brings about the very real possibility truck transport will become more efficient.

Yet another measure that would reduce the number of trucks required is to improve irrelevant practices in logistics such as small order lots, having a designated time in just-in-time delivery and disorganized distribution centers where loading and unloading takes too much time. The two former measures would require tough negotiation with customers, but all three measures would lead to more efficient truck transport and would certainly reduce the number of trucks needed.

Although the severe truck driver shortage has made truck transport logistics unstable and, the appropriate implementation of the measures discussed above have the definite possibility of not only improving the unstable truck transport situation, but also to encourage greener logistics and make transport more efficient on the whole. It is valuable to pay attention to the evolution happening in logistics as it is of importance to us all.

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FRAMEWORK FOR STRATEGIC PLANNING IN SME ROAD TRANSPORT COMPANIES – WORKSHOP METHODOLOGY AS A PRACTICAL APPROACH

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ABSTRACT
The road transport industry is traditionally comprised of very operationally-managed businesses, especially in small- and medium-sized companies. As a result, there is a need for strategic thinking, process management and value management in the SME road transport industry. A series of eight workshops were planned and conducted to handle diverse approaches related to the vitality and profitability of the road transportation industry. The workshops aimed to improve the competencies of SME transportation and logistics service operator companies, increase the attractiveness of the business area, improve entrepreneurial qualities and education, and increase competencies in the field of logistics. This paper provides new information about using a workshop methodology in a transportation system context.

Keywords: Transportation, supply chain management, strategy planning.

INTRODUCTION

The road transport industry is traditionally comprised of very operationally-managed businesses, especially in small- and medium-sized companies. In a continuously and increasingly dynamic business environment, road transport companies also serve as actors in a diversity of supply networks, which should determine their role, targets, service supply and positioning. This situation demands a clear strategic approach as well as strong leadership to recognize and determine essential approaches. Large companies, generally with a wide variety of service suppliers, face a different situation: they are more logistics service providers or logistics network leaders instead of single transportation companies. These larger companies in the industry usually have stronger leadership available, while smaller companies are often entrepreneur-driven transportation companies.

This research was conducted in Finland, where the average size of trucking companies is only 3,5 trucks per company, and nearly 70% of the companies have only one or two trucks (SKAL 2011). The profitability of these companies is rapidly decreasing. Something has to be done to improve the vitality of the road transport industry as this business area serves a crucial role in Finnish trade and industry. Although Finland was the starting point for this research, benchmarking was conducted with other countries through literature research.

RESEARCH PROCESS AND METHODOLOGY

The research is based on both literature research and a series of workshops. The progress and results of the workshops form the main part of the paper while also providing the most valuable new information to academic discussion in the field.

Workshops are a form of participatory research using facilitated group processes to deal with actual problems concerning the group. Participatory methods are more likely to produce normative than analytic results, and therefore, these methods can be used to produce general strategies rather than detailed plans (Vidal, 2006; Glenn, 2009). The series of workshops in this paper followed the basic principles and phases of future workshops by Vidal (2006):

- preparation (invitations, facilities, timetable, facilitators, orientation)
- critique (critical and open discussion of the current situation)
- fantasy (brainstorming, free visioning of the future and ideas for achieving the future)
- implementation (critical evaluation of ideas and development of strategy, action-plan elaboration)
- follow-up (reporting and dissemination of results)

There were a total of eight workshops. The duration of each workshop was four hours. The entire process involved interactive development: after each workshop, the next topics were re-planned and fine-tuned according to responses gained from workshop participants. The final topics of the series of workshops were as follows:

1. The significance of logistics as a success factor for companies – but what is the role of logistics service operators in this success?
2. The role of transportation companies in supply chain management – partnership as a main success factor?
3. Entrepreneurship and common values as a basis of partnership networks
4. How to repair processes and process management in the field of logistics – the basis for the success of industry and commerce in Finland?
5. Socially-responsible operations models as a basic element for profitable business operations
6. Development of working conditions and education as an essential component for the future of logistics as a business area – opportunities or just additional costs?
7. Value-added services in logistics
8. What has been learned and how to proceed?

Workshop participants were representatives of small- and medium-sized transportation companies, logistics service providers, industrial and commercial representatives, researchers, consultants, educators, business developers and representatives of various transportation-related interest groups. The number of participants varied from 15 to 40, and the composition of participants also differed in each workshop. The first two workshops had the largest number of participants and also had representatives from a wide variety of groups. More specific topics had fewer participants; at the same time, these workshops focused more on transportation companies and diverse business developers. There were five representatives from small- and medium-sized transportation companies who participated in the whole series of workshops. The workshops were organized in Southern Finland, and with a few exceptions, the representatives were geographically focused on this area.

All of the workshops included two to four expert presentations focused on the topic chosen for the workshop. The idea was to give different perspectives on the topic before group work. After presentations, participants were divided into three to six groups (five to six participants per group) that worked on given assignments. This group work usually took 30-60 minutes depending on the scope and number of topics chosen. The learning café methodology was used, where participants changed groups according to the time schedule, improving the work and adding new approaches to the results of previous groups. Each session ended in a culminating discussion, where main results were examined, and the most important development targets or needs were identified and discussed to reach consensus.

In workshop planning, we decided to begin from the broader perspective by examining the business environment and proceeding towards topics involving factors that affect the performance of drivers. However, after each workshop, there was comprehensive discussion of the results and feedback. As a result of these discussions, we adjusted the upcoming topics based on participants' actual needs. We also rearranged the order of the topics according to feedback.

THE MEANING OF STRATEGIC PLANNING IN LOGISTICS COMPANIES

Strategy, as a concept, is rich and nuanced, with the literature suggesting many different definitions for it. The most common definitions relate primarily to the top management's plans for achieving outcomes consistent with the organization's missions and goals. All in all, strategy sets the direction, focuses efforts, defines the organization and provides consistency (Mintzberg, 1998). In the competitive market-oriented business environment, transportation managers need to maintain a particular focus on customer service and competitive strategies (Bardi et al., 2006). A company's competitive strategy defines the set of customer needs that it seeks to satisfy through its products and services relative to its competitors (Chopra and Meindl, 2010). Researchers see successful logistics strategies as a true competitive advantage (Bardi et al., 2006). The way a company competes in the marketplace is called a competitive priority, and such priorities include cost, time, innovation, quality and service (Sanders, 2012).

Mintzberg (1998) points out that strategy requires a number of definitions. He describes strategy with five Ps: a plan, a pattern, a position, a perspective and a ploy. Strategy can be seen as a direction of action into the future, a path to get from here to there. In terms of pattern, strategy requires consistency in behaviour over time. While strategy as a pattern looks at past behaviour, strategy as a plan means looking ahead. Strategy as a position requires locating particular products in particular markets, for instance. Perspective strategy is more interior to the organization, while strategy as a ploy refers to a specific "manoeuvre" intended to outwit an opponent or competitor.

A strategic plan is an agreed-upon plan of action that supports the company's vision and mission, including top management's strategic themes. Strategic planning is an ongoing process, providing direction to the company and driving decisions and actions. In the strategic planning process, entrepreneurs make risk-taking decisions systematically based on the best current knowledge and future projections. The strategic planning process means systematically organizing the efforts needed to carry out the decisions and measuring the results of the decisions. Three fundamental questions in strategic planning are as follows: 1) Where are we? 2) Where do we want to go? and 3) How are we going to get there? (Palmatier, 2008).

Sanders (2012) emphasizes that a company must have a long-range business strategy if it is going to maintain a competitive position in the marketplace. A business strategy involves a plan for the company that clearly defines the company's long-term goals, how it plans to achieve these goals and the way the company plans to differentiate itself from its competitors. A business strategy should leverage the company's core competencies, or strengths, and carefully consider the characteristics of the marketplace. Harrison and van Hoek (2008) discuss the logistics strategy and define it as the set of guiding principles, driving forces and ingrained attitudes that help to coordinate goals, plans and policies. These goals, plans and policies are reinforced within and between partners across a network. The four building blocks of supply chain strategy are operations strategy, sourcing strategy, distribution strategy and customer service strategy (Sanders, 2012). A company's distribution strategy includes how it plans to get its products and services to customers (Sanders, 2012).

When developing a supply chain strategy, it is important to understand the company's strengths and weaknesses. This understanding permits a realistic determination of what the company can and cannot perform. The company must play to its strengths and understand how much influence or power it exerts in the marketplace (Sanders, 2012). Depending on the size of the company, strategies for success and completion can differ in the markets. For example, Jacobides and MacDuffe (2013) introduce different strategies and actions to shift value for companies who are incumbents and for those who are challengers in the markets. Though the aims may be the same, the path to achieve them diverges. In this kind of situation, the strategic planning process provides a continuing opportunity for strategic thinking, which enables the management team to think through the qualitative aspects of the business and its environment (Palmatier, 2008).

DEVELOPMENT PROCESS BY WORKSHOP RESULTS

The target for the complete series of workshops was to improve competencies of SME transportation and logistics service operator companies, to increase the attractiveness of the business area, to improve entrepreneurship qualities and education and to increase competencies in the field of logistics. In addition, these workshops aimed to investigate the point of views of diverse stakeholders for network-based business models, responsibility and new service concepts. These approaches form the basis for better profitability and vitality for the road transport industry in the SME-focused business area.

The first workshop dealt with the significance of logistics as a success factor for companies and the role of logistics service operators in the success of supply chain management. The second workshop continued this approach by focusing on a deeper analysis of the role of the transportation companies in supply chain management as well as the principles of partnership related to road transportation companies. These first two workshops highlighted the need for clear strategies, strategic thinking and planning. The significance of process integration also emerged, and therefore, the fourth workshop was re-planned to focus on process management and integration. Usually, road transportation companies are not very integrated in the supply chain processes of trade and industrial companies. Therefore, effective planning and using the company's own critical resources remains difficult or incomplete.

Participants recognized entrepreneurship as one basic characteristic in SME road transportation companies, which they considered to be a strength in the business area. There are many important values related to entrepreneurship, including commitment, customer service and results orientation. At the same time, there is often a need to increase leadership capabilities and corporate planning practices.

After these fundamental workshops, participants selected socially responsible operations models as a basic element for profitable business operations as a workshop topic. There are increasing demands for transparency in quality and responsibility approaches, and these must be taken into account in the transportation business as an essential part of global supply chains. Participants also chose development of working conditions and education as a basic element for the future of road transportation companies as a topic for the workshop series, a topic that relates quite closely to responsibility and quality issues. The main question for this topical area was whether or not this issue includes opportunities or just additional costs?

Participants also chose value-added services in logistics as a topic due to its increasing significance in the business environment of road transportation companies. Logistics is a service business as a fundamental characteristic, but it still includes many opportunities to form profitable business models for SME road transportation companies. The starting point for value-added services is the knowledge of business processes in customer companies and capabilities to develop service models, which adds value to these customers' business processes. This approach requires innovation and the ability to implement new operations models in practice.

The last workshop converged on the results of the entire workshop series. The primary question for this workshop was, "What have we learned, and how should we proceed"? The main target was to find concrete steps in terms of how SME road transportation companies can further develop their operations to meet the increasing demands set by the business environment. This series of workshops continued with R&D projects with selected case companies. The results of this project are not included in this paper.

STRATEGIC PLANNING FRAMEWORK FOR ROAD TRANSPORT COMPANIES

The results from the workshops have been collected and illustrated in the framework presented in Figure 1. The framework describes the main approaches to assisting SME road transportation companies in developing their operations into real service businesses that offer value to the customers' supply chains. This framework can also help transportation companies to be strategic partners to their customer companies.

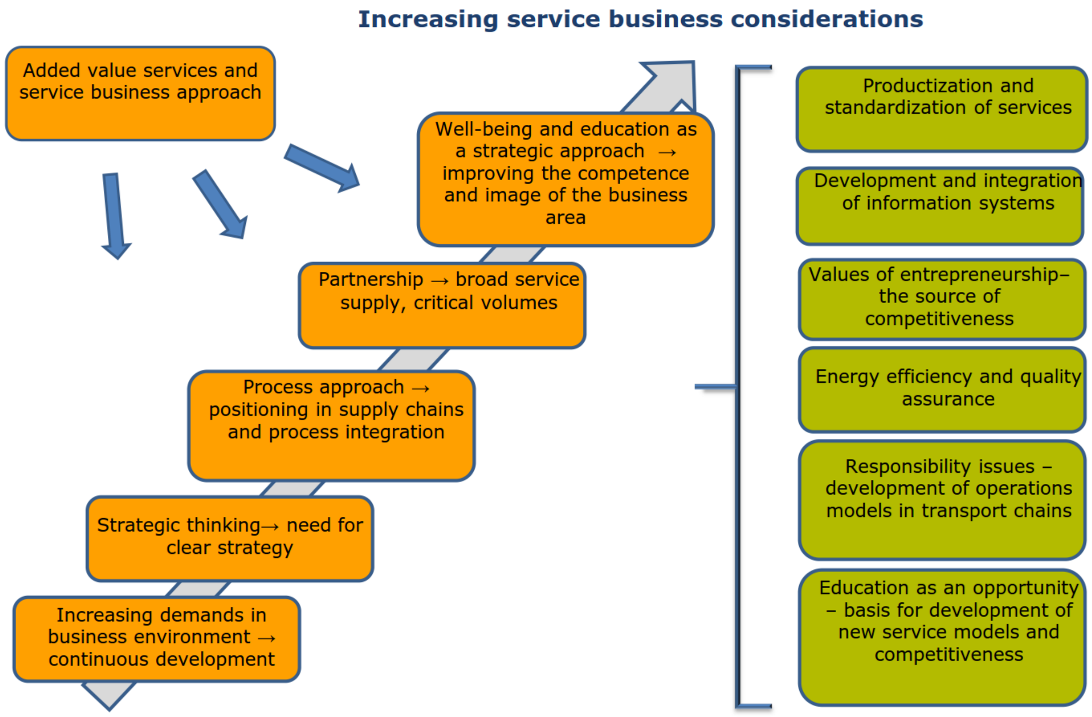

Figure 1. The success factors of SME road transportation companies in the future business environment.

DISCUSSION AND CONCLUSIONS

This study provides an important approach for combining the supply chain management and logistics literature. Therefore, the research results offer a practical framework applicable for diverse interest groups. The findings of the paper suggest that strategic development in the road transport industry requires wide-ranging examination and special attention to understanding the attributes that promote and hinder the strategy creation process. More precisely, strategic development demands diligent business environment analysis, recognition of competitive factors in the road transport sector and utilization of key features of entrepreneurship.

This paper provides new information about utilizing a workshop methodology in the transportation system context, which is traditionally a less active business area in terms of research and development. This paper presents the essential nature of different elements of strategy-level development while shedding light on the challenges and development areas for different network levels in this business area. The presented viewpoint adds new information to the current scientific understanding of logistics and transportation systems, and therefore, it provides a useful framework for strategic and operational level development in the road transport sector.

As this paper has demonstrated, there is a need for strategic thinking, process management and value management in the SME road transport industry. Such strategic thinking includes a diversity of detailed approaches, which are presented in the framework (Figure 1). The business environment of road transportation is becoming more challenging, with increasing demands for cost efficiency and high-quality customer service. Legal and responsibility issues are emerging as well. Without continuous development in operations, there is no future for the road transportation-oriented company. Transportation companies as logistics operators must position and integrate their operations models with the supply chains of their customers' companies in trade and industry. This process requires clear strategy and commitment to implementation at the managerial and employee levels.

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RESTRUCTURING DISTRIBUTION NETWORKS IN HUMANITARIAN LOGISTICS: THE CONCEPT OF "FREIGHT VILLAGES"

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ABSTRACT
Humanitarian logistics is a complex environment which needs a better management of the relief operations and encounters an additional challenge – the limited collaboration among humanitarian organizations. The aim of the paper is to evaluate the possibility of transferring the concept of freight villages to the humanitarian logistics environment and to examine its effect on the performance of disaster relief operations. The conducted SWOT analysis and case study (on the 2010 Haiti Earthquake) showed that humanitarian freight villages would improve the disaster relief operations in different areas: collaboration among humanitarian organizations, preparedness, benefits for small and medium sized humanitarian organizations and the performance of emergency response.

INTRODUCTION
With the high number of people affected by natural and man-made disasters, humanitarian organizations need to deliver their aid in a more efficient and effective way (1). One of the key issues that relief organizations can address is the distribution network configuration which has a great impact on delivery time and costs (2), two significant elements in humanitarian logistics (3), whose central purpose is to rapidly provide aid to the affected population (4).
Given the conditions under which relief aid organizations are acting (uncertain demand, short lead times, lack of resources), their supply chain is complex and managing it is very difficult (5). One of the core challenges in the humanitarian logistics environment is the limited collaboration among the actors (4).
One solution to tackle this situation is to look into corporate logistics concepts, which are more advanced (4). Freight villages are an example of a concept which is present in companies' distribution networks. In freight villages, companies are sharing equipment, logistics facilities and services (6). Such kind of collaboration could help humanitarian organizations in managing the relief operations (4).
The purpose of the paper is to investigate the contributions and limitations of introducing in the humanitarian logistics field the concept of "freight villages". The objectives of the paper are the following: [1] to analyze the environmental settings and constraints of humanitarian logistics, [2] to investigate the characteristics of commercial freight villages and [3] to evaluate the effect on relief operations of transferring freight villages to the humanitarian settings.
The paper proceeds as follows. The second section analyses topics such as humanitarian logistics characteristics, relief chain structure, collaboration in humanitarian logistics and humanitarian distribution networks. The third part focuses on commercial freight villages. In the fourth section, the concept of humanitarian freight villages is introduced and analysed in detail through a SWOT analysis. By means of a case study, the fifth section evaluates if humanitarian freight villages could have improved the performance of emergency operations during the Haiti earthquake in 2010. The strengths, limitations and main findings of the paper are discussed in the last parts.

LITERATURE REVIEW
Humanitarian logistics characteristics
Even if humanitarian logistics is a critical part of disaster relief operations, representing 80% of them (1), the topic gained interest after the Asian tsunami in 2004 (7). The main aim of humanitarian operations is to alleviate the suffering

of vulnerable people (4) and the notion of profit, essential in commercial logistics, is missing (3). The basic features of the humanitarian environment are: limited human and capital resources, high uncertainty of supply and demand, urgency and politicized environment (8). Furthermore, relief operations are taking place in three stages: preparedness (the phase before a disaster), immediate response (operations during the first days of a disaster) and reconstruction (the post-disaster operations) (9) (7). The key players in the humanitarian environment are the following: aid agencies, governments, military, donors, non-governmental agencies, the affected population and the private companies (10) (7).

Relief chain structure

The flow of goods in a general relief chain is shown in Figure 1. Emergency goods are either procured globally and/or locally or in-kind donations (11). To improve their response, humanitarian organizations started to pre-position critical relief goods in strategic locations (5), on different levels: global, regional or local (12). First, supplies are usually shipped to a central warehouse which is located next to a port or an airport. Next, the relief goods are brought to an intermediary permanent warehouse, situated in a large city. From this point, the goods are going to different local warehouses, being stored and prepared for the last mile distribution to beneficiaries. The goods can also be shipped from the suppliers or from any level of the distribution network directly to the beneficiaries (11).

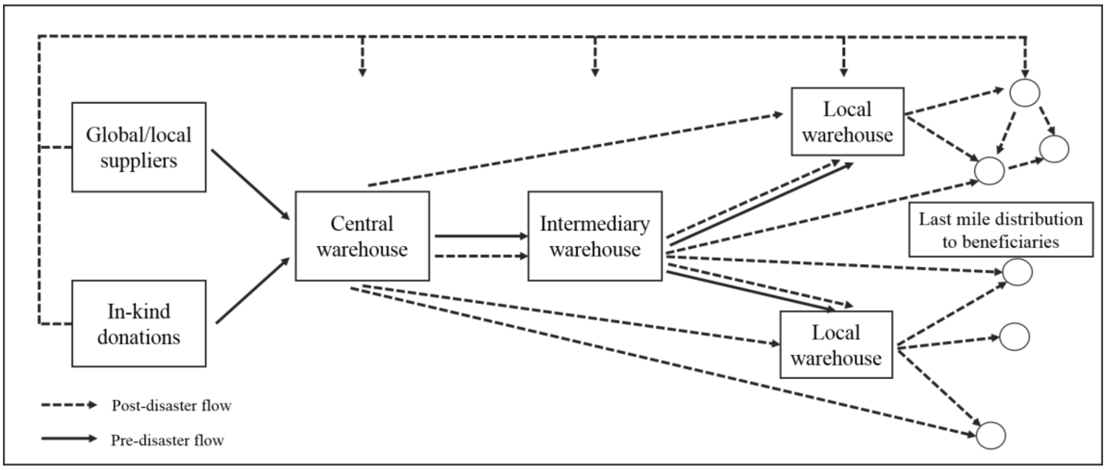

Figure 1: Relief chain structure, modified from (Balcik et al. 2009)

Supply chain collaboration

Collaborative supply chains are defined as “two or more independent companies (which) work jointly to plan and execute supply chain operations with greater success than when acting in isolation” (13). Terms such as collaboration, coordination and cooperation are used interchangeably in the humanitarian logistics field (14) (15). For the purpose of this paper, the term collaboration will refer to the jointly operations among different actors in the relief chain.

Collaboration is seen as a typical challenge for the relief chain operations (4), being affected by various factors: i) the large number of actors and their geographical, cultural and organizational diversity (12) (1), ii) the competition for funding especially during the immediate response phase (12) (8), iii) the cost of coordination for all the engaged actors (16) (12), iv) the level of unpredictability in disaster relief (12), v) the lack of a strong leadership to foster the collaboration among different actors (8) and vi) the lack of resources or the oversupply (unsolicited items and information) (12). Despite all the impediments, the donors have started to consider the inter-agency collaboration as a key performance indicator for the emergency response (8).

One of the main collaboration methods currently used is the cluster approach (17) in which groups of relief organizations are working together to improve the humanitarian immediate response (18). Furthermore, an "umbrella" organization is a facilitator of their horizontal collaboration (12). The most present collaboration mechanisms are mentioned by BALCIK et al. (2009): collaborative procurement (mainly through "umbrella" organizations during the response and reconstruction phase) and warehousing (through "umbrella" organizations and private partners in all phases of the disaster cycle) (12).

COMMERCIAL FREIGHT VILLAGES

Characteristics of freight villages

Some authors and organizations are using interchangeably the following terms: logistics centre, freight village, distribution centre, central warehouse, transport node, logistics depot, transport terminal, distripark etc. (19).

For the purpose of this paper, one of the most detailed definitions, the one given by the UNESCAP (2009) will be used. They are defining a freight village as "an area of land that is devoted to a number of transport and logistics facilities, activities and services which are not just located in the same area but also coordinated to encourage maximum synergy and efficiency" (6). In addition, different characteristics are considered. Firstly, a freight village is situated next to a seaport and it includes an intermodal terminal as a facilitator transfer of goods to rail and/or road. Secondly, a freight village is characterized by a central management. The managers are responsible for operational activities (e.g. maintenance of the village infrastructure) or strategic ones (e.g. growth of the village, environmental management). Lastly, in a freight village, the facilities, equipment and services are shared. The freight village members have the possibility to use their own facilities or to pay for them to other members. Additionally, there are some services and facilities that can be used by everyone in the freight village such as: customs services, conference and training rooms, truck cleaning areas. Some of the freight villages are also concerned with the well-being of the employees by building cafes, canteens or child care areas (6). Alternative definitions for freight villages are given by given (20), (21), (22).

The main services performed by the operators of a freight village are: loading/unloading, handling, storage, and consolidation/deconsolidation (23). These are complemented by multiple value-added services such as: inventory management and control, shipment scheduling, re-packaging, freight rate negotiation, performance measurement etc. (24).

Benefits and shortcomings of freight villages

Most of the benefits of freight villages are related to the synergies created among the operators. Increased flexibility, lower logistics costs and higher profit margins are observed due to the sharing of logistics facilities, IT-systems and know-how (25) (26). Moreover, small and medium-sized companies are in particular positively affected. They benefit from the economies of scale and advantages of being located within a freight village, such as intermodal equipment and better planning tools for their operations (26). Tacit knowledge exchange and trust among employees seem to be important advantages that proximity brings along (25). Collaboration among forwarders results in less carriers' trips with better capacity usage and the intermodal terminal shifts the long distance transports from road to rail, thus reducing the emissions and the traffic congestions (27).

Regarding the shortcomings of freight villages, they are mostly generated when impediments for collaboration appear (23). An exploratory study, analysing the obstacles for horizontal collaboration within a logistics centre, found that while for unprofitable companies it is very hard to find suitable partners for cooperation, for the most profitable ones the following two factors are the impediments: i) fair allocation of the workload in advance and ii) fair allocation of the gains (28). In some of the existent freight villages, companies are just collocated, without any form of collaboration (29). The high costs of investment are seen as one of the essential shortcomings (30), although there is no conclusive evidence to evaluate if the benefits of freight villages outweigh the costs of investments (29).

INTRODUCTION OF HUMANITARIAN FREIGHT VILLAGES

Distribution networks of major humanitarian organizations

The introduction of freight villages in the humanitarian logistics environment would lead to a change in the humanitarian distribution networks.

Several examples of successful restructuring of relief distribution networks exist. For instance, after an unsatisfactory performance during Hurricane Mitch in 1998, IFRC started a plan to redesign its supply chain. By decentralizing its operations, prepositioning relief items, personnel and fleet and providing a local coordinator for the logistics activities, IFRC achieved a six times faster emergency response and a significantly better service than in previous emergency operations (31).

The goals of the distribution networks restructuring affected by the introduction of freight villages will be similar to IFRC's aims: to be closer to the affected population for improving the emergency response and to enable parallel humanitarian organizations to enter the supply chain as collaborating partners.

A visual representation of the decentralized distribution networks of four major humanitarian organizations (UNICEF, WFP, UNHCR and IFRC) is provided in Figure 2. There strategically positioned warehouses are used for the prepositioning of relief goods during the preparedness phase (32) (33) (34) (35). For further considerations, it is important to note that there are some locations such as Panama City or Dubai where international organizations already have their distribution centers situated and that could foster inter-organization collaboration. The second part of this section will focus on creating the framework for introducing a new concept – humanitarian freight villages.

Figure 2: Regional pre-positioning warehouses of major relief organizations

Humanitarian freight villages' characteristics

For a complete overview of a humanitarian freight village, the authors looked at the definition, the tenants, the special features (facilities, management, preparedness tool, and intermodality) and the location of the villages. These were the main points derived from the description of commercial freight villages' characteristics, in a previous section.

It is important to mention that a humanitarian freight village will be just one type of freight village that will enable the collaboration among relief organizations. Therefore, it will be defined, similarly to a commercial freight village, *as an area*

of land that is devoted to a number of transport and humanitarian logistics facilities, activities and services which are not just located in the same area but also coordinated to encourage maximum synergy and efficiency.
Further characteristics of this newly introduced concept – humanitarian freight villages – are introduced in Table 1.

Humanitarian freight village	
Tenants	International and local humanitarian organizations that are providing relief items to the affected population
Facilities	Warehouse and transport facilities, conference and training rooms, office buildings and additional facilities (truck cleaning, gas station, cafes); can be used by all the tenants
Management	A single humanitarian organization, responsible of the strategic decisions
Preparedness tool	Relief items pre-positioned in warehouse facilities within a humanitarian freight village
Intermodal feature	The transfer of relief goods from one transport mode to another enabled by the proximity to an airport or sea port
Location	Locations where humanitarian organizations already have their central and regional warehouses or new locations (e.g. Panama City, Dubai)

Table 1: Characteristics of a humanitarian freight village

SWOT analysis
Through a SWOT analysis, represented in Figure 3, this sub-section will further analyse the concept of humanitarian freight villages.

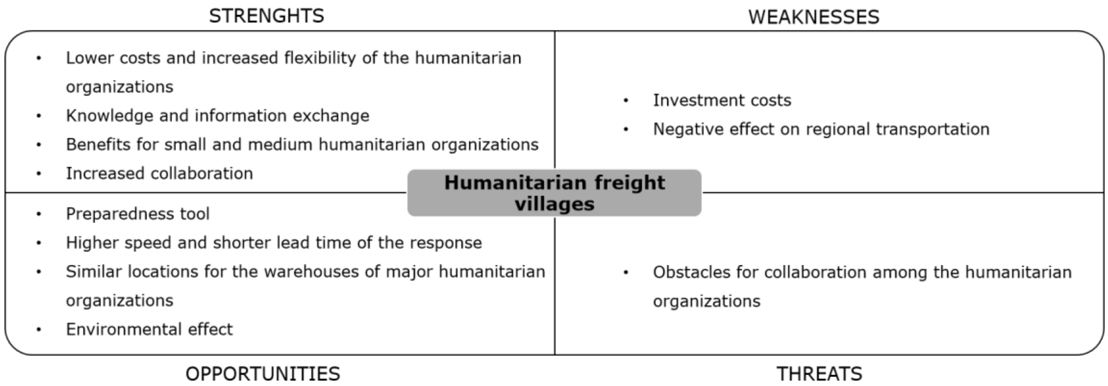

Figure 3: SWOT analysis for humanitarian freight villages

Regarding the strengths of humanitarian freight villages, most of them will be similar to the internal benefits of commercial freight villages described in a previous section. In addition, freight villages will further improve the coordination of relief activities, by excluding some of the collaboration impediments, previously presented. For instance, a humanitarian freight village will eliminate the geographical diversity factor and will decrease the cost of collaboration, which includes the salaries of the personnel and travel costs for coordination meetings (16). Moreover, the humanitarian freight village tenants will be managed by one leading organization, facilitating the collaboration process.
One crucial weakness of humanitarian freight villages is the high investment costs (30). However, further research is needed to conclude if the costs of humanitarian freight villages are higher than the benefits (29).
With regard to the opportunities of humanitarian freight villages, they are more related to external factors present in the humanitarian logistics environment. According to BALCIK et al. (2009), most of the collaboration mechanisms in the humanitarian world are addressing the post-disaster phase (12). However, a humanitarian freight village would be used as a preparedness tool. This will result in shorter lead times and increased speed of the emergency response (5). Similar

locations of the central and regional warehouses of major humanitarian organizations (see Figure 2) will facilitate the establishment of humanitarian freight villages in particular locations, without significant changes in the upstream and downstream relief chain. Additionally, due to the sharing of transportation equipment, the number of carrier trips will be lower, with a better capacity use. This will have a positive impact on the emissions and traffic congestions (27).
Collaboration impediments among tenants is seen as the main threat of humanitarian freight villages. This is an important point to be mentioned because it would have a negative impact on the already defined strengths of humanitarian freight villages. The competition for funding from the donors, which sometimes stops aid agencies from collaborating (8), will still be present. Additionally, the differences in organizational and cultural structures of the relief organizations, could hinder collaboration (1). Furthermore, it is not obvious how significantly the lack of technological, personnel and funding resources, seen as an obstacle in humantarian collaboration, will be influenced by the equipment and costs sharing within a humanitarian freight village.

THE HAITI EARTHQUAKE CASE STUDY

Description of the case study

> "On January 12, 2010, at 4:53 PM, a powerful 7.0-magnitude earthquake struck 15 miles southwest of Port-au-Prince, Haiti, destroying not only that capital city–home to 3 million people–but also the towns of Léogâne, Gressier, Petit-Goâve, Grand-Goâve and Jacmel, as well as countless mountain villages. The 35-second tremor devastated the administrative infrastructures of the government, several healthcare delivery facilities, and many nongovernmental relief agencies. It left more than a million people displaced, more than 300,000 injured, and an estimated 230,000 to 316,000 dead, making it one of the deadliest natural disasters in modern history. The cost of the destruction was estimated at 120% of the country's gross domestic product" (36).

Because of the magnitude of the earthquake and the precarious social and living conditions prior to the disaster (37), the infrastructure of Haiti was damaged on a great extent. For instance, the seaport was not operational in the first days, the airport had several damages and the telecommunication networks were hardly working (38). Furthermore, despite the large number of NGOs operating in Haiti before the earthquake, a major percentage of the humanitarian personnel was affected. Research data, homes and offices were destroyed, which made the assessment of the affected population needs very challenging (39).
Most of the reports consider collaboration and weak leadership to be some of the biggest failures of the Haiti emergency response (36) (40) (41). The cluster system improved the immediate relief operations, but not with the desired speed. Additionally, the lead agencies didn't supply sufficient emergency items (42). Indeed, one of the mistakes, as outlined in the literature, was the deficient preparedness planning. Because of the low inventories of pre-positioned relief items, but also of the highly damaged infrastructure, it took 2 days for the first US airborne division to get to Haiti, even if Port-au-Prince it's just 1 hour and 20 minutes by flight from Miami. This led to a delay of several days for the affected population to receive the relief goods (36). Additionally, the high number of humanitarian organizations, many of whom not experienced enough, became an obstacle in providing an efficient relief response (42) (40) (41).

Effect of humanitarian freight villages

While some of the problems encountered such as extensively damaged infrastructure, lack of immediate assessment of the affected population needs or weak leadership could have not been changed by the use of humanitarian freight village, others could have been positively altered.

The paper proceeds by assuming that one of the locations of humanitarian freight villages would have been Panama City, Panama.
A humanitarian freight village would have enhanced the inter-agency collaboration in terms of sharing of warehouses facilities, transportation modes, equipment and information. The positive effect would be just medium due to the existence of organizations such as UNHRD and of umbrella organizations that offer the possibility of these services. Colocation would have improved knowledge sharing and costs of collaboration to a large extent. The deficient preparedness planning could have been addressed by the use of this humanitarian freight village as a preparedness tool. A humanitarian freight village would have enabled the joint planning of multiple relief organizations. This would have resulted in higher amounts of relief items and in a better coordination in order to meet the needs of a larger part of the affected population, in a shorter time, with lower costs and higher flexibility. However, because the locations of the humanitarian freight villages would be hypothetically similar to the locations where humanitarian organizations have already warehouses, the emergency response performance would not be significantly improved, but only to a medium extent.
Furthermore, humanitarian freight villages, as the one established in Panama City or in other locations worldwide, would have brought high benefits for small and medium sized organizations, which in the case of Haiti earthquake did not perform suitably. By being co-located with major players in the relief logistics within a humanitarian freight village, small and medium NGOs could have beneficiated from the experience, knowledge and better equipment and training. In this way, personnel operating in the immediate response and reconstruction phase would have been more professional. This would have decreased the number of unexperienced humanitarian organizations. Obviously, for including humanitarian freight villages in the distribution networks of relief organizations, financial resources would be initially needed. The current research indicates that these costs are high, which is definitely a shortcoming of the hypothetical situation of distribution networks with humanitarian freight villages.
To conclude, humanitarian freight villages would have improved the emergency response in the 2010 Haiti earthquake, by tackling problems such as deficient preparedness, numerous unexperienced organizations and lack of collaboration.

DISCUSSION

One of the strengths of this paper is the original method of tackling humanitarian logistics issues. According to Balcik and Beamon (2008), most of the studies in humanitarian logistics are focusing on the operational relief activities through the already existing distribution networks (5). This thesis is, however, introducing a new concept which requires the restructuring of current humanitarian distribution networks. In addition, it complements the amount of studies that are addressing one essential challenge: the limited collaboration among relief organizations. Moreover, to the best of the authors' knowledge, the concept of freight villages has never been used in humanitarian logistics.
There are also some limitations of this paper. Because of the scarcity of quantitative data about the performance of commercial freight villages, a large part of the benefits and shortcomings of the humanitarian freight villages was based on theoretical and qualitative information. Besides, there was no research about the real investment costs for a freight village in order to evaluate whether the costs outweigh the benefits. Furthermore, the concept was validated in a single real-life situation, by means of the case study of the Haiti earthquake in 2010. Finally, by being a theoretical concept, humanitarian freight villages are expected to encounter alterations after the transfer to practice.

CONCLUSION

The main goal of the thesis was to investigate the contributions and limitations of introducing in the humanitarian logistics field the concept of "freight villages". The analysis demonstrated that humanitarian freight villages would improve the disaster relief operations in different areas: collaboration among humanitarian organizations, preparedness, benefits for small and medium sized humanitarian organizations and the performance of emergency response.
The concept could be enhanced by further research regarding the suitable locations and number of humanitarian freight villages. Furthermore, a quantitative evaluation of the costs of establishing such a concept in practice is required to fill the research gap in this field. It would also be interesting to study the implications of including both commercial logistics providers and humanitarian organizations as tenants within a freight village.
As a practical implication, humanitarian freight villages would address one of the most important challenges for relief organizations – the limited collaboration. In addition, they would have an impact on the management of disaster relief operations. The concept introduction in real life would positively influence the emergency response, which means the relief items would arrive faster and to a larger percentage of the affected population.

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WHO CONTROLS CARBON EMISSIONS FROM TRANSPORT AND WHO CARES? INVESTIGATING THE MONITORING OF CO2 FROM A LOGISTICS SERVICE PROVIDER'S PERSPECTIVE

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ABSTRACT
This article explores the environmental impact of logistics service provider (LPS) activities in the light of increased customer priorities and the fragmentation of the industry. The research is based on a narrative literature review, an interview study, a case survey, and three in-depth case studies. A framework on sustainability challenges in supply chains derived from the literature is used to structure and analyse the findings. Despite the ambitious environmental schemes communicated by several LSPs, they show little interest in and exert little control over the actual emissions generated from their transport operations. Any real concern for environmental solutions that negatively impact the cost and time requirements from customers of logistics services are not yet a reality.

INTRODUCTION
For the past decade, the largest multinational companies have published an increasing number of sustainability reports, Corporate Social Responsibility (CSR) reports, and codes of conduct (Carter and Rogers, 2008), often as part of their annual reports or as separate documents. Consequently, they are showing an increased interest in and paying more attention to the environmental performance of their outsourced activities. Considering the high level of outsourcing of logistics activities and the large number of emissions these activities account for in the supply chain (Wu and Dunn, 1994), the environmental performance of logistics service providers (LSPs) becomes both crucial and challenging to address. However, how this pressure or attention is transformed into practice is not clear from the relevant literature, especially in the large networks of actors involved in supplying logistics services. Furthermore, many firms act in ways to maximize their own profits and not to maximize supply chain performance (Narayanan and Raman, 2004). As a result, despite the excessive impact logistical activities have on the environment, the way of dealing with environmental challenges in the logistics industry is rather immature (Isaksson and Huge-Brodin, 2013). For example, in the literature review on third-party logistics (3PL) by Selviaridis and Spring (2007), environmental issues are not emphasized as central themes or put forward as areas of interest for further research. Considering that 3PLs typically own a terminal network but only limited transportation resources (e.g. trucks) (Klaas-Wissing and Albers, 2010), it is difficult to influence and monitor emissions of outsourced logistics activities. Freight transportation from an LSP perspective is crucial to address, but fragmentation in the industry makes both studying and managing environmental performance very challenging (Sternberg et al., 2013). As shown by Sternberg et al. (2013), the road transportation market (accounting for the majority of transportation emissions) is dominated by small road hauliers both in North America and in Europe in terms of quantity; in the US, small road hauliers make up 75% of all road hauliers (ibid.). The authors also show in case studies how the efficiency of logistics operations suffers from coordination difficulties between a plethora of different actors, due to a lack of clear areas of responsibility (ibid.).

The purpose of the research presented explores the environmental impact of LSP activities in light of increased customer priorities and fragmentation of the industry, and the extent to which LSPs can actually monitor and control the environmental impact of logistics activities in the supply chain.

2. METHODOLOGY

To meet the research purpose and to gain understanding of the different factors involved, a research design was selected consisting of an initial narrative literature review followed by three empirical investigations: an interview study, a case survey and three in-depth case studies.

Based on Abbasi and Nilsson's (2012) research, a framework addressing current themes and challenges in making supply chains environmentally sustainable was deemed applicable for designing the empirical investigation. The framework consists of five categories of challenges: costs, complexity, operationalization, mindset and cultural changes, and uncertainties.

A sample number of 30 LSP companies (including 3PLs, various transport operators and mid-sized hauliers) operating on the Scandinavian market were identified and contacted for interviews. In total, 10 companies agreed to participate (Table 1). The interviews were divided into two parts: the first part with open-ended questions asking about current and future activities related to environmental issues and company challenges. The second part consisted of structured interview questions based on the framework. This research process provided insights into the difficulty of answering some of the issues addressed, while others were much easier to answer.

The data for the case survey were generated from information gathered for a European sustainability award in the road freight business. This yearly award has been in existence since 2008 and requires (amongst other things) a standardized questionnaire to be filled in by the candidate logistics companies (LSPs or shipping/transport departments of retailers). Data was selected from the years 2012-2014, since in the first years of the award no data regarding subcontractors or the relationship to these were recorded. In addition to basic details on company size (home country, scope of activities, turnover, employees, sendings, volume and fleet size), the questionnaire recorded the level of maturity of environmental activities with regard to greenhouse gas emissions (CO_2 accounting, CO_2 measurement, CO_2 management, environmental sustainability reporting) and the characteristics of the relationship to subcontractors. The candidates were asked in particular if they passed environmental sustainability requirements on to their subcontractors. Overall, we analysed 20 questionnaires from 7 large, 8 medium-sized and 5 small LSPs. Since the award is mainly driven by German institutions, the majority of companies were based in Germany (14) or German speaking Switzerland (2). However, since the call is also made on a European scale, there were also four non-German speaking applicants from Slovenia (1), Slovakia (1) and Italy (2). The case survey data was based on sustainability award candidates who responded voluntarily with a high self-motivation and conviction regarding environmental sustainability.

The interview study and the case survey revealed a number of areas that are challenging for LSPs, not least concerning the costs and difficulties in managing customers and suppliers when it comes to sustainability issues. It was decided to further explore these areas in more detail in three case studies. The case study design was chosen because it focuses on understanding the dynamics present in single settings (Ellram, 1996) and to gain deeper insights into the phenomena being studied. The three cases were selected from the interview study companies. They involved two of the major LSPs operating pan-European networks and with a strong presence in the Scandinavian market and one medium-sized LSP operating in the Nordic market. All were selected for their environmental profiles, accessibility, and their interest in the research area. Data was gathered from the cases based on interviews, sustainability reports, websites, and internal documentation of the number, setup, and type of subcontractors involved. A selection of the subcontracted hauliers were interviewed to study follow-up procedures.

3. Findings

3.1. Interview study findings

The following sections present the findings from the interview study based on the framework by Abbasi and Nilsson (2012): a) costs, b) complexity, c) operationalization, d) mindset and cultural changes, and e) uncertainties.

A. Costs. That it must pay to be green is something most respondents find important. Only one interviewee (I2) had a different view, recognizing that the challenge of becoming sustainable must be prioritized and that the benefits for the company are indirect and long-term. All the interviewees argued, more or less explicitly, that transportation is too inexpensive and that the aspects their customers primarily prioritize are cost and time. Yet, most of the interviewees agree on the difficulties in quantifying the environmental costs of logistical operations/activities and processes.

Some of the interviewees argued that sustainability-prioritized logistical solutions can cost less (I1, I2, and I4) or the same (I3, I9, and I10) in the long-term and/or if the costs are shared among the supply chain stakeholders.

B. Complexity. CO_{2e} emissions was the environmental effect most elaborated on concerning the complexity involved in sustainable development. Just as the LSPs have different perceptions of the difficulties in diagnosing environmental effects, they also report different degrees of difficulty in measuring and assessing the environmental effects of logistical operations and processes.

Some of the interviewees shed light on Corporate Social Responsibility (CSR) and highlighted some of its aspects like education, training, safety, and customer satisfaction, "*We are not the direct employer of the drivers … but of course we have to take responsibility for road accidents involving trucks that have our logotype … We communicate this to our hauliers. We also have training modules for drivers and interactive programmes for hauliers that they can access on the internet. […] We have, of course, direct communication with our hauliers as well."* (I8) Almost all the interviewees put forward the existence of dilemmas related to sustainable development. I8 elaborates on the dilemma concerning decreasing fill rates/resources utilization, higher service levels, and environmental degradation by stating: *"There is a dilemma when it comes to 'customer service'! We would like to offer daily departures for our customers but then we would have a lower degree of utilization … so, we have to find out what is acceptable for the customers and at the same time increase the fill rate … And I think that our industry or line of business is a little guilty as we have been competing with daily departures and perhaps the transportation buyers may not need these services …".*

C. Operationalization. One challenge raised concerning the operationalization of sustainable development was the difficulty in interpreting and integrating all its dimensions/pillars. Similarly, the majority of the interviewees experience difficulties in interpreting and implementing sustainable development in the context of logistics. Challenges raised in the literature were organizational inertia and resistance to change in developing environmentally sustainable operations (Abbasi and Nilsson, 2012). These challenges are less often mentioned by the LSPs interviewed (5 interviewees regard inertia as low and only 3 as high).

D. Mindset and cultural changes. To change mindset and culture calls for awareness about sustainable development. Its dimensions/pillars are raised in the literature as key factors in sustainable development. Just as they have major difficulties in operationalization of sustainable development, LSPs have similar difficulties in making their customers aware of what sustainability development means and the dimensions it has: *"We have customers of all sizes … the bigger ones are well aware and to some extent even push us. However, the majority are not well aware or at least not willing to change their buying patterns"* (I8). Although it is fairly difficult to increase sustainability awareness of customers, it is even more difficult to change their behaviour according to the interviewees. I6 states that, *"They are very good at placing demands on us. And they tell us what they think we should do although they do not do it themselves. They put pressure just on us."* The interviewees had different perceptions when it came to increasing sustainability awareness and changing the behaviour of decision makers and organizational co-workers.

E. Uncertainties. The LSPs interviewed are unaware of and uncertain about future regulations, policies, and legislation formulated by governments and policy makers. They are also very uncertain about sustainability-related strategies formulated by supply chain stakeholders as well as customers' future demands.

3.2. Case survey findings

From all the 20 surveyed cases, only two show the pattern of an LSP passing customer requirements on to its subcontractors.

Case seven has a consistent profile regarding carbon emission management and subcontractor relations. Driven by customer requirements, the company perceives itself as having a rather high level of competency in sustainability issues and carbon accounting and control. The company is heavily dependent on subcontractors and consequently passes these requirements on to its very broad subcontractor base. However, the company behind case seven is a major, world leading LSP, which currently is dealing with the challenge to assist its subcontractors in developing more sustainable operations. In case 14, the LSP states that it also passes on the customer's requirements to its subcontractors. But the LSP itself does not appear to have a very high level of competency in the fields of sustainability and carbon accounting and control. It seems that the LSP only passes the requirements on, but the data delivered by subcontractors is not really used for the calculation of Scope 3 emissions. Hence, the intercompany use of the carbon emission data is clearly limited. In three of the 20 cases, no subcontractors are used (Cases 6, 12 and 20). Thus, the task of passing on CO_2 emission control to subcontractors plays a minor role. All three companies are rather small and do not subcontract any transport activities. Two of (Cases 6 and 20) have to deal with the carbon control requirements of their customers and therefore have to deal with the accounting and control of CO_2 emissions internally. Case 12 provides no further specifications on customer requirements. Due to the limited explanatory power of these three cases, they were excluded from further analysis. However, reflecting on the context of the sustainability award, it was interesting to see, that these companies must have viewed themselves as a somewhat advanced sustainable logistics companies.

In 15 out of the 20 cases, the LSPs do care about their own internal carbon emissions in some way, but do not pass this issue on as a requirement to their subcontractors. The case survey analysis substantiates the general perception in praxis that passing on customer requirements regarding CO_{2e} emissions from LSPs to their subcontractors is not yet common practice in the logistics and road transport business. With the positive self-selection in mind, the low share of companies dealing with carbon emissions on an intercompany level is rather surprising and represents a good and presumably valid reflection about the current situation.

3.3. Case study findings

The literature review and interview study revealed, among other things, that two main themes – customer attention and the fragmented industry (large LSPs and small hauliers) – are challenging for sustainable development. The case survey highlighted the low level of monitoring of subcontractors in practice, which may indicate that customer requirements are not really prioritized. The large LSPs rarely own or govern any trucks but instead purchase transportation and other logistics services from hauliers (Sternberg et al., 2013). One of the LSPs interviewed was in the process of selling off their proprietary fleet (150 trucks) in order to be more flexible and competitive. Some of the hauliers report that the requirements from LSPs have increased in terms of certificates and follow-up questionnaires. Consequently, the three case studies elaborate on how the environmental policies of large LSPs are applied in practice and how these companies are working with their subcontracted transportation suppliers.

Case A consists of a large LSP (I3's company in the interview study) and one of their thousands of subcontractors, a haulier (I7 in the interview study). I7's trucks are profiled with I3's logo and colours. Manager I3 states: "*We work really hard with measurements and calculations", and "We are well ahead in the holistic perspective".* The LSP assists their customers to a great extent in setting up various environmental performance measurement processes, such as CO_2 reporting. The claims from the LSP were followed up with I7 (Table 2).

Table 2: Case A: Summarizing perspectives on environmental policy and follow-up.

	LSP	Subcontracted haulier
Environmental policy	Runs an extensive environmental programme and has an ambitious CSR policy.	No environmental policy.
Reporting	Produces detailed environmental reports for customers. Supervises environmental reporting.	Produces pro forma reports for the LSP, sometimes under supervision from the LSP.
Sample environmental activities	Central organization pushing sustainable vehicles (e.g. gas-fuelled trucks) to subcontractors.	No activities dedicated to the environment.

I7 told the authors about when the LSP called the haulier and wanted them to purchase environmentally friendly vehicles. Currently, they mostly use Euro3 trucks and I7 stated*: "They tell us to drive environmentally friendly vehicles, but in the end, all they really care about is the lowest price"*[1]. The LSP generally pays their subcontracted hauliers a fixed price based on either the line operated or the actual distance/weight of an assignment.

An additional interviewee (sales manager) of the LSP was contacted. When asked about how the environmental programme of the LSP is carried out, he explained: "*Our environmental programme is very ambitious, but the main goal is for it to be selling. When the goods are moved by our subcontractors, we actually don't know how they do it."*

The majority of the trucks belonging to the member companies are painted with the logo and colours of the LSP (I8): *"They are not our trucks, but they are*

[1] During the interviews, the interviewed hauler was close to bankruptcy.

painted with our logotype and we have to take responsibility". When asked about whether it should be financially beneficial to be green, I8 commented: *"If you look at individual/small haulage companies, it is not fair that they should be the ones to carry the burden …".*

Table 3: Case B: Summarizing perspectives on environmental policy and follow-up

	LSP	Subcontracted haulier
Environmental policy	Runs an environmental programme and has an ambitious CSR policy.	Obligated to apply the environmental policy of the LSP.
Reporting	Produces detailed environmental reports for customers. Supervises environmental reporting.	Produces detailed reports for the LSP, actively monitored and supervised by the hauliers' interest organization.
Sample environmental activities	Training programmes for subcontracted hauliers.	Activities are agreed on between the LSP and the interest organization.

"We do work together on most questions and share most of the objectives for the future", stated one of the managers of the interest organization. The annual follow-up survey the LSP and the interest organization carry out jointly contains questions on driver training (e.g. details on the percentage of drivers with eco-driving or dangerous goods training), driver social conditions (e.g. union agreements and contracts), and truck specifications (e.g. engine types).

An additional interviewee from the LSP, working with environmental calculations explained: *"Sometimes we just use standard aggregate values, but whenever possible we use the audits on the fleets from the subcontractors involved in moving a particular customer's goods… The methods we use could hardly be called scientific, but at least we try. In tenders, customers sometimes ask us to turn in information on the expected environmental impact and we calculate it based on the local subcontractors' fleets, but we have no clue as to how our competitors calculate."*

This LSP mainly operates based on revenue-sharing contracts with most of their subcontracted hauliers. Given the high level of commitment and in-depth collaboration with their subcontractors, we asked a market manager of the same LSP for his opinion about offering logistics services with a relatively higher level of environmental and social responsibility, compared to competitors. He answer: *"We are increasingly facing difficulties in competing; in the south of Sweden we are unable to sell any full truck loads, because the customers are not prepared to pay for our responsible service."* Table 3 summarizes the perspective in Case B.

The third case (the company of I1) is based on previous joint research studies along with follow-up studies of actual outcomes and reflections. Being an LSP focused on environmental solutions, one of the central services they provide for their customers is the coordination of deliveries to stores by intermodal transportation (freight train and last-mile truck service). The goods being handled are mainly fast-moving consumer goods sold in the retail stores where the LSP focus is on delivery operations: the pickup, loading, distribution, unloading, and return flow of products in the Swedish and/or Nordic region. Based on advanced planning and visualization tools, the company developed different alternatives for their customers that explicitly provide environmentally friendly alternatives together with competitive time, quality, and cost setups.

One of their major customers, which the LSP (I1) had served for several years, was in the process of procuring logistics services for a coming three-year period. In the request, the environmental aspects were highlighted as very important.

The LSP responded with different solutions, all incorporating environmental priorities.

Table 4: Case C: Summary of a suggested delivery setups presented to the LSP customer.

	Current setup (deliveries M,T,W)	Suggested setup (deliveries M,W,T)
Deliveries	56	56
Pallets	120	120
Delivery distance (KM)	9558	6599
Trucks needed	40	24

Table 4 illustrates one of the suggestions, combining train and truck, where the LSP coordinates the deliveries with other customers in one region in Sweden: instead of having deliveries on Mondays, Tuesdays, and Wednesdays, it delivers on Mondays, Wednesdays, and Thursdays. The trade-offs are that the deliveries cannot offer the same time precision as before, and involve more costly administration (planning, billing, registering, etc.). The suggested solution lowers transportation distance by 31% in the delivery stage and thus also the environmental impact in terms of CO_{2e}. Including the first stage transportation by train, the solution in total showed even greater reduction of CO_{2e} compared to road transportation all the way. Due to the fewer trucks needed (i.e. improved fill rates), the areas where the stores are located have in total fewer trucks driving around, which also is beneficial for traffic and the people in the area. Nonetheless, the customer decided to procure the logistics services from another LSP, only using road transportation solutions, with the motivation that the competitor was both less costly and provided higher delivery time precision. Consequently, while the importance of environmental solutions was raised, at the end of the day it was all about cost and time. Or, as the manager at the LSP company expressed it: "Customer behaviours today are the opposite of what is needed" in order to reach the targets set for CO_{2e} reductions. He continued by arguing that: *"It is not the more environmentally friendly solutions, but the less environmentally friendly solutions that should cost the most."*

3.3.1. Synthesis

Having policies is one thing, acting on them is another. The interview study and the three case studies confirmed that, from an LSP perspective, a majority of buyers of logistics services focus on service quality and price – not on sustainability. Furthermore, as found in the case survey, there are seldom systematic follow-ups related to emissions from subcontractors by the LSPs. Consequently, the incentives to really improve and contribute to lowering carbon emissions are easily prioritized down in favour of others, most often, business related aspects such as costs and deliver accuracy. The case studies revealed a great difference between how two LSPs (Case A and Case B), with similar CSR and environmental policies, enforce and monitor their subcontractors. This difference in actual practice may bring into question the validity of environmental reports. As shown in the literature, the fragmented industry means that many hauliers are subcontractors to other hauliers. We found no evidence that what are called "sub-hauliers" are involved in the environmental monitoring of LSPs, as illustrated in Figure 1. One representative of the LSP in Case B expressed: *"I have never experienced a customer asking for any environmental reports in the procurement process…"*

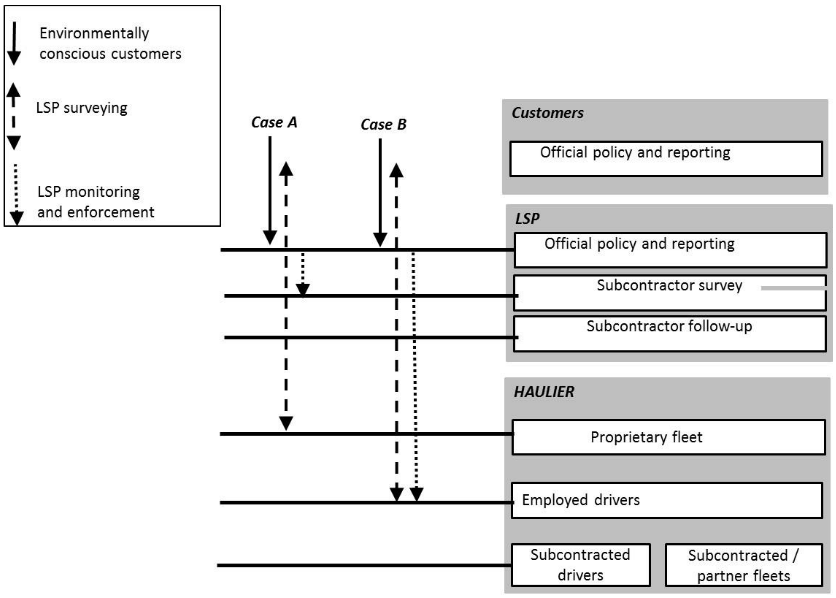

Figure 1: An illustration of the difference between LSP policy and practice. Some customers actually do not reflect over the environment at all, which means they are not depicted in the figure.

4. CONCLUDING DISCUSSION

Overall, it can be concluded from the interview study that the issues of sustainability are complex, involve a great deal of uncertainty, and are challenging to operationalize; all of which are also raised and discussed in the relevant literature. This complexity may also be a reason for the absence of meaningful environmental monitoring of subcontractors and LSPs in general. However, for the specific context of logistics services there are some interesting aspects that need further exploration. One is how problematic the current business models are, where all the pillars of sustainable development are more or less sacrificed for short-term financial sustainability, especially due to the customer's single focus on time and cost when selecting logistics service suppliers. Consequently, the hunt for ever less costly activities at the same time as the margins in the industry are very low, lead to operational fix solutions rather than strategic directions and innovations that, in the long-term can lead to sustainable development. As reported in literature (Wagner, 2008) innovation focus and the number of innovators are low in the logistics industry. In addition, when innovation activities are carried out by LSPs the focus is most often on proactive cost improvement and proactive performance improvement in order to generate customer loyalty. The dominating cost and efficiency focus has led to an earning-without-paying perspective in more than half of the LSPs interviewed. From this perspective, it is acceptable to make a profit without paying attention to environmental degradation or social vulnerability or making any financial efforts to reduce it. Consequently, one of the industries with the greatest environmental impact is under cost and efficiency pressure from its customers at the same time as the level of innovation is low. As a result, as already concluded by Wu and Dunn (1995, p. 34): *"Logistics has been a missing link in providing green products and services to the consumer"*. Logistics seems still to be the missing link and a non-prioritized area in supply chains.

In this paper we have illustrated the complexity involved when large LSPs try to monitor hundreds of domestic suppliers. The majority of the activities in physical distribution are not carried out by the LSPs themselves. Supply chain managers looking for sustainable or "green" logistics services need to look further than LSP reports in order to ensure the degree of sustainability promised by logistics service providers, and they also need to scrutinize how LSPs are performing follow-ups. It is also clear from this study that any real interest from customers of logistics services is not yet a reality; policy makers and senior managers need to address the issues of more environmentally friendly solutions if the goals needed and changes set by the EU and others are to be reached.

While this research has investigated how environmental policies are put into practice, we have not addressed the social aspects of the LSPs' CSR policies. Considering the fragmentation in the industry and the low transparency and follow-up of environmental policies, social sustainability in the transportation industry may show similar characteristics.

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PRODUCT RETURNS MANAGEMENT:
VALUE CREATION AND APPROPRIATION IN A SUPPLY CHAIN TRIAD

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INTRODUCTION

Product returns management (PRM) is a core supply chain management process (Rogers, Lambert et al. 2002). Extant literature on PRM typically focuses on the cost dimension of the returns process (e.g., Stuart, Bonawi-tan et al. 2005), such as efficiency of reverse logistics activities (e.g., Richey, Chen et al. 2005), disposition of the returned products – product reuse, material recycling and salvage – and the associated aspects of production planning and inventory management (e.g., Li and Olorunniwo 2008). Though the importance of value creation and appropriation are acknowledged, studies on value in product returns tend to be limited to the residual asset value (cost recovery) of the returned products (Huge-Brodin and Anderson 2008). Any broader discussion of value in PRM is generally restricted to the value implications for a single party in the returns transaction rather than the supply chain (Blackburn, Guide et al. 2004). Given the boundary spanning nature of supply chain management, this seems a severe restriction.

This paper overcomes the limitations in extant literature on PRM – it explores value creation and appropriation by several parties in the product returns chain. Specifically it answers the following research questions:

- What constitutes value in the product returns process for parties involved in the returns chain?
- How is value created in the product returns chain?
- Who appropriates this value in the product returns chain?

BACKGROUND LITERATURE

The conceptualisation of value can be grouped under three broad areas. The first area builds on the notion of total product proposed by Levitt (1980) and developed by Lovelock (1995), Evans and Berman (2001), and Frow, Ngo et al. (2014). The second area rests on the notion of value as a trade-off between benefits and sacrifices (Khalifa 2004, Lindgreen and Wynstra 2005). Quality, of the offering and the service elements surrounding delivery, is considered a potential intangible benefit in these studies (Zeithaml 1988). The third group focuses on understanding how the relationship between the parties contributes to understanding value (Lindgreen, Hingley et al. 2012).

Importantly, value, or the benefits and costs from which value is assessed, is not necessarily tied to monetary units. Within the context of inter-organisational transactions, value can be derived from multiple sources: goods, services and the revenue they generate, intangible elements such as inventory information or demand forecasts (Allee 2000), and relational elements (Ulaga 2003).

Value creation has long been recognised as an important innovative supply chain outcome that gives chain members competitive advantage (Walters and Lancaster 1999) and the value-added concept has been studied as a mechanism for supply chain integration (Fawcett and Fawcett 1995). The bulk of these studies, however, has been conducted in the context of the forward product chain. Comparable discussions in reverse logistics are few and far between, let alone in the specific field of product returns management (Mollenkopf, Frankel et al. 2011). Although reverse logistics has been defined as the management of the reverse flow of product for the "purposes of *capturing or creating value* or proper product disposal" (Rogers and Tibben-Lembke 2001), the locus of value has centred on the product and product flows. The sources of value have concentrated on product disposal activities and value has been interpreted as the economic gains made from recycling, reuse and salvage (Bernon and Cullen 2007, Pokharel and Mutha 2009).

In practice, parties in the supply chain dedicate little effort to exploring the value potential of the product returns process or taking an extended supply chain view (Mollenkopf and Dapiran 2007). Extant research on RPM also reflects this narrow focus on a single entity within the supply chain. With few exceptions, (e.g., Rainbird 2004), the boundary spanning nature of supply chain management and the product returns process is ignored, with little emphasis on linking both customers and suppliers. Walters and Lancaster (2000) discussed the simultaneous importance of both customer value and supplier value. Rainbird (2004) considered both the supplier and customer side of the relationship through the notion of simultaneous supply and demand chains that interact through a value catalyst. A recent study in product returns management reports the potential for value creation from tangible and intangible elements (Dapiran and Mollenkopf 2010).

Using evidence from seven case studies, Mollenkopf and Closs (2005) extended the analysis beyond costs alone to show the impact of effective PRM on revenue stream and company assets. Their analysis illustrated the potential marketing advantage that can flow from effective PRM, such as enhanced customer perceptions of quality and the goodwill that can accrue to organisations practising good corporate citizenship through product returns. Recent studies highlight the need to consider internal firm integration to fully understand the value implications of product returns (Mollenkopf, Frankel et al. 2011). In summary, PRM is a key supply chain process and needs to be studied from a multi-party perspective in the context of value creation.

This paper applies a multi-firm focus to examine how value is created and appropriated in PRM using a triad of related organisations – a retailer, two of its suppliers and a third party logistics service provider (3PL).

METHODOLOGY

Value is an ill-defined construct in the product returns chain. Further, while many departments at different levels within an organisation are typically involved in the processing of returns, these departments tend to be poorly integrated in this task. This lack of integration coupled with the heterogeneity in product return processing suggest that a qualitative case study approach is needed in data gathering and analysis (Flyvbjerg 2006) to explore such diversity (Barbour 2001). We thus employed an inductive qualitative approach to examine how companies in the same supply chain create and appropriate value from PRM to build theories (Eisenhardt 1989).

Case and participant selection

The consumer electronics industry was chosen as the context for this research. The management of returns in this sector has become more pressing because of mounting regulation in many countries regarding the collection and proper disposal of electrical and electronic waste (Environment Protection and Heritage Council 2010), galloping technological change, and the high level of returns. Flyvbjerg (2011) suggested an information-oriented approach to selecting cases to maximise the usefulness of information that can be extracted from a single case study. To this end, an "extreme" case consisting of a triad of organisations was considered best to explore the complexity of inter-organisational interactions in value creation and appropriation.

The organisations selected were a major retailer (TVCity – all names are fictitious), two of its suppliers (AsiaTel and Sonic), and a 3PL specialising in reverse logistics management (LogBack) employed by TVCity just a few months prior to the interviews. The recent appointment of the 3PL provided the opportunity to conduct a quasi-longitudinal study of a triadic set of organisations in the same supply chain.

Data collection

Semi-structured interviews were conducted with nine participating executives:

- TVCity: General Manager Operations, Freight Manager, Business Analyst
- AsiaTel: General Manager Logistics, National Parts Manager
- Sonic: National Customer Service Manager
- LogBack: Managing Director, General Manager, Retailer Account Manager.

Interviews were open-ended, focusing on topics such as returns policy, returns process, monitoring and measurement of product returns, disposition of returned products, and PRM relationship with other product return chain entities. Each interview lasted between 60 and 120 minutes and was audio-recorded. The interview transcripts were subsequently analysed to identify emerging themes.

Credibility of the analysis was gained from triangulation of descriptions and interpretations continually throughout the study (Stake 2005). To seek convergence of data, the interviews were supplemented with company supplied documentation and data available from corporate websites.

CASE DESCRIPTION

The Retailer - TVCity

TVCity was a major consumer electronic and home entertainment equipment retailer with some 150 outlets around Australia. Prior to appointing LogBack, returns from TVCity outlets to suppliers were independently handled and managed by individual retail stores, which separately negotiated with each supplier. Each store manager processed the store's returns in compliance with each supplier's returns policy. As the core function of a retail store is to sell new products, processing returns is a distraction. Understandably, handling returns was of a lower priority than selling, which resulted in returned products languishing at back-of-store until staff had time to process them, with associated holding costs, impact on cash flow, and higher probability of product damage. In addition, suppliers required TVCity to pay for the return freight. From TVCity's perspective, the process was ruled by the returns policies of scores of suppliers, each with various forms, authorisation methods and returns procedures.

In search of a more effective solution, TVCity engaged LogBack to advise, design and centralise the PRM process through LogBack's returned product facility. TVCity levied a fee on each supplier for operating the centralised returns process based on a percentage of the value of the returned product. It justified the charge on the ground that suppliers stood to gain from the consolidated product returns process, due to reductions in transport, administrative and transaction costs for suppliers. The new process and centralised facility also led to returned products arriving at suppliers' premises in better condition than previously and with fewer incidences of damaged packaging. Moreover, through the know-how delivered by LogBack, suppliers could receive reports providing statistics on product defects by product model, which allowed suppliers to identify poorly performing or poorly designed products. Implementation of the centralised network with the suppliers relied essentially on the power of TVCity to force the change. The top 100 suppliers were given advanced notice and the opportunity to discuss the pending change. Other suppliers were simply advised of the change.

The Suppliers – AsiaTel and Sonic

AsiaTel and Sonic were similar in many respects. They were both the Australian subsidiary of a Japanese manufacturer of consumer electronic and home entertainment equipment. AsiaTel and Sonic marketed, distributed, and serviced the imported products, which were globally recognised brands. TVCity was an important customer for AsiaTel, which stocked and sold almost the entire range of AsiaTel's products. Reciprocally, AsiaTel was valued by TVCity because of the quality of its products and the attractiveness of the brand to consumers.

The 3PL - LogBack

LogBack was a large Australian 3PL specialising in reverse logistics operations. It had links with overseas specialist firms from which it had acquired specialised IT systems and PRM know-how. LogBack provided TVCity with strategic advice on PRM. It supplied the IT system, designed the network structure, implemented product returns procedures in store, trained staff of its retail clients, designed the performance measurement systems, and provided benchmarking data and on-going advice on cost-effective approaches. LogBack had also implemented product testing operations in its returns facility to enable larger suppliers to test their products on-site without the need to return product to supplier premises. This avoided unnecessary product transfers.

FINDINGS AND DISCUSSION

What is Value?

The case study shows that the product returns process resulted in value creation for all three parties in the supply chain beyond any residual asset value of the returned product. TVCity perceived a net value gain. The high tangible cost in the use of the 3PL was recouped by the fee charged to the suppliers. The streamlined procedures introduced by LogBack and the centralised 3PL facility allowed TVCity to lessen its administrative burden. Improved in-store procedures enabled TVCity's staff to focus on selling, rather than handling consumer product returns. The centralised facility and the IT systems put in place by LogBack gave the retailer the ability to measure performance of the returns process. The level of returns for different products and different suppliers could now be measured accurately, giving the retailer leverage in negotiating the returns policy with its suppliers. LogBack's access to performance data on product return levels experienced by international retailers was shared with TVCity to allow the latter to benchmark its performance. This was not possible until the 3PL was used. Through the facilitation role of LogBack, TVCity created value in the returns management process.

The suppliers, however, viewed the change from decentralised to centralised process differently. AsiaTel was particularly dissatisfied by the way the centralised network was introduced and by the outcome, which it thought resulted in a more costly and less effective solution. It was galled by the imposition of the fee, which, it thought, was far too high. AsiaTel also felt that it had lost some level of control over the PRM process with TVCity exercising supply chain leadership and imposing its returns policy unilaterally on the suppliers. Though AsiaTel conceded that there were some transport consolidation savings, it felt that the level of returns had increased following the introduction of the centralised network. It remained to be convinced that there was a net benefit overall. In contrast, Sonic was receptive to the centralised network. It recognised some of the benefits accrued from the new approach.

The challenge for TVCity was to convince its suppliers that they also benefited in the value created. According to TVCity, the difficulty for the suppliers was that their thinking was clouded by the cost side of the equation and failed to identify some of the tangible benefits and did not recognise any of the intangible benefits accruing to them. From the suppliers' perspective the fee being asked by the retailer for the centralised service was excessive. In addition, the suppliers' return policies had been supplanted by TVCity's, giving rise to a feeling of having lost control of the returns management process. The absence of any effective measurement system on the part of the suppliers also gave rise to an impression that the level of returns had increased. TVCity explained that the consolidation action of the central facility created the illusion of a high return level compared to the previous decentralised process in which products were returned from individual stores around Australia in an *ad hoc* manner.

Reluctantly, AsiaTel and Sonic admitted to some benefits. Administration of product returns had improved as well as the speed of returns. TVCity's store staff gained gate-keeping skills through training and procedures provided by LogBack. The flow-on to the suppliers was that some returns had been avoided. Also, training had improved the condition of the returned products and their packaging. Consolidated returns from LogBack's centre had resulted in tangible transport cost savings. Though there appeared to be a net value gain for the suppliers, this was clouded by the cost side of the equation.

For LogBack, the fee charged was a tangible benefit. There was also value derived from its association with a prestigious retail brand, which it could leverage in acquiring other clients. The experience it gained from handling TVCity's complex returns could increase its efficiency in managing future accounts. LogBack had an ambition to present a centralised approach as an industry standard for PRM. Success with TVCity was seen to contribute to realising this ambition.

In sum, there was value creation in this PRM process that drew from a range of tangible and intangible sources beyond the inherent residual asset value of the product. Value creation was being facilitated by the 3PL. Table 1 summarises the costs and benefits of the centralised returns network as experienced or perceived by the product return chain entities.

Organisation	***Costs***	***Benefits***
AsiaTel ***Sonic***	• Fee to retailer. • Perceived higher level of returns. • Returns procedure supplanted by retailer's returns procedure. • Perceived loss of control over returns.	• More effective gate-keeping by retailer store staff. • Less product and packaging damage of returned products. • Speedier returns. • Consolidated returns and associated transport savings. • Reduced returns administration costs.
TVCity	• Fee to 3PL.	• Fee from suppliers. • Freeing up retail staff resources to focus on selling, not handling returns from consumers. • Reduced unsaleable stock. • 3PL-supplied services: returns facility, IT systems, strategic advice, returns management procedures, performance measurement system, benchmarking data, staff training.
LogBack	• Cost of running returns centre and supplying know-how, advice and systems to the retailer	• Fee from retailer. • Association with retailer brand. • Experience from returns network.

Table 1: Summary of costs and benefits of centralised return network

How is value created?

The PRM process before and after the appointment of LogBack underscored the key role played by the 3PL. TVCity had under–developed forward supply chain and logistics capabilities on which to draw to improve its product returns process. The employment of LogBack had been a necessary step towards acquiring these capabilities. Prior to the centralised return system, suppliers and the retailer all had individual returns management processes. Through centralisation, LogBack brought about an alignment of the PRM process between TVCity's retail outlets and each of its suppliers.

Findings from this case also indicate that to achieve this alignment each of the parties in the product returns chain had to abandon a self-centred cost-focused view of PRM and adopt a value orientation that encompasses a broader perspective of costs and benefits. The alignment of the PRM process resulted in process efficiencies in the form of consolidated transport, improved product handling, reduced product and package damage and speedier returns. Resources were also more effectively managed – retail store staff had more time to focus on sales and through training became more effective gatekeepers, reducing the volume of products entering the returns chain. Information systems were more effective in capturing data on the nature, types, and frequency of returns, enabling a more comprehensive analysis of returns and contributing to long term product improvement. This in turn led to increased returns chain value.

The findings also show that two factors were instrumental in creating value in the PRM process – a firm's value orientation, and a facilitation role played by an internal or external agent to bring about alignment between the product return chain parties. A value focused organisation understands that value creation is not simply an exercise in cost containment and control, but requires an appreciation of both the tangible and intangible benefits accruing from the operations.

However, a value orientation alone is not sufficient to maximize value creation in the returns process. Both supplier and retailer processes need to be aligned to bring about resource effectiveness and operational efficiency. Alignment is the process of integration, which builds linkages and explores ways of working towards common goals (Pagell

2004). Aligning supplier and customer supply chains is seen as a key element of business success (Jüttner, Christopher et al. 2007). In the returns management process, our case study reveals that alignment occurred around a common returns policy, standardised procedures, common performance metrics, shared information on the causes of returns, jointly negotiated reverse logistics activities, and a move towards a common understanding of what constituted value in the returns process.

Alignment is a complex process and needs to be facilitated by an external or an internal agent. A firm with the necessary capabilities can facilitate process alignment internally; otherwise external facilitation must be sought. In this case TVCity, which lacked logistics capabilities, relied on LogBack to provide the necessary external facilitation.

The case findings suggest that value creation in a product return chain can be conceptually summarised in a matrix (see Figure 1) that shows the relationship between value orientation and facilitation.

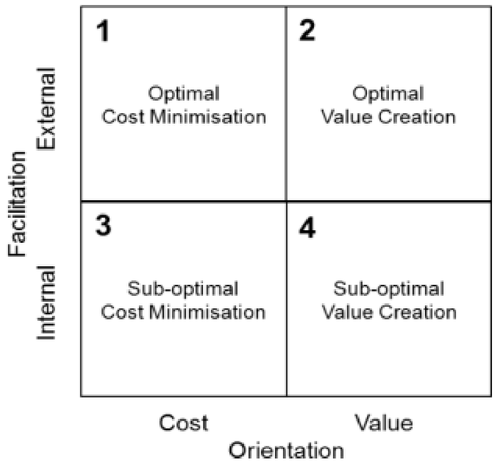

Figure 1: Returns chain value creation matrix

In a product returns chain in which the parties have a value orientation and there is external facilitation, value will be optimised (Quadrant 2) as demonstrated by the facilitation by LogBack in this case study. Where there is a value orientation but only internal facilitation there will be sub-optimal value creation since there will be a deficit of capabilities to bring about effective alignment of the returns process (Quadrant 4). This is the position TVCity was in prior to the appointment of LogBack. A returns chain in which the parties have only a cost orientation but rely on external facilitation will most likely achieve a level of alignment that will result in optimum cost control but will miss the intangible contributions to value creation (Quadrant 1). This was the situation the suppliers found themselves in after the intervention of LogBack. In Quadrant 3, firms have only a cost orientation and rely on internal facilitation. They will be unable to maximise the benefits from process alignment and will therefore achieve sub-optimal cost minimisation. The suppliers experienced this before LogBack became a part of the product returns management process.

Who appropriates value?

The third research question examines value appropriation in a product return chain. The case findings show that a value orientation is a pre-condition to value appropriation. A value orientation draws attention away from tangible costs alone and prompts the organisation to explore intangible costs and exploit both tangible and intangible benefits. The two suppliers in the case study were less open to a value analysis of the centralised PRM process and so appropriated less value than the retailer.

The case study also reveals that relationships between the two suppliers and the retailer were tense because of the way the centralised system was implemented. This hampered the negotiation process that could have led to a larger value appropriation by the suppliers. An integral element of value appropriation is the relative power of the parties involved (Cox 1999). In the case study, the retailer dominated the relationship and so was able to appropriate more value than the suppliers. Trust, or the lack of it, also played a part in preventing the suppliers from appropriating more value in the product returns process. It was also clear that the parties placed more emphasis on managing the transactions rather than managing the relationships. These relationship issues complete the value creation and appropriation framework shown in Figure 2.

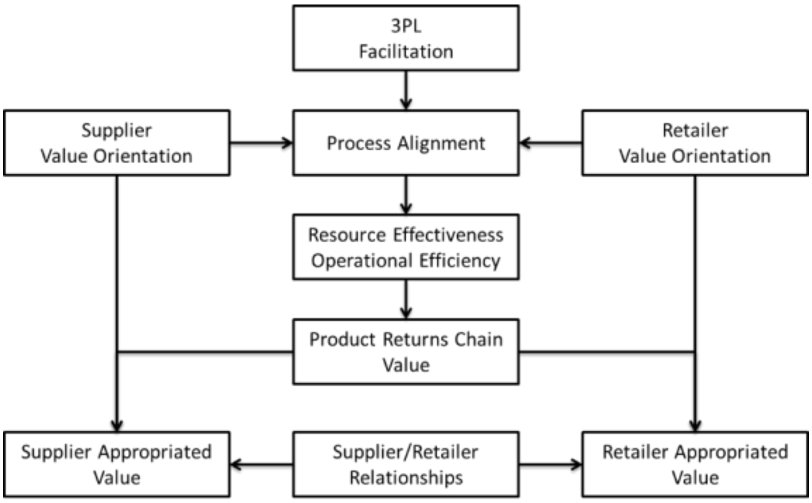

Figure 2: Conceptual product returns chain value appropriation framework

LIMITATIONS AND FURTHER RESEARCH

This study suffers the usual limitation related to the reliance on a single case, though no claim to generalisability is made. As the case description indicates, this case is highly dynamic with the recently implemented centralised returns process still undergoing negotiation. Evidently, interviews undertaken either side of this slice in time could have yielded different responses. This study thus lends itself to an extended longitudinal follow-up – to assess if indeed value has been created in the long term and the extent to which it has been appropriated to the satisfaction of the product return chain parties.

Another dimension left under-explored in this study is the role of power in implementing the centralised network and the ability of the parties to appropriate value. The power of the retailer was apparently recognised by the suppliers, with the retailer also being aware of the power it had vis-à-vis the suppliers – hence its ability to implement the PRM process in the way it did. The retailer did acknowledge the countervailing power the suppliers wielded through the strength of the brands they marketed. It is unclear whether the suppliers were aware of the power source they had at their disposal. Issues of trust are among the relationship factors in value creation in need of further study (Lindgreen, Hingley et al. 2012).

CONCLUSION

This case study of a product return chain involving a retailer, two of its suppliers, and a 3PL specialising in reverse logistics, has unearthed a complex set of interactions in PRM that led to value creation. It confirms the notion that value can be generated from multiple sources, including intangible processes and inter-organisational interactions (Allee 2000). More importantly, it shows how value is created and appropriated by supply chain parties in the product returns process, highlighting the role a 3PL can play in creating value for both retailer and supplier. Beverland (2012) identified the critical need for research to examine organisational practices in value creation and value management across parties in a network. This study was an attempt to fill that critical need.

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ECO-EFFICIENCY ANALYSIS FOR PACKAGING AND DISTRIBUTION OF BOTTLED MINERAL WATER

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ABSTRACT
Eco-logistics represents logistics and distribution activities when environmental aspects are involved in the planning and managing of the related distribution network. Eco-logistics considers all logistics activities, from transportation, storage and warehousing, packaging and labelling, vehicle loadings and delivery, and, at the same time, it involves conscious use of resources and materials, as well as the monitoring of emissions and fuel consumption of the distribution process, the use of manufacturing technologies and advanced ecologically materials. Considering the relevance of the mineral water consumption in Italy, in this work an eco-logistics application example to bottled mineral water distribution is presented.
The main purpose of this research is to compare the use of PET plastic bottles and glass bottles for drinking water. Both economic value as well as environmental impact are involved in the analysis, considering production, use and end-of-life phases for both bottle types. Two models are proposed, in order to evaluate the eco-efficiency of bottled mineral water in the cases of PET and glass. Numerical analysis shows that, under certain assumption, PET bottles ensures lower costs, mainly due to the relevance of transport costs, higher for glass bottles, related to the whole distribution chain. On the other hand, glass bottles demonstrate better environmental results, thanks to lower environmental impacts in production and end-of-life phases. A sensitivity analysis on different models parameters is also presented.

Keywords. Mineral water, packaging, eco-logistics.

1. INTRODUCTION
It seems that today has become a fad to add the suffix *eco* before a name, in order to make it appear more *sustainable*. Actually, the good intentions are not enough to ensure the survival of our planet, and in support of philosophy of sustainability there must be concrete and targeted intervention efforts. Techniques such as Life Cycle Assessment (LCA) and Material flow analysis (MFA) enable the evaluation of different alternatives, in order to develop, manufacture and distribute products with low environmental impacts combined with a saving of resources. Even logistics chain activities can become sustainable, thanks to a proper monitoring system of resource use and emissions, without losing sight of efficiency.
The WBCSD (World Business Council for Sustainable Development), defined in 1992 for the first time the concept of *eco-efficiency*, as the ability to produce competitively priced products and services that satisfy human needs, progressively reducing ecological impacts and use of natural resources during product life-cycle, in line with the load capacity of the earth. This concept can be further summed up simply as "creating more gain with less impact", that perfectly fits to the logistics earnest attention to environmental issues. This leads to the definition of *eco-logistics*.
Eco-logistics represents logistics and distribution activities when environmental aspects are involved in the planning and managing of the related distribution network. Eco-logistics considers all logistics activities, from transportation, storage and warehousing, packaging and labelling, vehicle loadings and delivery, and, at the same time, it involves conscious use of resources and materials, as well as the monitoring of emissions and fuel consumption of the distribution process, the use of manufacturing technologies and advanced ecologically materials.

In this paper an example of application of the principles of eco-efficiency for the distribution of bottled mineral water is presented.
The relevance of the distribution of mineral water in Italy is demonstrated by the per capita consumption of close to 200 litres/year, an amount that places Italy among the largest consumers in the world, as shown in the following figure. Of the total, about 80% is distributed with PET bottles and 20% with glass bottles.

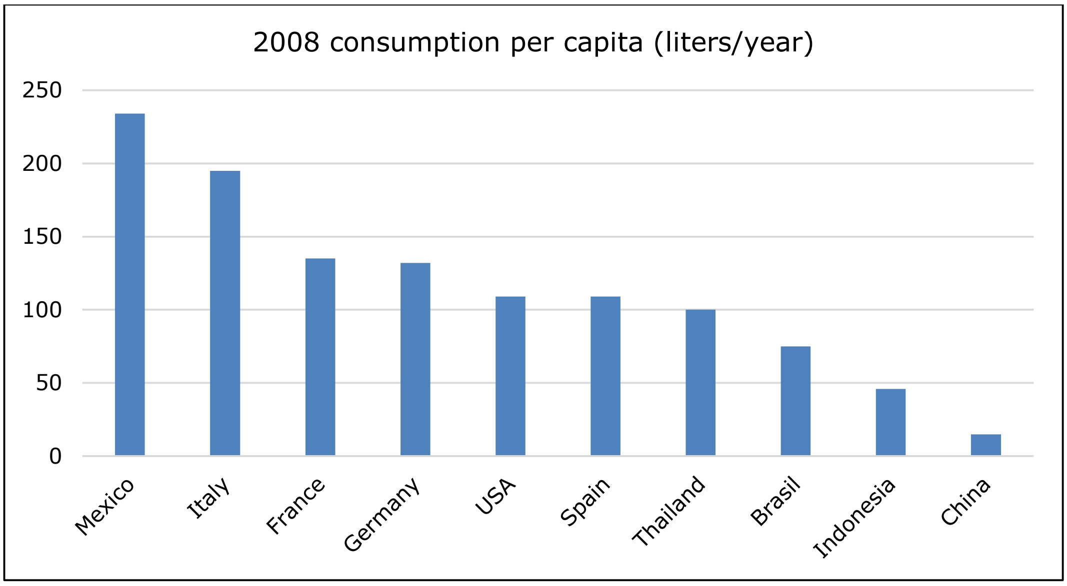

Figure 1. Annual consumption per capita of bottled mineral water.

One of the main relevant aspects of the distribution of bottled mineral water is related to the packaging and on the consequent distribution network configuration, also considering the high pollution potential related to packaging materials disposal and fuel-consumption of vehicles for the distribution activities. On the other hand, these elements can represent sources of economic and environmental benefits, i.e. they represent a key issue in order to achieve eco-efficiency.

Mineral water bottles must fulfill specific technical requirements, such as chemical inertness, strength, lightness, convenience, and many others. Bottles must be aesthetically pleasing, considering that they are also a marketing mean: throughout packaging, a company can communicate to consumers its efforts in environmental issues, conveying emotions in water *goodness* not only considering quality, healthy properties and flavor, but also for the environment.
For these and other purposes many designers have been committed to develop bottles design suitable for material saving, recycling and reuse options, as well as ergonomic handling and, at the same time, for communicating to consumers all company efforts in environmental-friendly solutions research for all life-cycle phases of the product.

Bottled mineral water production process is quite simple, and management costs of the production plant are relatively low when compared to other situations.
The production of glass bottles or PET takes place through the blowing technique (blow molding) in special molds preforms or that reach temperatures of 180°C for PET bottles and up to 1200°C for glass bottles. Once the bottle is washed and sanitized, then it is filled with the water, capped and labelled.
Secondary packaging for PET bottles consists of a plastic film burden of six bottles, that envelopes the bottles and allows their handling. Glass bottles instead, are secondary packed with special reusable plastic crates or resistant cardboard boxes, which have the function of protecting them against impacts. Usually crates and boxes receive twelve glass bottles. Both solutions, PET as well as glass bottles, are designed and manufactured for load resistance; moreover they allow a good saturation of transport

vehicles and storage areas, as they are stackable and their sizes fit well with standard pallet, which are usually used for logistics activities. Finally, glass bottles and plastic crates are reused 25 times on average, so the production costs can be spread over a lifetime much longer than the PET bottles.

The rest of the paper is organized as follows. In section 2, the economic models for both PET and glass bottles are presented, with their main assumptions and hypothesis. Section 3 proposes the environmental impacts evaluation methodology, while in section 4 results of the numerical analysis are presented. Concluding remarks and summed up in the last section.

For both economic and environmental impacts models, "1 liter glass bottles" and "1.5 liters PET bottles" are considered. Then numerical analysis have been carried out assuming an average per capita consumption of 200 liters/year, and results are presented with reference to one liter of water consumption.

2. ECONOMIC MODEL

In order to understand the costs adopting glass or PET bottles for mineral water distribution, the main phases are presented in the Figure 2.

Following the main process phases highlighted in Figure 2 for both glass and PET bottles, the following cost components have been considered:

- *Purchase*: bottles production, caps (metal crown caps for glass bottles and plastic screw caps for PET bottles), labels (paper labels for glass bottles, plastic labels for PET bottles), plastic crates (glass bottles) and plastic film burden (PET bottles).
- *Bottling plant*: plant investment, labor cost, energy cost, processing water (not intended as the mineral water, that is excluded from the analysis, but tap water for industrial food processing), sodium hydroxide (only for glass water sanitization).
- *Transport*: (1) from bottling plant to distribution center (glass bottles) or supermarket (PET bottles) considering a mean distance of 150 km; (2) from distribution center to retailers (glass bottles) considering a routing scheme of distribution vehicles in a 20 km radius-served area, or consumers travelling to the supermarket from a mean distance of 10 km (PET bottles).
- *Disposal*: economic contribution of bottles reuse (25 times for glass bottles, 100 times for plastic crates), and recycling (80% of glass and 35% of PET is recycled).

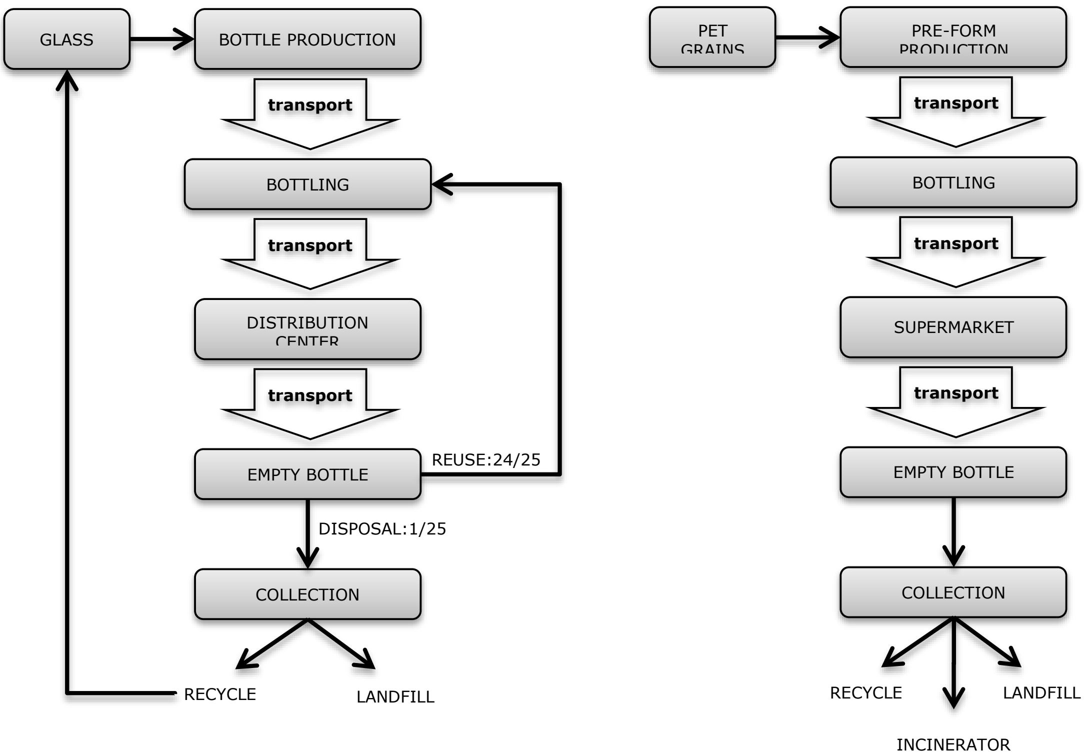

Figure 2. Lifecycle of mineral water bottles
(glass bottles on the left, PET bottles on the right).

To have an eye on the cost differences between total costs related to glass and PET bottles, unit cost for each secondary packaging (expressed as €/litre) are presented in Figure 3. It is clear that almost 85% of the cost difference between the two formats, is attributable to transport.

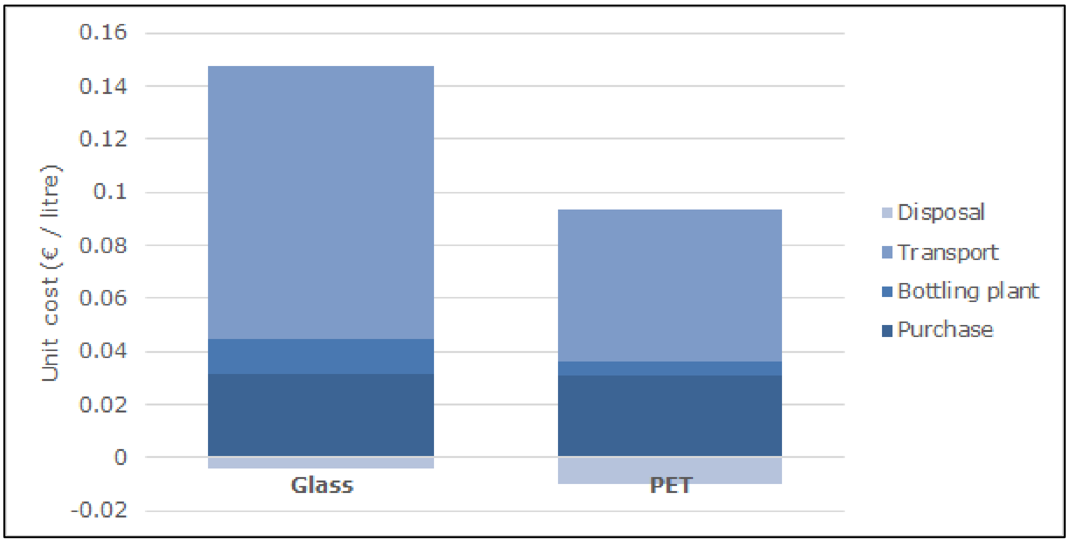

Figure 3. Lifecycle cost of mineral water bottles.

3. ENVIRONMENTAL IMPACTS

There are several ways to define what are the environmental impacts related to a production process and to evaluate them.
The first step in the definition of ecological parameters is their identification based on several aspects: raw material consumption, energy consumption, emissions, toxicity

potential, potential risks. Then a method to evaluate each single impact is to be define and applied, in order to compute the overall environmental impact result.
In the studies of eco-efficiency, it should be noted the existence of tools to support the calculation, in order to quantify precisely the emissions of each production phase, based on different evaluation methods. An example of these tools is the software GEMIS (Global Emission Model Integration System), which is produced at the Öko-Institute in Germany. This software allows the evaluation of air, water and soil emissions, as well as other possible environmental impacts resulting from energy conversion, manufacturing processing and transportation activities. GEMIS presents both a database of processes for the identification of all involved input and output of a process, as well as a set of methods to evaluate the impacts of such processes.
In this work, GEMIS tool is employed to conduct a comparative analysis of the two described formats of packaging of mineral waters (1 liter glass bottles and 1.5 liters PET bottles), evaluating for both their environmental impacts, and estimating their emissions of pollutants, such as CO_2 equivalent or CED (Cumulative Energy Demand), considering a fixed distribution network (as described in the previous section). The purpose is to give an indication of the differences, in the form of environmental impact, of the two modes of bottling.

To assess the environmental impact of the life cycle of a bottle glass are considered the following steps: extraction of raw materials, manufacturing glass, bottle production and bottling, taking also into account transport and production of accessories (cap and crates). In the GEMIS database does not exist a process related to the production of "bottles", so that specific models has been built, starting from the raw material production processes (glass or PET) and then representing all the relevant phase of bottles production, bottling, transport and disposal, as represented in Figure 2 for glass and PET bottles.
By GEMIS modelling tool it is possible to analyze only one use of the bottle at a time. In the case of glass bottles, they return on average 25 times to the bottling plants. Therefore, emissions until bottling are considered to be only 1/25 of the total computed impact related to these phases, while the contribution from the bottling phase and transport is taken into account as 100%.
Even the disposal involves an environmental impact: in the case of glass bottles, it is assumed that once they reach the end of life, 80% of them are recycled, while the remaining 20% go to landfill. Since the disposal will occur on average every 25 cycles, as in the case of bottling upstream phases, also for the environmental contribution of the end of life, a single cycle counts for 1/25 of the total computed impact related to disposal phase.

Unlike the case of glass, PET bottles performs a single cycle, so in this case all emissions including those of disposal are considered as 100%. From the literature it is clear that 53% of the bottles go to landfill, 36% are recycled and the remaining 12% go to the incinerator.
As mentioned before, the environmental impact of a process can be determined on the basis of (at least) two elements: (1) the impacts inventory, i.e. the list of inputs and outputs of the process, considering raw materials, energy, emissions and wastes; (2) the impact assessment method, i.e. a set of rules used to determine the environmental effects of all considered impacts. These two elements refers to the LCI (lifecycle inventory analysis) and LCIA (lifecycle impact assessment) phases of the LCA method, described in the International Standard ISO14040. In this work, such a standard has not been applied extensively, but it has been used as a reference guideline.
In order to evaluate environmental impacts of both glass and PET bottles, *Climate Change* impact category has been evaluated as the most relevant, taking into consideration the nature of elements involved in the considered processes. Climate Change characterization factor (i.e. what can represent Climate Change in practice) is the *Global Warming Potential*, which is measured as kilograms of CO_2-equivalent emissions per functional unit (in this case functional unit are 1 liter glass, and 1.5 liters PET).

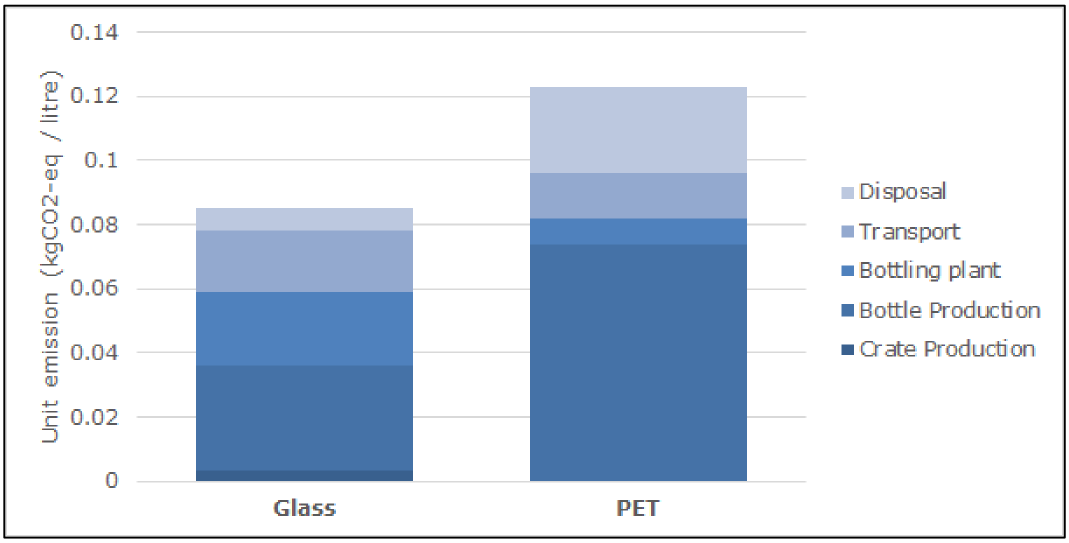

Figure 4. Lifecycle environmental impacts of mineral water bottles, using GEMIS tool.

4. NUMERICAL ANALYSIS

After implementing the models considering data related to a single bottle (1 liter glass bottle, 1.5 liters PET bottle), the two process are considered and evaluated separately, whereas in the case of the glass the 25 times-bottle reuse is implemented. Moreover, a 150 km distance from the bottling plant to the distribution center (glass models) or to the supermarket (PET models) is considered. center of the site bottling distribution. Glass bottles are delivered directly to the customer at home by the local distributor (20 km radius-served area), while PET bottles are purchased by the customer at the supermarket (mean distance : 10 km) and share part of the journey with the other part of the purchased items (mineral water is considered to correspond to one third of weekly purchased items weight).

In the case of glass bottles, the production and purchase of components contribute together to more than 42% of emissions, being responsible only for the 22% of total unit cost. Disposal contributions to economic as well as environmental result corresponds to 1/25 of the total computed, since these processes are carried out only once in the lifecycle of a bottle.

Another important fact concerns the transport emissions, which correspond to approximately 22% of total: the relevance of this value is given by its comparison with the economic relevance of transport activities, which covers about 72% of total cost.

Considering PET bottles, the most relevant environmental impact is related to bottles production and components purchasing, which covers about 60% of total CO_2-equivalent emissions. On the other hand, it corresponds to about 37% of total cost. Transport cost is the most relevant components, while it corresponds only to the 12% of environmental result. Environmental impact related to disposal stage is relevant (22%), but lower than glass (9% covers only one of the 25 bottle cycles). Bottling plant cost and environmental contribution are low for both glass and PET bottles.

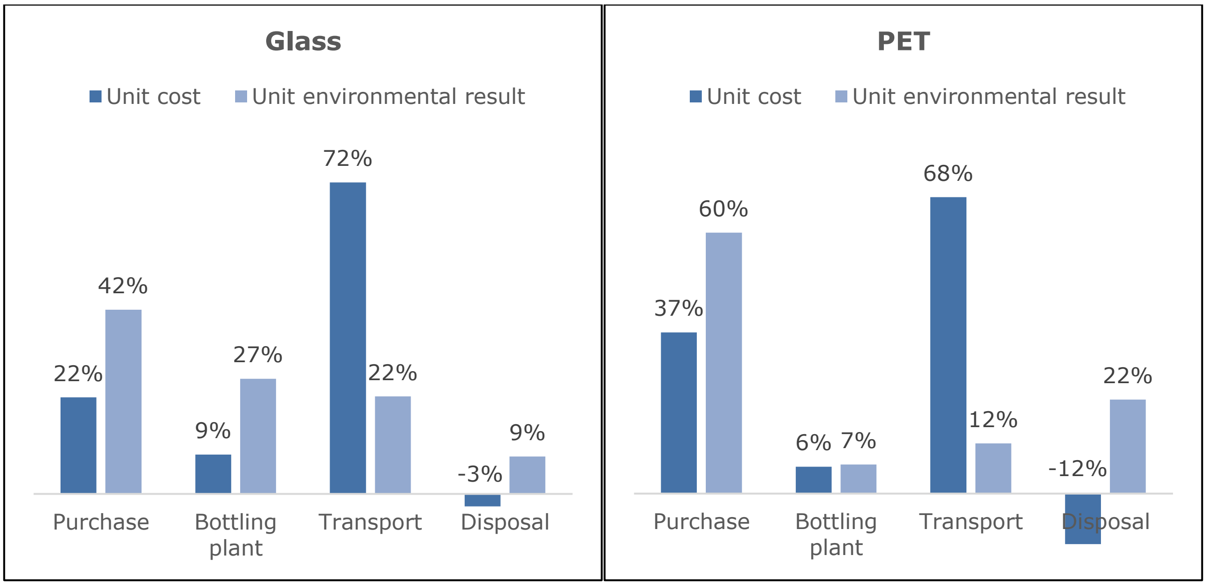

Figure 5. Lifecycle cost and environmental impacts of mineral water bottles.

4.1 Eco-efficiency analysis

After cost and environmental impact analysis have been carried out separately, also a joint analysis has been developed, and the so called *eco-efficiency solutions* related to glass and PET bottles have been determined.

In order to develop a structured eco-efficiency analysis, some parameters involved in the distribution chain models, i.e. the distance between the bottling plant and distribution center (supermarket), the mean distance between distribution center (supermarket) and the customer, the proportions of packages for each end of life option (reuse, recycling, disposal in landfill or incinerator).

An eco-efficiency analysis is represented as a trade-off analysis between two or more elements, i.e. using glass or PET bottles, both in terms of economic and environmental results: such an analysis can be represented by the eco-efficiency graph (Figure 6), which results are normalized, i.e. are reported as values between 0 and 1.

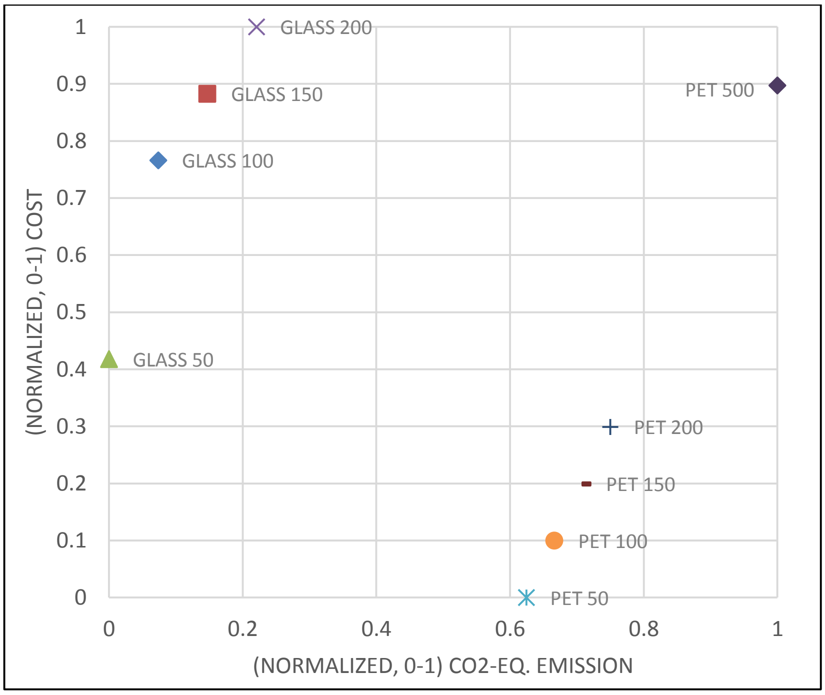

Figure 6. Eco-efficiency normalized results.

Of course the most eco-efficiency solutions are placed at the bottom left in the graph in Figure 6 as the worst in the top right.
Figure 6 also shows that the two bottling formats are placed in different areas: the glass in total involves higher costs, especially due to an inefficient transport (low saturation of the means). At the same time, the environmental impact related to glass bottles is significantly less damaging than the one related to PET bottles, mainly because of the reuse, which avoids the production of a new bottle at each cycle of bottling. On the other hand, PET proves to be more economical and more convenient to carry, but its life cycle involves disposable CO2 equivalent greater than glass.

CONCLUSIONS AND FUTURE DEVELOPMENTS

Better management of waste PET (less use of landfills and recycling more) you can assume that the gap in emissions between the two formats will tend to shrink. This is due mainly to the two components of PET recycling and the increasing separation of waste at the expense of the use of recovery through the incinerator.
The result of the trade-off arises as a result of the choice of the glass low distances, while on long distances also due to the higher saturation of the means you may prefer the "disposable bottles", and then the PET. Furthermore, one should not forget all important developments of technology and engineering that involve experiments for the manufacturing of plastic bottles with environmentally friendly and bio-compostable materials. These materials would be able to enclose in a single product the advantages of packaging materials resulting from biological or reusable several times with a consequent saving of materials and energy. However, even recent studies on these materials (for example with reference to the PLA - Polylactic Acid) are controversial with reference to the real environmental benefit. In fact, if on one hand the PLA can reduce the consumption of non-renewable resources, on the other side it causes a significant environmental impact as to obtain the raw material (corn) an intensive use of pesticides and fertilizers in agriculture is necessary.

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A TYPOLOGY ON LAST MILE DISTRIBUTION SYSTEMS

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Key Words: Last mile distribution systems, Typology

Abstract: This paper investigates typologies of last mile distribution systems (hereafter LM). It begins by observing the evolving LM's and demonstrating the limitations of the extant typologies in the literature. The research develops from two LM typological building blocks, *i.e. typological character* and *character state*, and draws potential configurations defined by coherent arrangements of a defined list of candidate typological characters. These configuration patterns are tested by mapping emerging LM's against the newly defined typological characters, leading to a new LM typology. The research contributes theoretically to LM's typological pattern recognition, typological advancement, and typological development of other organisational types; and practically to LM's practice database expansion, benchmark development, and innovation source provision.

1. Introduction

The recent decade has witnessed the dramatic growth of internet-based transactions, which can be illustrated, for example, by the soaring online sales in the UK (Verdict Research, 2008). Relating to this, last mile distribution systems have undergone changes concerning alternative models supporting emerging market dynamics. However, the experience in the UK suggests that most new entrants to the Internet-based market opted for new business models prematurely (Fernie et al., 2010). For instance, Sainsbury, Somerfield and Asda all set up pick centres and closed them down within a few years. This suggests that their LM's had lost fit with changing customer requirements due to the introduction of new customer service business models.

In the discipline of organisation science, the issue of fit has been analysed constantly through the identification of ideal organisational types, *i.e.* typology (McKelvey, 1982). Examples of such analysis include Miles et al. (1978), Mintzberg (1979, 1993), Porter (1980, 1985), *etc.*. These typological theories have offered guidance for practitioners in the sense that some specific outcomes, *e.g.* organisational effectiveness (Mintzberg, 1979, 1993), competitive advantage (Porter, 1980, 1985), operational capabilities (Srai and Gregory, 2008), are at the highest level in the ideal types of organisation identified in the theories, because the fit among contextual, structural, and strategic factors is at a maximum (Doty and Glick, 1994).

Likewise, typological theories have been attempted in the LM field. The recent proliferation in LM types by the traditional bricks amd mortar retailers, logistical firms and e-tailers has resulted in significant innovations and experimentation; however, a literature review (elaborated in Section 3.2) into this field has revealed that LM typological studies have been limited and not replicated since 2005, despite that replication has been thought to contribute greatly to the credibility of development in many fields, such as the social sciences (Berthon et al., 2002). In addition, the extant LM typologies are inconsistent, and therefore detrimental to system design as well as confusing for practitioners.

This paper seeks to develop new LM typologies, extending from previous studies by (1) identifying critical dimensions that capture possible and observed innovations in the field, (2) deriving a new LM typology with these recent advances incorporated, and (3) setting out a list of LM archetypes for practitioners to consider during LM design and operation.

2. Methodology

The methodological procedures of this paper are rooted in the generally held argument that all organisational typologies are the ‘‘selection’’ of very few characters, taken from a larger number of variables, upon which the typologies are based (McKelvey, 1982: 40). The selections are made by typologists deliberately, as opposed to on a random basis, with some patterns involved.

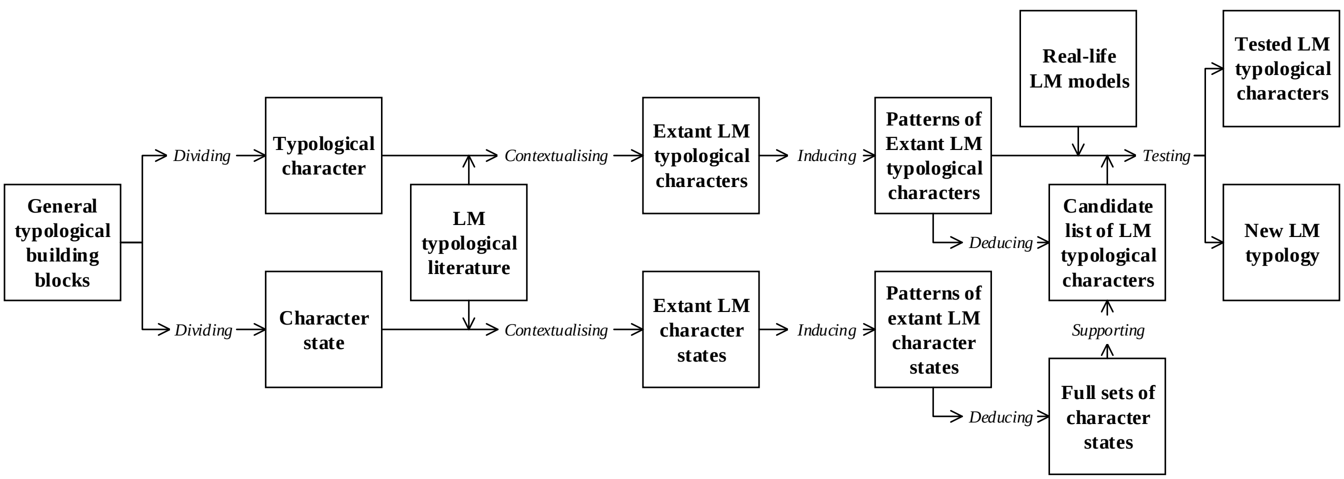

Figure 1 Methodological procedure of this paper

The research is thus designed to achieve the objectives through the exploration of ‘‘typological selection patterns’’ in LM’s context. It proceeds in four steps (see Figure 1): (1) Due to the inconsistent nature of the extant LM typological works, general typological design literature and typological building blocks are reviewed. Two main general typological dimensions, *i.e. typological character* (measures of differences across types) and *typological state* (values of measures when contextualised) are highlighted. (2) Extant LM typological works are referred to in order to contextualise the main typological dimensions under the LM’s context, resulting in extant LM typological characters and character states. The extant LM typological works are thus ‘‘standardised’’. (3) The extant typological characters and character states define current organisational typologies. In order to advance the LM typological provisions, it is essential to examine the patterns governing the selections of the extant LM typological characters and character states. We therefore induce the patterns from the extant LM typological characters and character states by resorting to their underlying theories, *i.e.* general supply chain theories and organisational boundary decision mechanism theories, on which we deduce candidate LM typological characters to be tested. (4) Supported by the deduced character state permutations, the candidate typological characters are compared against LM models currently in operation, yielding a list of tested typological characters, and a new LM typology with real-world case examples.

3. Findings

3.1 Review on general typological building blocks and their characteristics

In typological systems, the object of study is referred to as *Operational Typological Unit* (McKelvey, 1982: 337; Rich, 1992; Sneath and Sokal, 1973: 68, hereafter OTU). The feature attached to an OTU or to its subcomponents, and varying from one to another, are reflected in *typological characters* (McKelvey, 1982: 348; Michener and Sokal, 1957; Rich, 1992; Sneath and Sokal, 1973: 71). The kind of variation a character takes, for a given individual, is defined as its *character state* (McKelvey, 1982: 349; Michener and Sokal, 1957: 71; Rich, 1992). To illustrate, based on the typological character, *i.e.* key coordination mechanism, dominant part of organisation, and type and degree of centralisation, Mintzberg (1979, 1993) proposed a typology dividing the OTU, *i.e.* general organisations, into five character states, *i.e.* simple structure, machine bureaucracy, professional beaucracy, divisionalised form, and adhocracy.

A typological character is closely related to its OTU or OTU's subcomponents. It can be interpreted as consisting of two parts, *i.e.* part p_1 and part p_2, illustrated as below:

	Typological character	=	OTU or its subcomponents (p_1)	+	Feature (p_2)
Example:	Dominant part of organisation	=	Part of organisation	+	Dominant role

In summary, character states correspond to individual types, *e.g.* simple structure, whereas typological characters correspond to OTU's, *e.g.* dominant part of organisation.

3.2 Derivation of extant LM typological characters and character states

No matter how typologies vary in formats, there are always descriptive discourses characterising individual types, containing some sorts of *values* corresponding to character states. In the LM's case, the key values identified within the only two works available from the EBSCO database, *i.e.* Chopra (2003) (hereafter W_1) and Boyer et al. (2005) (hereafter W_2), are labelled from v_1 to v_{19} as below:

W_1: There are six distinct distribution network designs that are classified as follows: […]

> Manufacturer storage with direct shipping. In this option, product is shipped directly from [v_1] *the manufacturer* to [v_2] *the end customer*, bypassing [v_3] *the retailer* (who takes the order and initiates the delivery request). […]
>
> Manufacturer storage with direct shipping and in-transit merge. […] When [v_4] *a customer* orders a PC from Dell along with a Sony monitor, [v_5] *the package carrier* picks up the PC at [v_1] *the Dell factory*, the monitor at [v_1] *the Sony factory* and merges the two together at [v_6] *a hub* before making a single delivery to [v_2] *the customer*. […]
>
> Distributor storage with package carrier delivery. Under this option, inventory is not held by manufacturers at the factories but is held by [v_7, v_8] *distributors/retailers* in intermediate warehouses and [v_5] *package carriers* are used to transport products from the intermediate location to [v_4] *the final customer*. […]
>
> Distributor storage with last mile delivery. Last mile delivery refers to [v_7, v_8] *the distributor/retailer* delivering the product to [v_4] *the customers home* instead of using [v_6] *a package carrier*. […]

Manufacturer/distributor storage with customer pickup. In this approach, inventory is stored at [v_9] *the manufacturer* or [v_7] *distributor warehouse* but [v_4] *customers* place their orders online or on the phone and then come to [v_{10}] *designated pickup points* to collect their orders. Orders are shipped from [v_9, v_7] *the storage site* to [v_{10}] *the pickup points* as-needed. […]

Retail storage with customer pickup. In this option, inventory is stored locally at [v_8] *retail stores*. [v_4] *Customers* either walk into the retail store or place an order online or on the phone, and pick it up at [v_{11}] *the retail store*. (Chopra, 2003)

W_2: First, order fulfillment, or the picking of items for consumer orders, can be accomplished either in [v_{12}] *existing stores* or in [v_{13}] *a centralised distribution center*(*s*). […] Second, delivery to the end consumer can be direct, as in delivery to [v_{14}] *the consumer's home*, or indirect, wherein [v_{15}] *the consumer* is required to pick up their order, or [v_{16}] *a third-party provider such as Federal Express or UPS* provides the deliveries. (Boyer et al., 2005: 18)

In addition to the above materials, Gevaers et al. (2011) (hereafter W_3) claimed that in the case of customer pickup, the pickup location can be embodied in [v_{17}] distribution center, [v_{18}] shop, or [v_{19}] clustering point.

The contextual information in which the values are embedded is also extracted. Based on the values identified and the embedding contextual information extracted, LM's typological characters from c_1 to c_9 are derived and character states from s_1 to s_7 are summarised (see Table 1):

Table 1 Derivation of LM typological characters and character states

Source	**Key value identified**	**Embedding contextual information extracted**	**Typological character derived**		**Character state summarised**
			p_1	**p_2**	
W_1	[v_1] Manufacturer	Product is shipped from the manufacturer.	Shadowing organisation of	[c_1] Shipping origin point	[s_1] Manufacturer
W_1	[v_2] Customer	Product is shipped to the customer.		[c_2] Shipping destination point	[s_2] Customer
W_1	[v_3] Retailer	The retailer initiates the delivery request.		[c_3] Delivery requesting point	[s_3] Retailer
W_1	[v_4] Customer	A customer orders a PC.		*Ibid.* [c_3]	*Ibid.* [s_2]
W_1	[v_5] Package carrier	The package carrier makes a delivery.		[c_4] Order delivery	[s_4] Carrier
W_1	[v_6] Hub	The PC and the monitor merge at a hub.		[c_5] Order merging point	[s_5] Distributor
W_1	[v_7] Distributor	Inventory is held by distributors.		[c_6] Inventory holding point	*Ibid.* [s_5]
W_1	[v_8] Retailer	Inventory is held by retailers.		*Ibid.* [c_6]	*Ibid.* [s_3]
W_1	[v_9] Manufacturer	Inventory is stored at the manufacturer.		*Ibid.*	*Ibid.* [s_1]
W_1	[v_{10}] Retail store	Customers pick up an order at the retail store.		[c_7] Order pickup point	*Ibid.* [s_3]
W_2	[v_{11}] Store	Order fulfillment is accomplished in existing stores.		[c_8] Order fulfilling point	*Ibid.* [s_3]
W_2	[v_{12}] Distribution center	Order fulfillment is accomplished in a centralised distribution center(s).		*Ibid.* [c_8]	*Ibid.* [s_5]
W_2	[v_{13}] Consumer's home	Delivery is to the consumer's home.		*Ibid.* [c_2]	*Ibid.* [s_2]
W_2	[v_{14}] Customer	The consumer is required to pick up her order.		[c_9] Order pickup	*Ibid.* [s_2]
W_2	[v_{15}] Third-party provider	A third-party provider provides the deliveries.		*Ibid.* [c_4]	[s_6] Third-party provider
W_3	[v_{16}] Distribution center	N/A		*Ibid.* [c_7]	*Ibid.* [s_5]
W_3	[v_{17}] Shop	N/A		*Ibid.*	*Ibid.* [s_3]
W_3	[v_{18}] Clustering point	N/A		*Ibid.*	[s_7] Clustering point

3.3 Formation of pools of LM character states

This section form pools supplying options for typological characters. Character states divide the totality and set boundaries for types; In LM's case, where does one type "end" and another "begin"?

The derived character states s_1, s_2, s_3, s_4, and s_5 are mutually exclusive supply chain participants shadowing different sets of supply chain activities (Copacino, 1997). The character state s_7 is analogous to the former five. These kinds of activities are all supported by appropriate resource portfolio and governed by *competence mechanism* (hereafter *mech*$_1$), being a choice of resources for organisational portfolio (Santos and Eisenhardt, 2005).

By comparison, the character state s_6 is named in a way to accentuate distinctiveness from the "first" and "second" party providers, *i.e.*, *vendors* and *customers* (s_2). Such characters states are governed by *efficiency mechanism* (hereafter $mech_2$), minimising the cost of governing activities and making a choice of whether to conduct transactions inside organisations or outside through market exchanges (Santos and Eisenhardt, 2005). As such, the character states s_1, s_2, s_3, s_4, and s_5 form the pool of $mech_1$ type character state, and the character states s_2, s_6, and *vendor* form the pool of $mech_2$ type character state.

3.4 Formation of candidate list for LM typological characters

This section forms a candidate list for LM typological characters. We only analyse the parts p_1 of the derived typological characters since their parts p_2 are invariant. The parts p_1 should be deliberately selected by the LM typologists, as is the case for most organisational typologies (McKelvey, 1982). The patterns associated with the selection can be identified as follows:

Firstly, given LM's are operated within broader networks of supply chain (Bowersox, 2013), Lambert & Cooper (Lambert and Cooper, 2000)'s general supply chain management framework is consulted to subdivide LM's into three broad components, *i.e. network structure*, *business processes* and *management components*. It is the *business processes* component from which all the derived LM typological characters are sourced because of their nature of ''structured and measured sets of activities designed to produce a specific output for a particular customer or market'' (Davenport, 1993). Further analysis is therefore performed on this component only. Secondly, per the *Supply Chain Operations Reference (SCOR)* model (Supply Chain Council, 2008), the component is further subdivided into six subcomponents, *i.e. source* (sc_1), *make* (sc_2) and *deliver* (sc_3) of information flow and *source* (sc_4), *make* (sc_5) and *deliver* (sc_6) of goods flow. The correspondence relationship between the sourcing subcomponents and the typological characters is demonstrated in Table 2.

Table 2 Correspondence relationship between sourcing subcomponents (sc) and typological characters (tc)

sc	***tc***	***sc***	***tc***	***sc***	***tc***	***sc***	***tc***	***sc***	***tc***	***sc***	***tc***	***sc***	***tc***	***sc***	***tc***	***sc***	***tc***
c_1	sc_5 & sc_6	c_2	sc_2 & sc_3	c_3	sc_6	c_4	sc_6	c_5	sc_5	c_6	sc_4	c_7	sc_5 & sc_6	c_8	sc_5	c_9	sc_6

The pattern emerges that all the extant typological characters source from the subcomponents sp_2 to sp_6. Because typological characters should be distributed as widely and evenly as possible (McKelvey, 1982; Sneath and Sokal, 1973), **it is hypothesised that further p_2 part of LM typological characters appear from the identical source, *i.e.* sp_2 to sp_6**. In order to test the hypothesis, each of the six subcomponents is lastly subdivided into an indeterminate number of consecutive *unit subcomponents*, where the $mech_1$ and $mech_2$ type character states can demonstrate differences between any two consecutive unit sub-components, within any one subcomponent from sp_2 to sp_6, for any LM individuals (see Figure 2).

Combining these unit subcomponents with the invariant parts p_2, we obtain a list of candidate LM typological characters, *i.e.* the total candidate typological characters from cc_{11}~cc_{1n} to cc_{61}~cc_{6n} excluding the extant LM typological characters. Testing the hypothesis is converted to verifying the existence of valid typological characters out of the total candidate typological characters.

3.1 Test of candidate list of typological characters and formation of new typology

The models used for the test consist of three groups, *i.e.* group g_1, g_2 and g_3. Both group g_1 and g_2 emerge from representative companies documented in W_1 and W_2. Particularly, the former coincides the models of W_1 and W_2, and the latter encompasses other models from the same company set. The group g_3

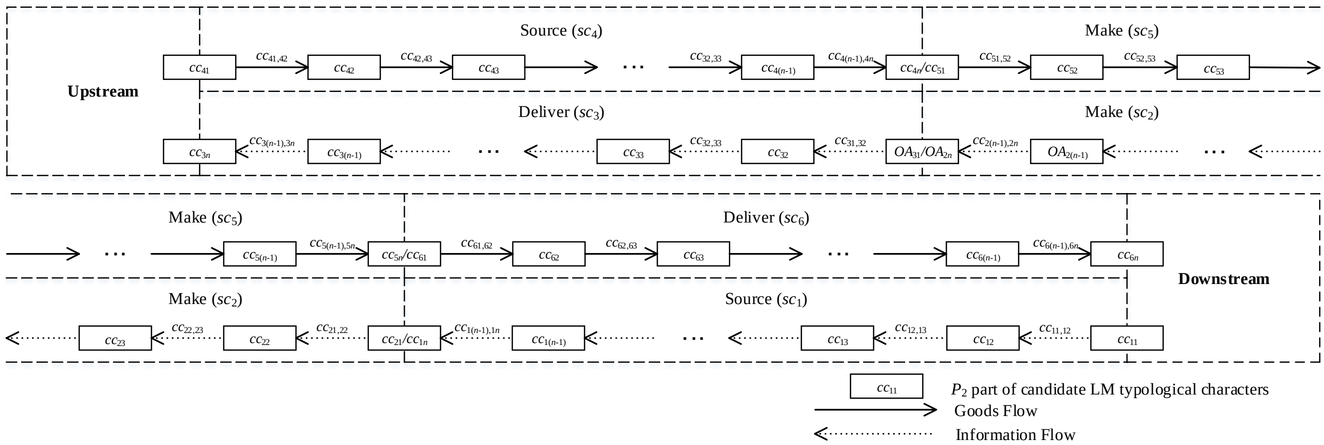

Figure 2 p_2 part of candidate LM typological characters on business process component

involves five organisations who have been studied through face-to-face interviews and archival analysis. The information regarding source, key feature, correspondence relationship between company and model group is summarised in Table 3.

Three groups of models are individually mapped out against the candidate LM typological characters using the $mech_1$ and $mech_2$ type character states. As an exemplar, a schematic of the mapping outcome of the model m_{27} is provided in Figure 3. The full result (see Appendix) reveals that 8 candidate typological characters have passed the test, *i.e.* cc_{32}, $cc_{32,33}$, cc_{33}, $cc_{33,34}$, $cc_{51,52}$, cc_{62}, $cc_{62,63}$, and $cc_{63,64}$ (coloured in grey in the Appendix, in comparison to the extant typological characters coloured in black), therefore the hypothesis has been validated. In addition, a new LM typology is also formed as a result of the test, whose types are labelled from t_1 to t_{46} (see Table 4).

4. Contributions

From a theoretical perspective, firstly, the paper has identified the patterns associated with LM's typologies, *i.e.* the pattern of boundary decision mechanisms of typological states, and of the sources of LM typological characters. These patterns have been tested and are anticipated to be generalised. Secondly, an up-to-date LM typology has been achieved as a result of examining real-world LM's. Thirdly, in retrospect, the process followed by this research has suggested a methodological guideline: (1) derivation of typological character and character state; (2) pattern recognition and typological attribute expansion; (3) empirical test and typology creation. These may be generalised to other organisational types.

From an operations practice perspective, firstly, some recent LM practices have been captured and have been built into the new typology, expanding the extant LM-practice database. Secondly, in line with the core thesis of the typology concept explained earlier, the new typology has offered an up-to-date list of LM ideal types possessing the maximal level of efficiency for practitioners to benchmark against, together with the tested list of typological characters and the pools of character states, setting out design attributes and options that are of significance to the sector. Thirdly, the candidate typological characters failing the test, *i.e.* cc_{21}, $cc_{21,22}$, $cc_{31,32}$, $cc_{41,42}$ suggests prospective design attributes and options, based on which practitioners can actively innovate. Once successful, they can be validated as typological characters.

Table 3 Summary of LM models used to test candidate LM typological characters

Company	Model	Group	Source
7 Eleven	m_9	g_1	Chopra, 2003
	m_{12}	g_2	(Lee and Whang, 2001)
	m_{13}	g_2	(Westlake, 2012)
Alberston's	m_3	g_1	Boyer et al., 2005: 81,82
	m_8	g_1	*Ibid.* m_9
	m_{10}	g_1	*Ibid.* m_9
Amazon.com	m_1	g_1	Boyer et al., 2005: 27,28,29,30
	m_7 (1)	g_1	*Ibid.* m_9
	Ibid. m_5	g_1	*Ibid.* m_9
	m_{25}	g_2	Greg, 2012
America New	*Ibid.* m_3	g_1	*Ibid.* m_9
Best Buy	m_2	g_1	Boyer et al., 2005: 49
Caremark	*Ibid.* m_1	g_1	*Ibid.* m_1
Circuit City	*Ibid.* m_2	g_1	*Ibid.* m_2
Dell	*Ibid.* m_1	g_1	*Ibid.* m_1
	m_5	g_1	*Ibid.* m_9
	m_{11}	g_2	Maguire, 2003

Company	Model	Group	Source
Dell & Sony	m_6	g_1	*Ibid.* m_9
Drugstore.com	*Ibid.* m_1	g_1	*Ibid.* m_1
eBags	*Ibid.* m_5	g_1	*Ibid.* m_9
NewDirect	*Ibid.* m_1	g_1	*Ibid.* m_1
Grainger	*Ibid.* m_3	g_1	*Ibid.* m_3
	Ibid. m_5	g_1	*Ibid.* m_9
	Ibid. m_7	g_1	*Ibid.* m_9
	Ibid. m_9	g_1	*Ibid.* m_9
	Ibid. m_{10}	g_1	*Ibid.* m_9
Grocery Gateway	m_4	g_1	Boyer et al., 2005: 107,108,109
Lands' End	*Ibid.* m_1	g_1	*Ibid.* m_1
L.L.Bean	*Ibid.* m_1	g_1	*Ibid.* m_1
Lowes Foods	*Ibid.* m_2	g_1	*Ibid.* m_2
Netflix	*Ibid.* m_1	g_1	*Ibid.* m_1
Nordstrom.com	*Ibid.* m_5	g_1	*Ibid.* m_9
Ocado	*Ibid.* m_4	g_1	*Ibid.* m_4

Company	Model	Group	Source
Office Depot	*Ibid.* m_4	g_1	*Ibid.* m_4
Office Max	*Ibid.* m_4	g_1	*Ibid.* m_4
Omaha Steaks	*Ibid.* m_1	g_1	*Ibid.* m_1
Peapod	*Ibid.* m_8	g_1	Chopra, 2003
Publix Direct	*Ibid.* m_4	g_1	*Ibid.* m_4
REI	*Ibid.* m_2	g_1	*Ibid.* m_2
Rite-Aid	*Ibid.* m_2	g_1	*Ibid.* m_2
Roomstogo	*Ibid.* m_4	g_1	*Ibid.* m_4
Sainsbury	*Ibid.* m_3	g_1	*Ibid.* m_3
	m_{17}	g_2	Shrimpton, 2013
Sears Canada	*Ibid.* m_2	g_1	*Ibid.* m_2
Tesco	*Ibid.* m_3	g_1	*Ibid.* m_3
	m_{15}	g_2	Delfmann et al., 2011
	m_{16}	g_2	Quinn, 2013
	Ibid. m_{17}	g_2	Wood, 2012
Walgreens	*Ibid.* m_2	g_1	*Ibid.* m_2

Model	Key feature
m_1	Distribution center fulfillment & indirect delivery
m_2	Store-based fulfillment & indirect delivery
m_3	Store-based fulfillment & direct delivery
m_4	Distribution center fulfillment & direct delivery
m_5	Manufacturer storage with direct shipping
m_6	Manufacturer storage with direct shipping and in-transit merge
m_7	Distributor storage with carrier delivery
m_8	Distributor storage, last mile delivery
m_9 (1)	Manufacturer storage with consumer pickup
m_9 (2)	Distributor storage with consumer pickup
m_{10}	Retail storage with customer pickup
m_{11}	Brick-and-mortar mini-store with an e-commerce option
m_{12}	Items ordering from a multimedia kiosk at the store
m_{13}	Home delivery
m_{15}	Click & collect based in store
m_{16}	Click & collect based in convenient location
m_{17}	Dark store fulfillment & home delivery
m_{25}	Distribution Customer pickup from delivery lockers

Company	Model	Group	Source
Abby Couriers	m_{18}	g_3	Interview
	m_{24}	g_3	Interview
Asda	m_{20}	g_3	(Logan, 2013)
	m_{22}	g_3	(Cope, 1998)
Auchan	m_{23}	g_3	(Cavill, 2009)
X library services	m_{25}	g_3	Interview
	m_{26}	g_3	Interview
	m_{27}	g_3	Interview
	m_{28}	g_3	Interview
	m_{29}	g_3	Interview
X library services	m_{30}	g_3	Interview
	m_{31}	g_3	Interview
Nightline	m_{19}	g_3	(Gallagher, 2012)

Model	Key feature
m_{18}	Local depot storage, home delivery
m_{19}	Order collection from self-service storage lockers
m_{20}	Store fulfillment, collection from stand-alone point
m_{22}	Central warehouse fulfillment, home delivery
m_{24}	Local depot storage, customer collection
m_{25}	Online borrowing, library fulfillment, library collection
m_{26}	Online borrowing, warehouse fulfillment, library collection
m_{27}	Online borrowing, interlending fulfillment, library collection
m_{28}	Online borrowing, publisher fulfillment, library collection
m_{29}	Borrowing from library, warehouse fulfillment, library collection
m_{30}	Borrowing from library, interlending fulfillment, library collection
m_{31}	Borrowing from library, supplier fulfillment, library collection

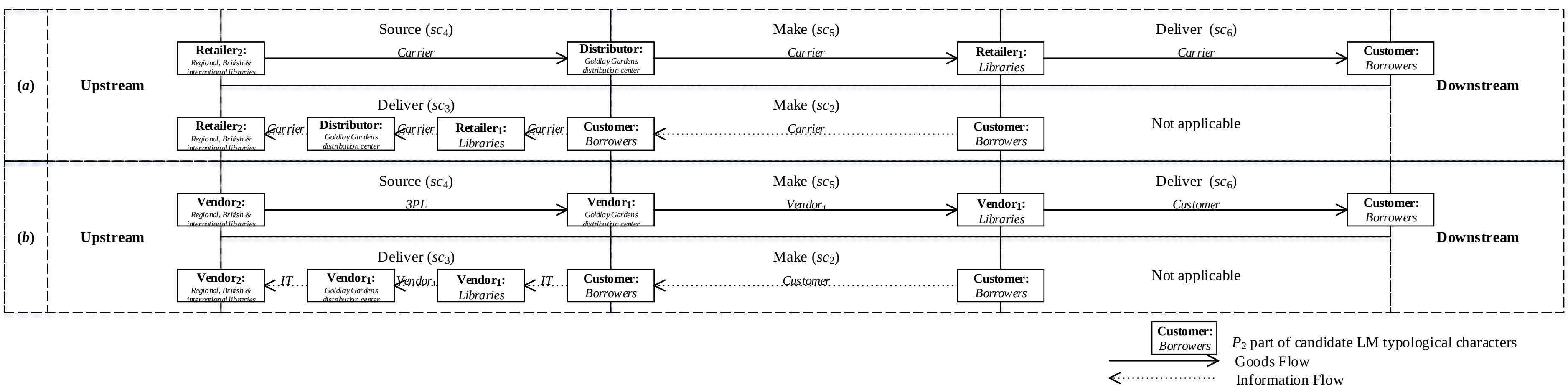

Figure 3 Exemplar schematic: LM model m_{27} mapped against candidate typological characters using the using mech$_1$ (a) and mech$_2$ (b) type character states

Table 4 Derivation of new LM typology

Model	Type	Model	Type	Model	Type	Model	Type	Model	Type	Model	Type
m_1	**t_1**	m_{11}&m_1	**t_9**	m_{12}&m_1	N/A	m_{13}&m_1	N/A	m_{16}&m_1	N/A	m_{25}&m_1	**t_{14}**
m_2	t_2	m_{11}&m_2	N/A	m_{12}&m_2	N/A	m_{13}&m_2	N/A	m_{16}&m_2	N/A	m_{25}&m_2	N/A
m_3	**t_3**	m_{11}&m_3	N/A	m_{12}&m_3	N/A	m_{13}&m_3	N/A	m_{16}&m_3	**t_{13}**	m_{25}&m_3	N/A
m_4	**t_4**	m_{11}&m_4	N/A	m_{12}&m_4	N/A	m_{13}&m_4	N/A	m_{16}&m_4	N/A	m_{25}&m_4	N/A
m_5	**t_5**	m_{11}&m_5	**t_{10}**	m_{12}&m_5	N/A	m_{13}&m_5	N/A	m_{16}&m_5	N/A	m_{25}&m_5	**t_{15}**
m_6	**t_6**	m_{11}&m_6	N/A	m_{12}&m_6	N/A	m_{13}&m_6	N/A	m_{16}&m_6	N/A	m_{25}&m_6	N/A
m_7	*Ibid.* t_1	m_{11}&m_7	N/A	m_{12}&m_7	N/A	m_{13}&m_7	N/A	m_{16}&m_7	N/A	m_{25}&m_7	*Ibid.* t_{15}
m_8	*Ibid.* t_4	m_{11}&m_8	N/A	m_{12}&m_8	N/A	m_{13}&m_8	N/A	m_{16}&m_8	N/A	m_{25}&m_8	N/A
m_9(1)	**t_7**	m_{11}&m_9(1)	N/A	m_{12}&m_9(1)	**t_{11}**	m_{13}&m_9(1)	**t_{12}**	m_{16}&m_9(1)	N/A	m_{25}&m_9(1)	N/A
m_9(2)	**t_8**	m_{11}&m_9(2)	N/A	m_{12}&m_9(2)	N/A	m_{13}&m_9(2)	N/A	m_{16}&m_9(2)	N/A	m_{25}&m_9(2)	N/A
m_{10}	*Ibid.* t_2	m_{11}&m_{10}	N/A	m_{12}&m_{10}	N/A	m_{13}&m_{10}	N/A	m_{16}&m_{10}	N/A	m_{25}&m_{10}	N/A
m_{15}	*Ibid.* t_2										
Model	**Type**	**Model**	**Type**	**Model**	**Type**	**Model**	**Type**	**Model**	**Type**	**Model**	**Type**
m_{18}&t_1	**t_{16}**	m_{18}&t_{10}	**t_{22}**	m_{19}&t_4	**t_{25}**	m_{19}&t_{13}	N/A	m_{24}&t_7	N/A	m_{20}	**t_{37}**
m_{18}&t_2	N/A	m_{18}&t_{11}	N/A	m_{19}&t_5	**t_{26}**	m_{19}&t_{14}	N/A	m_{24}&t_8	N/A	m_{22}	**t_{38}**
m_{18}&t_3	**t_{17}**	m_{18}&t_{12}	N/A	m_{19}&t_6	**t_{27}**	m_{19}&t_{15}	N/A	m_{24}&t_9	**t_{35}**	m_{23}	**t_{39}**
m_{18}&t_4	**t_{18}**	m_{18}&t_{13}	N/A	m_{19}&t_7	N/A	m_{24}&t_1	**t_{30}**	m_{24}&t_{10}	**t_{36}**	m_{25}	**t_{40}**
m_{18}&t_5	**t_{19}**	m_{18}&t_{14}	N/A	m_{19}&t_8	N/A	m_{24}&t_2	N/A	m_{24}&t_{11}	N/A	m_{26}	**t_{41}**
m_{18}&t_6	**t_{20}**	m_{18}&t_{15}	N/A	m_{19}&t_9	**t_{28}**	m_{24}&t_3	**t_{31}**	m_{24}&t_{12}	N/A	m_{27}	**t_{42}**
m_{18}&t_7	N/A	m_{19}&t_1	**t_{23}**	m_{19}&t_{10}	**t_{29}**	m_{24}&t_4	**t_{32}**	m_{24}&t_{13}	N/A	m_{28}	**t_{43}**
m_{18}&t_8	N/A	m_{19}&t_2	N/A	m_{19}&t_{11}	N/A	m_{24}&t_5	**t_{33}**	m_{24}&t_{14}	N/A	m_{29}	**t_{44}**
m_{18}&t_9	**t_{21}**	m_{19}&t_3	**t_{24}**	m_{19}&t_{12}	N/A	m_{24}&t_6	**t_{34}**	m_{24}&t_{15}	N/A	m_{30}	**t_{45}**
										m_{31}	**t_{46}**

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Appendix:

LM models mapped against candidate typological characters using $mech_1$ and $mech_2$ type character states

LM subcomponent		sc_2			sc_3							sc_4			sc_5			sc_6						
LM model	Character state type \ Candidate typological character	cc_{21}	$cc_{21,22}$	cc_{22}	cc_{31}	$cc_{31,32}$	cc_{32}	$cc_{32,33}$	cc_{33}	$cc_{33,34}$	cc_{34}	cc_{41}	$cc_{41,42}$	cc_{42}	cc_{51}	$cc_{51,52}$	cc_{52}	cc_{61}	$cc_{61,62}$	cc_{62}	$cc_{62,63}$	cc_{63}	$cc_{63,64}$	cc_{64}
m_1	$mech_1$	Cus	Ca	Cus	Cus	Ca					D	D	Ca	D	D	Ca	D	D	Ca					Cus
	$mech_2$	Cus	Cus	Cus	Cus	IT					V	V	V	V	V	V	V	V	3PL					Cus
m_2	$mech_1$	Cus	Ca	Cus	Cus	Ca					R	R	Ca	R	R	Ca	R	R	Ca					Cus
	$mech_2$	Cus	Cus	Cus	Cus	IT					V	V	V	V	V	V	V	V	Cus					Cus
m_3	$mech_1$	Cus	Ca	Cus	Cus	Ca					R	R	Ca	R	R	Ca	R	R	Ca					Cus
	$mech_2$	Cus	Cus	Cus	Cus	IT					V	V	V	V	V	V	V	V	V					Cus
m_4	$mech_1$	Cus	Ca	Cus	Cus	Ca					D	D	Ca	D	D	Ca	D	D	Ca					Cus
	$mech_2$	Cus	Cus	Cus	Cus	IT					V	V	V	V	V	V	V	V	V					Cus
m_5	$mech_1$	Cus	Ca	Cus	Cus	Ca					M	M	Ca	M	M	Ca	M	M	Ca					Cus
	$mech_2$	Cus	Cus	Cus	Cus	IT					V	V	V	V	V	V	V	V	3PL					Cus
m_6	$mech_1$	Cus	Ca	Cus	Cus	Ca					M	M	Ca	M	M	Ca	D	D	Ca					Cus
	$mech_2$	Cus	Cus	Cus	Cus	IT					V	V	V	V	V	3PL	V	V	3PL					Cus
m_7	$mech_1$	Cus	Ca	Cus	Cus	Ca					D	D	Ca	D	D	Ca	D	D	Ca					Cus
	$mech_2$	Cus	Cus	Cus	Cus	IT					V	V	V	V	V	V	V	V	3PL					Cus
m_8	$mech_1$	Cus	Ca	Cus	Cus	Ca					D	D	Ca	D	D	Ca	D	D	Ca					Cus
	$mech_2$	Cus	Cus	Cus	Cus	IT					V	V	V	V	V	V	V	V	V					Cus
m_9 (1)	$mech_1$	Cus	Ca	Cus	Cus	Ca					M	M	Ca	M	M	Ca	M	M	Ca	D	Ca	R	Ca	Cus
	$mech_2$	Cus	Cus	Cus	Cus	IT					V	V	V	V	V	V	V	V	V	V	V	V	Cus	Cus
m_9 (2)	$mech_1$	Cus	Ca	Cus	Cus	Ca					D	D	Ca	D	D	Ca	D	D	Ca			R	Ca	Cus
	$mech_2$	Cus	Cus	Cus	Cus	IT					V	V	V	V	V	V	V	V	Cus			V	Cus	Cus
m_{10}	$mech_1$	Cus	Ca	Cus	Cus	Ca					R	R	Ca	R	R	Ca	R	R	Ca					Cus
	$mech_2$	Cus	Cus	Cus	Cus	IT					V	V	V	V	V	V	V	V	Cus					Cus
m_{11}	$mech_1$	Cus	Ca	R	R	Ca																		Cus
	$mech_2$	Cus	Cus	V	V	V																		Cus
m_{12}	$mech_1$	Cus	Ca	R	R	Ca																		Cus
	$mech_2$	Cus	Cus	V	V	V																		Cus
m_{13}	$mech_1$	Cus																	Ca			R	Ca	Cus
	$mech_2$	Cus																	V			V	V	Cus
m_{15}	$mech_1$	Cus	Ca	Cus	Cus	Ca					R	R	Ca	R	R	Ca	R	R	Ca					Cus
	$mech_2$	Cus	Cus	Cus	Cus	IT					V	V	V	V	V	V	V	V	Cus					Cus
m_{16}	$mech_1$	Cus	Ca	Cus	Cus	Ca													Ca	CP	Ca			Cus
	$mech_2$	Cus	Cus	Cus	Cus	IT													V	V	Cus			Cus
m_{17}	$mech_1$	Cus	Ca	Cus	Cus	Ca					D	D	Ca	D	D	Ca	D	D	Ca					Cus
	$mech_2$	Cus	Cus	Cus	Cus	IT					V	V	V	V	V	V	V	V	V					Cus
m_{18}	$mech_1$	Cus																	Ca	CP	Ca			Cus
	$mech_2$	Cus																		3PL	3PL			Cus
m_{19}	$mech_1$	Cus																	Ca	D	Ca	CP	Ca	Cus
	$mech_2$	Cus																		3PL	3PL	3PL	Cus	Cus
m_{20}	$mech_1$	Cus																	Ca	CP	Ca			Cus
	$mech_2$	Cus																		V	Cus			Cus
m_{21}	$mech_1$	Cus																	Ca	CP	Ca			Cus
	$mech_2$	Cus																		3PL	Cus			Cus
m_{22}	$mech_1$	Cus	Ca	Cus	Cus	Ca					D	D	Ca	D	D	Ca	D	D	Ca					Cus
	$mech_2$	Cus	Cus	Cus	Cus	IT					V	V	V	V	V	V	V	V	V					Cus
m_{23}	$mech_1$	Cus	Ca	Cus	Cus	Ca					D	D	Ca	D	D	Ca	D	D	Ca					Cus
	$mech_2$	Cus	Cus	Cus	Cus	IT					V	V	V	V	V	V	V	V	Cus					Cus
m_{24}	$mech_1$	Cus				Ca													Ca	CP	Ca			Cus
	$mech_2$	Cus																		3PL	Cus			Cus
m_{25}	$mech_1$	Cus	Ca	Cus	Cus	Ca					R	R	Ca	R	R	Ca	R	R	Ca					Cus
	$mech_2$	Cus	Cus	Cus	Cus	IT					V	V	V	V	V	V	V	V	V					Cus
m_{26}	$mech_1$	Cus	Ca	Cus	Cus	Ca	R	Ca			D	D	Ca	D	D	Ca	R	R	Ca					Cus
	$mech_2$	Cus	Cus	Cus	Cus	IT	V	V			V	V	V	V	V	V	V	V	Cus					Cus
m_{27}	$mech_1$	Cus	Ca	Cus	Cus	Ca	R_1	Ca	D	Ca	R_2	R_2	Ca	D	D	Ca	R_1	R_1	Ca					Cus
	$mech_2$	Cus	Cus	Cus	Cus	IT	V	V	V	V	V	V	3PL	V	V	V	V	V	Cus					Cus
m_{28}	$mech_1$	Cus	Ca	Cus	Cus	Ca	R	Ca	D	Ca	M	M	Ca	D	D	Ca	R	R	Ca					Cus
	$mech_2$	Cus	Cus	Cus	Cus	IT	V	V	V	V	V	V	V	V	V	V	V	V	Cus					Cus
m_{29}	$mech_1$	Cus	Ca	R	R	Ca					D	D	Ca	D	D	Ca	R	R	Ca					Cus
	$mech_2$	Cus	Cus	V	V	V					V	V	V	V	V	V	V	V	Cus					Cus
m_{30}	$mech_1$	Cus	Ca	R_1	R_1	Ca	D	Ca			R_2	R_2	Ca	D	D	Ca	R	R	Ca					Cus
	$mech_2$	Cus	Cus	V	V	V	V	V			V	V	V	V	V	V	V	V	Cus					Cus
m_{31}	$mech_1$	Cus	Ca	R	R	Ca	D	Ca			M	M	Ca	D	D	Ca	R	R	Ca					Cus
	$mech_2$	Cus	Cus	V	V	V	V	V			V	V	V	V	V	V	V	V	Cus					Cus

LAST-MILE LOGISTICS STRUCTURES: A LITERATURE REVIEW AND DESIGN GUIDELINE

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ABSTRACT
An initial survey into the articles on last-mile logistics (LML) structures revealed that, despite the significant LML innovations and experimentations, the extant knowledge on LML structures and the associated design variables has been limited. LML-related literature in the areas of operations management and supply chain within a time span of 15 years since 2000 to 2014 has been reviewed to gather previously researched LML structures and the design variables. A total of 67 articles and 13 conference papers were reviewed based on the adopted research protocol. The extant literature on LML structures was classified into *push-centric*, *pull-centric* and *hybrid* system based on the level of vendor and customer effort, while the design variables were classified as *merchant-oriented*, *merchandise-oriented*, and *customer-oriented*. Further, an application matrix linking the variables and the structures was described and a design guideline proposed. Finally, this paper sheds light on future research opportunities in LML structures.

1. INTRODUCTION
The recent decade has witnessed the dramatic growth of internet-based transactions, which can be illustrated, for example, by the soaring online sales in the UK (Verdict Research, 2008). Relating to this, Last-Mile Logistics (hereafter LML) systems have undergone changes concerning innovative models supporting emerging market dynamics. The emergence of innovative models are also in response to the deterioration of ecological environment of which LML is a key contributor (Knörr, 2011), and to the increasingly urbanised society which poses great challenges to LML service providers (Quak and Dekoster, 2007).

An initial survey into the writings in this field revealed that, despite the significant LML innovations and experimentations, the extant knowledge on LML structures and the associated design variables has been limited. In addition, they are inconsistent and fragmented, and are therefore detrimental to system design and are confusing for practitioners. To date, there has not been a comprehensive review undertaken to consolidate knowledge on last-mile distribution structures applied in urban cities, let alone to understand their different characteristics.

As a result, this paper seeks to address this gap and to build an updated LML descriptive knowledge encompassing LML structures and the associated design variables, through six steps. Existing LML definitions are first reviewed with their commonalities identified, based upon which a more synthesised definition is proposed. Second, the literature on existing LML structures is reviewed, clustered, and discussed. Third, the literature on the variables generally designed with LML systems is reviewed with reference to the reviewed LML structures. Fourth, the reviewed design variables are systematically applied to the reviewed structures to descriptively generate variances across the LML structures with the design variables via an application matrix. Fifth, the descriptive knowledge generated in the fourth step is converted into prescriptive knowledge and complemented with a proposed design guideline. Finally, the paper is concluded with some future research opportunities identified.

2. LAST-MILE LOGISTICS DEFINITION
Despite limited literature reported in the area of last-mile logistics (LML), the definition for LML has been hitherto loosely defined. While all available definitions converge to a common understanding that LML refers to the last part of a delivery process, the definitions lack the academic rigour to accurately define the origin and the destination as boundary conditions in the supply network. Furthermore, the term LML has been defined by some academics to be a general context where the deliveries could be carried out in an urban or non-urban environment. Others provided a more specific context for deliveries in the urban environment.

We reviewed the existing definitions from Esper et al. (2003), Kull et al. (2007), Gevaers et al. (2009), Ehmke and Mattfeld (2012), Fernie and Sparks (2009), Roel et al. (2011), Lindner (2011), Wohlrab et al. (2012), and Dablanc et al. (2013) and attempted to define a more rigourous working definition for LML to capture the whole cycle of last-mile delivery. Based upon the synthesised analysis, we propose the following working definition:

Last-mile logistics is the last stretch of a business-to-consumer (B2C) parcel. It takes place from the order penetration point (i.e., fulfillment centre) to the final consignee's preferred destination point (e.g., home or cluster/collection point), for reception of goods.

3. METHODOLOGY

The focus of this paper is in the LML context. The LML-related literature in the areas of operations management and supply chain within a time span of 15 years since 2000 to 2014 has been reviewed to gather previously researched LML structures and their design variables. The adopted review approach is illustrated in Fig 1. The grounded theory approach (Glasser and Strauss, 1967) was then used to code and classify emerging repeated concepts and terminologies. The coding was carried out manually by a single coder and the distinguishing terms and concepts were documented in a codebook which was subsequently used to categorise the structures. Consequently, three categories of last-mile distribution structures namely, *push-centric*; *pull-centric;* and *hybrid*, and three categories of associate variables critical to describing LML systems viz. *merchant-oriented*; *merchandise-oriented*; and *customer-oriented* emerged.

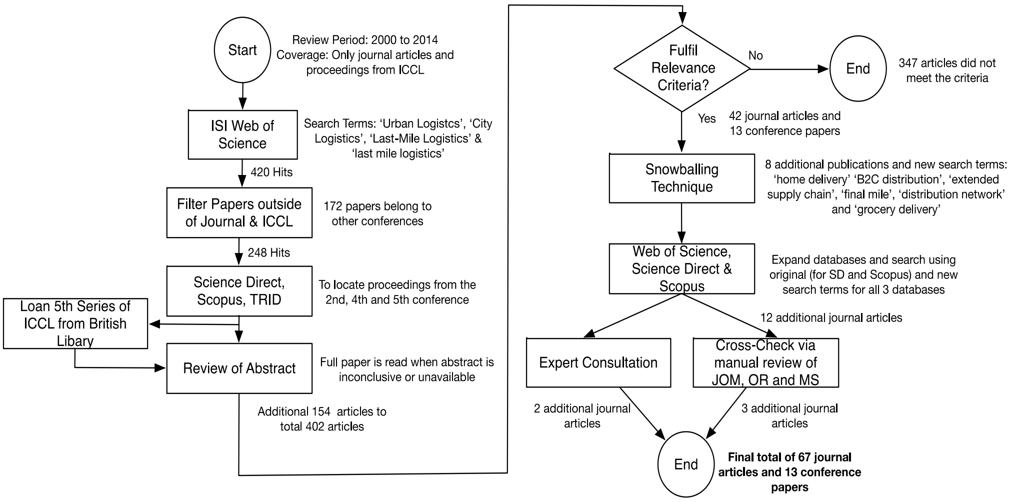

Fig 1: Review Approach

4. REVIEW OF PREVIOUS RESEARCH ON LML

The results are consolidated in Table 1 based on the classification scheme discussed.

Table 1: Summary of Reference

Level 1 Classification	Level 2 Classification	Level 3 Classification	References
Distribution Channel	Push-Centric System	Manufacturer-Based Pick (Manufacturer Storage)	Bucklin (1966), Chopra (2003), (Netessine and Rudi, 2006), (Randall et al., 2006), Rabinovich et al. (2008), Agatz et al. (2008), Dumrongsiri et al. (2008), van Loon et al. (2014)
		Distribution Centre (DC)-Based Pick (Distributor Storage)	Kämäräinen et al. (2001), Punakivi and Saranen (2001), Kämäräinen and Punakivi (2002), Hesse (2002), De Koster (2002), Chopra (2003), Koster (2003), Boyer and Hult (2005), Campbell and Savelsbergh (2005), (Campbell and Savelsbergh, 2006), Boyer et al. (2009), Crainic et al. (2009), Ehmke and Mattfeld (2012), Wanke (2012), Minguela-Rata and Leeuw (2013), Kuhn and Sternbeck (2013), Vanelslander et al. (2013), Wang et al. (2014), Sternbeck and Kuhn (2014)
		Local 'Brick-and-Mortar' (B&M) Store-Based Pick (Retailer Storage)	Yrjola (2001), Kämäräinen and Punakivi (2002), De Koster (2002), Chopra (2003), Koster (2003), Grando and Gosso (2005), Netessine and Rudi (2006), Randall et al. (2006), Agatz et al. (2008), Dumrongsiri et al. (2008), Boyer et al. (2009), Forman et al. (2009), van Loon, Deketele et al. (2014)
	Pull-Centric System	Local B&M Store	Yrjola (2001), Chopra (2003), Sternbeck and Kuhn (2014), van Loon et al. (2014)
		Information Store (Dematerialisation)	Lee and Whang (2001)
	Hybrid System	Collection Delivery Point (CDP) (Attended)	Pyke et al. (2001), Lee and Whang (2001), Kämäräinen et al. (2001), Steinfield et al. (2002), Hesse (2002), Chopra (2003), McKinnon and Tallam (2003), Fusco et al. (2003), Boyer and Hult (2005), Grando and Gosso (2005), (McLeod et al., 2006), Weltevreden (2008), Minguela-Rata and Leeuw (2013), Dablanc et al. (2013), Janjevic and Ndiaye (2014), van Loon et al. (2014), Wang et al. (2014)
		CDP (Unattended)	Småros and Holmström (2000), Punakivi et al. (2001), Kämäräinen et al. (2001), Punakivi and Saranen (2001), Kämäräinen et al. (2001), Punakivi and Tanskanen (2002), Kämäräinen and Punakivi (2002), McKinnon and Tallam (2003), Zanni and Bristow (2010), Quak (2012), Janjevic and Ndiaye (2014), Wang et al. (2014)
Design Variables	Merchant-Oriented		Chopra (2003), Boyer and Hult (2005), Boyer and Hult (2006), Grando and Gosso (2005), Thirumalai and Sinha (2005), Gevaers et al. (2009), Edwards et al. (2010), Aized and Srai (2013), Minguela-Rata and Leeuw (2013)
	Merchandise-Oriented		
	Customer-Oriented		

4.1 Last-mile distribution structures

As discussed in Section 2, a LML system involves linear movement of merchandise from the source of merchandise to customer homes. Technically this linear movement can only have three basic forms (see Fig 2): (1) push - merchandise 'sent' to customer homes by someone other than the customer; (2) pull - merchandise 'fetched' from the source of merchandise by the customer; (3) hybrid - merchandise 'sent' to some intermediate site from which the merchandise is 'fetched' by the customer. The three basic LML forms are briefly discussed from Section 4.1.1 to Section 4.1.3.

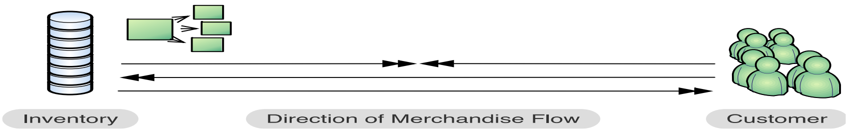

Fig 2: General Movement of Merchandise

4.1.1 Push-Centric System: N-Tier Direct to Home

In general, there exist three sub-types of distribution structures adopting the *push-centric* system concept. There are three possible start (or fulfillment) points namely, manufacturer, distribution centre (DC) or brick-and-mortar (B&M) retail store, where products ordered can be fulfilled (or picked). The trade-offs in decision-making related to distribution channel selection are typically centred on level of inventory, transportation cost and level of responsiveness achievable. The nearer the picking site is from the consumer segment, the more responsive the channel would be but at the expense of lower level of inventory aggregation; translating to higher inventory level and cost (see Fig 3 and 4).

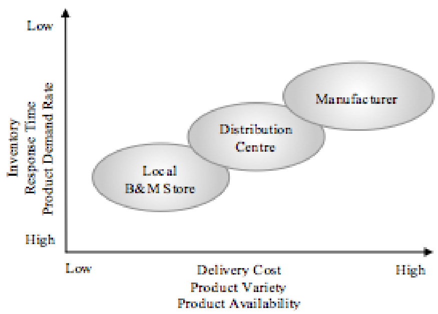

Fig 3: The Push-Centric System Paradigm

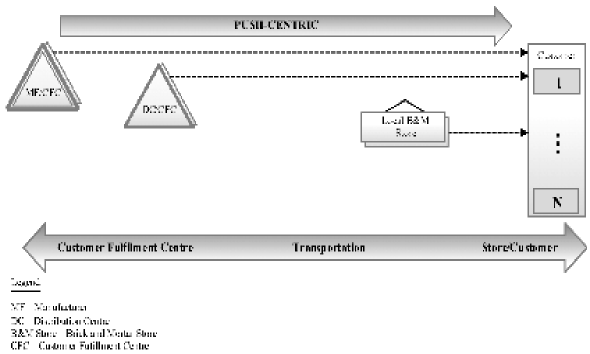

Fig 4: The Push-Centric Distribution Network

4.1.2 Pull-Centric System: Customer Self-Help

The next type of distribution system is known as the *pull-centric* system. In contrary to the *push-centric* system in which retailers are responsible to fulfil the orders and ensure products are 'pushed' or delivered to the customers' doorsteps, customers perform 'self-help' service to make purchase and collect their products from the fulfillment point (order fulfillment) and perform the "last-mile delivery". Characteristics of the *pull-centric* system are generally the same (with the exception of response times since no delivery service is provided) as that of the *push-centric* concept except for the fact that customers now perform the last-mile themselves. Logically, this would come at the expense of customer satisfaction. The study by Kämäräinen et al. (2001) affirms that customer satisfaction is typically lower compared to attended home delivery (AHD) as customer has to travel to and fro the store.

4.1.3 Hybrid-Centric System: N-Tier to Customer Self-Help Location

The *hybrid* system attempts to locate the middle ground and leverage on the attractiveness of both a wholly *push-* or *pull-centric* distribution structure. For instance, it permits the use of more economic transportation such as full truck load (FTL) vehicles for delivery of large quantity of goods to the DC, DC sorts the orders, and have the goods delivered using smaller vehicles to the designated shared RB for customers to collect. Several collection delivery point (CDP) types have been studied in the literature. Among the unattended CDPs are: independent (or unmanned) RB installed at customer's premise; 2) delivery box (DB) equipped with a docking mechanism which would be retrieved after the good has been accepted by customer; and 3) shared RB installed at a location and shared by multiple users. In terms of attended CDP, there are two types: 1) located at firm's own B&M store; and 2) located at a partner's B&M store which are manned. The decision on which types to use is mainly dependent on the market density, operational efficiency as well as order quantity as illustrated in Fig 5 and 6.

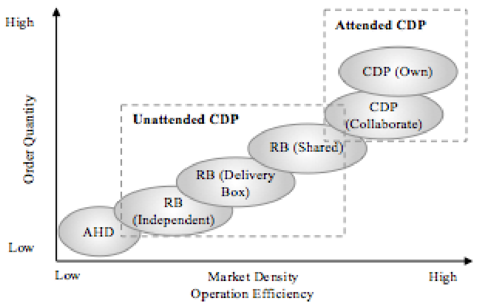

Fig 5: The Hybrid Paradigm

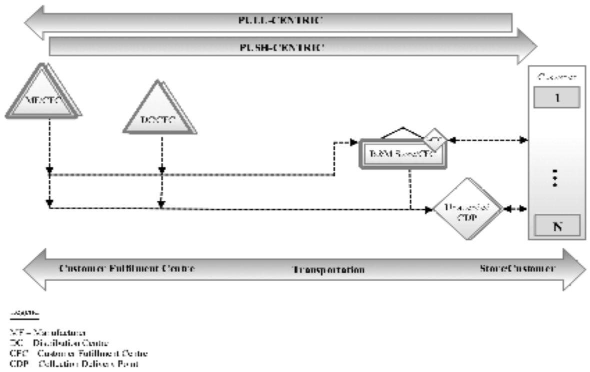

Fig 6: The Hybrid Distribution Structure

4.2 Critical design variables associated with LML systems

The literature survey also revealed that there is a set of design variables associated with LML systems, and that different permutations of these variables correspond to different LML structures. An initial grouping of the design variables suggests that they are in relation to either merchant-oriented (e.g., response time), customer/market-oriented (e.g., market density), or merchandise-oriented (e.g., freshness). Accordingly, these variables are introduced in these three groups, and would be discussed in detail with their connections to the different LML structures.

4.2.1 Merchant-oriented design variables

4.2.1.1 Order visibility

Order visibility is the easiest to provide if a LML model can be simplified as merely two connected nodes, with the one being a node of merchandise source, and the other being a node of merchandise destination. For instance, the LML model featured with distributor source and third-party logistics (3PL) delivery can be simplified as a 2-node network comprising a distributor (the node of merchandise source) and a customer home (the node merchandise destination), and therefore can provide high order visibility. This is because, in order to provide visibility, one has to integrate the information systems of all the 'nodes' involved in a LML network; a 2-node LML network is the easiest to integrate, and a multiple-node network should provide lower order visibility. In addition, for the LML models featured with customer pickup, high visibility must be strived for, owing to the fact that the pickup process will not be operational unless advance customer notification is properly given.

4.2.1.2 Reliability

3PL delivery is subjected to certain external conditions such as strikes, seasonal mailing bottlenecks, whilst self-delivery is not. As a result, those LML models whose merchandise is delivered by merchants' own fleet can provide higher reliability level than those LML models whose merchandise is delivered by a 3PL.

4.2.1.3 Response time

The companies targeting the customers who value short response time can achieve the goal by reducing unnecessary transportation time and by localising their operations with the merchandise sourced closer to customer homes. As a result, the LML models with their merchandise closely sourced can provide shorter response time than those with their merchandise remotely sourced. In addition, if a LML system is considered as a network formed by 'nodes' and 'ties', respectively representing the steps of 'processing' and 'transporting', the more 'nodes' there are in a LML network, the longer the response time is likely to be, since movement discontinues at the nodes when processing takes place. In the "in-transit merge" model, merchandise coming from different manufacturers is temporarily held at distribution centre for final assembly. This arrangement will lead to longer response time in comparison with, for example, that of the "drop shipping" model whose merchandise is delivered directly from manufacturers to customers.

4.2.1.4 Returnability

The point from which merchandise is sourced should be the one at which the merchandise is to be processed for return. Relating to this, if a merchandise sourcing point is far from its customer, the returned merchandise will be transported for long distance to be processed; the return operation thus becomes expensive and high returnability becomes difficult to provide. As mentioned in the previous section from a customer's point of view, a manufacturer is usually further away than a distributor, and a distributor is usually further away than a retailer. Therefore the returnability provided by a LML model with the merchandise sourced from a manufacturer should be lower than that provided by a LML model with merchandise sourced from a distributor. By extension, the returnability provided by a LML model with the merchandise sourced from a distributor should be lower than that provided by LML models with merchandise sourced from a retailer. In addition, a LML model with its merchandise delivered by the merchant's own fleet can provide higher returnability than one that is outsourced, in that the customers can return unsatisfactory merchandise directly to the fleet making deliveries. Likewise, a LML model with an element of customer pick up can provide higher returnability than one without, as the returns can potentially be handled at the pickup sites, which are usually located in proximity from customer homes.

4.2.2 Merchandise-oriented design variables

4.2.2.1 Variety and availability

In general, a manufacturer holds inventory of greater variety and quantity than a distributor does, since the former occupies a more central position in the LML network and is responsible for a wider range of customers; so does a distributor when compared with a retailer. Therefore, a manufacturer, a distributor and a retailer provide merchandise variety and availability in a descending order. Moreover, the LML models featured with 3PL delivery can provide greater variety than others, given the fact that a 3PL is a specialist carrier and is highly equipped to carry more different kinds of merchandise.

4.2.2.2 Margin

The LML models with central merchandise sourcing point, such as ''in-transit merge'' model and ''drop shipping'' model, are appropriate for merchandise of high value. This is because, the benefits from inventory aggregation are high, and the customers are willing to tolerate longer response time (Boyer and Hult, 2005). By comparison, those LML models with local merchandise sourcing point are compatible with merchandise that can generate higher revenue and offset the lower aggregation benefits. Such merchandise can either be of high margin and low demand volume, or of low margin and high demand volume. In other words, these LML models can accommodate the merchandise of both high and low margin, depending upon the revenue level the merchandise can generate. In addition, in terms of means of delivery, those LML models with a customer pickup element are more suitable for higher margin merchandise due to the extra cost incurred in a pickup facilitation process, e.g., carrying bulky merchandise from warehouse to pickup lane.

4.2.2.3 Freshness

Merchandise freshness level is influenced by the duration from the moment merchandise is fully manufactured to the moment when the merchandise arrives at customer homes. It can be twofold: (1) shipping distance between manufacturer and customer home; and (2) shipping 'directness' as to whether merchandise is shipped to customer home directly, or through one or more 'stops' for additional processing. Obviously, the longer the shipping distance is, or the greater the shipping directness is, the higher the freshness level would be, and vice versa. Firstly, related to (1) shipping distance, those LML models in connection with the manufacturers (regardless of whether the manufacturers are within or beyond the defined LML boundary) that are locally based can provide higher freshness level than those LML models in connection with the manufacturers that are remotely based. Secondly, related to (2) shipping 'directness', those LML models that 'stop' less often *en route*, e.g., ''drop shipping'' model which 'stop' nowhere, can provide higher freshness level than those LML models which 'stop' more often *en route*, e.g., ''in-transit merge'' model which 'stops' at distributor for the purpose of merchandise merging.

4.2.3 Customer/market-oriented design variables

4.2.3.1 Availability of time

Those LML models (i.e., *pull-centric* or *hybrid*) with a customer pickup element are suitable for customers with high availability of time, as extra time must be spent on picking up orders. Whereas LML models with direct delivery (i.e., *push-centric*) are better suited for customers with low availability of time.

4.2.3.2 Customer convenience

Customer convenience is normally excellent for LML models featured with direct delivery (to customer homes), since almost no physical effort is required from the customers. By comparison, LML models featured with customer pickup worsen customer experience, as it is essential for the customers to physically travel to the pickup sites.

4.2.3.3 Demand Volume

High demand merchandise should be sourced locally and closer to customer homes, so as to avoid unnecessary transportation cost and to achieve shorter response time. On the contrary, low demand merchandise should normally be stored centrally, in order to offer large geographical coverage and to gain benefit through aggregation. Exceptionally, it is possible for low demand but high margin merchandise to be sourced locally, since the benefit gained through the high margin may offset the loss incurred through the localised storage structure.

4.2.3.4 Market Density

Market density is closely related to means of delivery, and the key lies in fleet usage efficiency. When market density is high, merchant's own fleet can be efficiently utilised. On the other hand, when market density is low, 3PL can be shared by multiple merchandise types or companies to maintain fleet usage efficiency. Accordingly, Those LML models whose merchandise is directly delivered to customer homes, i.e., by merchant's own fleet, correspond to 'high' market density; whilst those LML models whose merchandise is indirectly delivered to customer homes (i.e., by 3PL) correspond to 'low' market density.

5. DESIGN GUIDELINE

In this section, we develop some descriptive knowledge for the LML structures by generating the variances of the LML structures against the established design variables (see Appendix 1). The variances are generated based upon the general pattern as to the connections between the design variables and the LML structures (see the Section 4). This descriptive knowledge is then converted to prescriptive knowledge (reference), i.e., LML design guideline, to assist with LML design. For example, the descriptive knowledge provides that the demand volume of the ''drop shipping'' structure is low. That is, if one is to design a LML structure suitable for low demand merchandise, the ''drop shipping'' structure may be considered as an option. As an aid to design an appropriate distribution structure, managers should first make a decision as to whether the product will be delivered to the customer location or picked-up from a designated location, and whether the product will flow through an intermediate location or direct to the customer (Chopra, 2003).

Then, LML designers can identify other appropriate LML structures by adopting the following guideline: (1) map the given LML environment against the established design variables; (2) to liken the mapping result with the profiled LML structures detailed in the Appendix 1; and (3) obtain an appropriate distribution structure by equating it with the LML structure maximally resembling the mapping result.

6. FUTURE RESEARCH OPPORTUNITIES

Four future research opportunities are identified from this research. First, the development of a comprehensive set of fundamental LML building blocks is necessary to permit the prediction of all the permutation possibilities for distribution structures. Further understanding on how to achieve product-channel-consumer alignment while maintaining distribution economics is essential given the rapidly expansion of product types and changing consumer behaviours. Second, the review of the design variables with LML systems suggests the existence of correlations between some LML structural variables and the reviewed variables. For example, the variable of ''demand volume'' has been said to influence the ''source of merchandise'', which is in connection with LML structure. However, such a list of structural variables has yet to be systematically developed and empirically tested. Third, this paper has only synthesised the prior work on LML 'chains'. However, LML 'networks', where multiple 'chains' are intertwined, are more widely practiced in the industry. The LML system with a 3PL shared by multiple companies is a case in point. The theoretical development for LML networks is of vital importance as they are more reflected in the current industrial practice. Lastly, individual 'nodes' in a LML system can be multi-functional in practice as opposed to uni-functional as discussed in the literature. For instance, a LML node can simultaneously be a 'manufacturer' and a 'distributor'. The multi-functionality of LML node introduces more structural variance, which also need to be theoretically addressed.

7. CONCLUSION

This paper has conducted a comprehensive literature review on LML definitions, structures and the associated design variables, based upon which a more synthesised LML definition is proposed, and the variances of LML structures against the LML design variables mapped. From the perspective of theoretical contribution, the literature analysis has identified three system dynamics viz. *push-centric*, *pull-centric* and *hybrid* system based on the level of vendor and customer effort, and three clusters of design variables namely, *merchant-oriented*, *merchandise-oriented*, and *customer-oriented*. A LML design guideline is then proposed following the review, culminating with four future research opportunities. An extension of this review can include return channel as well as consolidation schemes relevant in the LML context.

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Appendix 1: Application Matrix

System	Type	Merchant-Oriented				Merchandise-Oriented			Customer-Oriented			
		Order Visibility	**Reliability**	**Response Time**	**Returnability**	**Variety & Availability**	**Margin**	**Freshness**	**Availability of Time**	**Customer Experience**	**Demand Volume**	**Market Density**
Push-centric	Manufacturer-Based + Own Fleet	High	High	Long	High	High	High	High	Low	Low	High	High
	Manufacturer-Based + 3PL	Low	Low	Long	Low	High	High	Low	Low	Low	High	Low
	Manufacturer-Based + Own Fleet + In-Transit Merge	High	High	Long	High	High	High	High	Low	Low	High	High
	DC-Based + Own Fleet	High	High	Medium	High	Medium	Medium	High	Low	Low	Medium	High
	DC-Based + 3PL	Low	Low	Medium	Low	Medium	Medium	Low	Low	Low	Medium	Low
	Local B&M Store-Based + Own Fleet	High	High	High	High	High	High	High	Low	Low	High	High
	Local B&M Store-Based + 3PL	Low	Low	Short	Low	Low	Low	Low	Low	Low	Low	Low
Pull-Centric	Local B&M Store	High	High	Short	High	Low	Low	High	High	High	Low	-
	Information Store	High	High	High	High	High	High	High	High	High	High	-
Hybrid	Manufacturer-Based + Cross-Dock + CDP (Attended-Own)	Low	-	Long	Low	High	High	Low	High	High	High	-
	DC-Based + CDP (Attended-Own)	High	-	Medium	High	Medium	Medium	High	High	High	Medium	-
	Local B&M Store-Based + CDP (Attended-Own)	High	-	High	High	High	High	High	High	High	High	-

A SIMULATION MODEL FOR TRANSPORT SOURCING IN SUPPLY CHAIN

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ABSTRACT
Purpose of this paper:
Transport is among the most outsourced logistics activities, and cost reduction is considered as the one of the most cited reasons for outsourcing. However, in developed distribution network, there should be some circumstances where own-account transport can reach the economy of scale and so be cheaper than external carriers. In this paper, we examined the impact of temporal demand characteristics on transport sourcing decision. Consequently, we also looked for the economic rationale for total transport outsourcing, because the costs are the most cited reason for outsourcing. The research objective was to develop a tool for an optimal, or almost optimal transport fleet sizing and sourcing according to the temporal characteristics of transport demand throughout supply chain.

Design/methodology/approach:
We developed a relatively simple two-echelon hierarchical simulation model based on a real case, by using the academic version of the object-oriented software GoldSimPro, its tool Optimizer, and MS Office Excel for systematization of input and output variables into the spread sheets and graphics. We considered a system with three available transport "sources": own-account fleet, contract carrier and transport market.

Findings:
The main model outputs are an optimal fleet size and demand assignment to the different transport sources in the planning horizon. The numerical experiment shows that, in relatively developed market, a combination of multiple transport sources - a customized solution - gives better results than use of any of available single transport sources. Requested utilization of own-account fleet, transport contract details with carrier and demand characteristics have a significant impact on share of vehicles from particular sources.

Value:
The main conclusion of the research is that it is better to use a flexible, customized multi-source approach, than "either-or" approach and widespread total transport capacities outsourcing ("one size fits all") decision.

Research limitations/implications (if applicable):

Simulation model development requires balance between time consumption for model development and accuracy of the results. The model is developed according to the real historical data of an oil company. Further development and improvement of model could go toward its wider applicability and removing constraints and, consequently, increasing its practical value and utility. Supply chain strategy and transport market characteristics have a strong impact on transport demands characteristics, available options and selected criteria for transport outsourcing.

Practical implications (if applicable):
The "either-or" sourcing solution is usually a simplification of the problem. Optimal or satisfactory solutions are usually related with a customized transport sourcing mix. A company should incorporate the permanent process of planning and decision-making on transport fleet sizing and sourcing on a strategic level of management.

1. INTRODUCTION

Outsourcing means using external resources to perform operation which could be, or have been performed once in-house (Lynch, 2000). Logistics, as a service, is usually outsourced in non-logistics enterprises, and transport resources and operations are the first and most outsourced in logistics in all stages of logistics outsourcing trend and on all continents (Langley et al., 2014).

It might be the reason why a majority of papers on transport outsourcing decision-making is focused on the last step, related with carrier selection and operational level of management. However, nowadays some authors conceptually support the idea that outsourcing in logistics should not be treated as "all or nothing" kind of decision and that mixed solutions may often give the best results (e.g. Wilding & Juriado, 2004). Following this research stream, we put the attention on the earlier steps of transport outsourcing decision-making from the explanatory perspective. Thus, the paper focus is on strategic level of outsourcing decision-making. The research objective was to develop a tool for an optimal transport fleet sizing and sourcing according to the temporal characteristics of transport demand throughout supply chain.

In the literature, cost reduction is among the most cited reasons for outsourcing. However, in developed distribution network, there should be some circumstances where own-account transport can reach the economy of scale and so be cheaper than external carriers. Thus, our starting hypothesis is that own-account fleet should at least take a share in an optimal transport fleet, despite widespread reported tradition in the practice. Consequently, we also considered the economic rationale for total transport outsourcing. For that purpose, we developed a simulation model according to supply chain characteristics in an oil company. A system with three available transport "sources" is analysed, which consists of own-account fleet, contract carrier and transport market.

2. BACKGROUND/LITERATURE REVIEW

The literature body on "make or buy" decision-making normative models, methods, and procedures in transport planning is scarce. Instead, the research is rather focused on carrier selection techniques, whereby it is supposed that outsourcing transport capacities is the most suitable solution (Stojanović et al., 2011). The choice between own-account and hired vehicles traditionally belong to the "make or buy" decision-making, while the transaction cost economics (TCE) is often used as the theoretical background. Such research rarely include the possibilities for development of long-term contracts, i.e. middle solutions between private and common carriers (Alp *et al*., 2003).

Actually, uniform distribution of transport demands frequency during the planning horizon justifies economic rationale for own-account transport fleet and it is the ideal case for fleet managers. However, such cases practically does not exist in reality. Transport demands in supply chain are random variables with stationary or non-stationary distribution. There are many reasons for demand oscillations. The basic reasons are irregular demand for products by the end users and supply chain dynamics, caused by uncoordinated actions of the individual subjects in chains. In the literature, temporal characteristics of demand in supply chain, including its variability and amplification, are mainly examined in the context of production, inventory management and customer service (Potter, 2005). However, they have also an impact on transport processes and behaviour of elements in the transport subsystem. This aspect has been neglected in the literature. Some authors (Lee et al., 1997; Potter, 2005) argue that amplification may cause decreased fleet utilization, efficiency, vehicle filling and increased transport costs. For all these reasons, transport outsourcing seems to be a rationale solution. Companies most often outsource their transport operations (Langley, 2014), and thus transfer the negative impact of demand uncertainty and oscillations to external carriers. They are not considered as an internal problem of the company anymore and the circle is closed. Thus, it can be partly explained why the researchers and practitioners have generally focused on the problem of carriers selection in recent years.

The advantages of combined solution may be reached through the economy of scale of own-account fleet and the use of external carrier services in particular cases, e.g. at peak periods, or for particular parts of network and distances (Chopra and Meindl, 2004). Further, the problem of dual or even triple sourcing, which includes own-account transport is also rarely considered (Stojanović and Nikolić-Đorić, 2014). Experts are mostly focused on dual suppliers/vendors inventory problem, although some authors deal with the problem of transport tasks assignment between common and private carriage systems (e.g. Hall & Racer, 1995, Bienstock & Mentzer, 1999).

3. METHODOLOGY

We developed a relatively simple two-echelon hierarchical simulation model based on a real case, by using the academic version of the object-oriented software GoldSimPro and its tool Optimizer, as well the MS Office Excel for systematization of input and output variables into the spread sheets and graphics. It is a dynamic model, where the attributes of system are changed during the time, depending on input, output and state of the system. Model simulates temporal characteristics of daily demand, including demand variability and amplification in supply chain. In the broader sense, it belongs to the group of generic simulation models for inventory and transport management. In the narrower sense, it belongs to the control systems for inventory, order and transport resource management (Disney & Towill, 2005). Actually, it is the combination of inventory management models and the real data of an oil company, which has performed the business mostly in the north Serbian province of Vojvodina. In the observed period, the company has developed own-account fleet, capable to meet most of transport demand. The model was developed based on the five years historical database and then tested (by using the checking data) in another period.

The purpose of the model is to describe the transport subsystem behaviour in given supply chain. The next step is finding the most suitable solution for transport tasks assignment on available transport sources by the tool Optimizer. Daily consumption is a basic model input. Optimal distribution of transport orders between three sources – own-account fleet, contract carrier and external carriers on transport market is a primary output.

3.1. Basic conditions and constraints in the model

We adopted some additional specific conditions and constraints in simulation, as follows:

1. The number of daily demands $z^d(t)$ is a sequence of independent and identically distributed random variables with normal distribution $N(\mu, \sigma)$;
2. Transport demands have to be satisfied on the same day as they arrive;

3. The vehicles from the real case are classified into the classes, so a homogenous fleet, average transport distance, and shipment size are used in the calculation. Here is presented only the calculation for the vehicle class with an average load of 22.7 tons;
4. Unit transport costs of own-account fleet should be less than contract carrier's unit costs, while both have to be less than unit transport costs on market. All carriers on transport market use the same average freight rate for given (average) transport distance.
5. The number of own-account and contract carrier's vehicles (respectively N_{own} and N_{cc}) is limited, but the number of vehicles available on transport market (N_{tm}), and, consequently, the total number of vehicles (N_{total}) is unlimited.
6. In operative (daily) planning period, priorities in task scheduling have first own-account fleet, and then contract carriers. If transport needs exceed both of their capacities, than carriers from transport market will be engaged;
7. In-house trucks have to achieve at least a margin of profitability in the planning horizon and high fleet utilization. Contract carrier has to achieve a minimum of agreed fleet utilization to offer the discount unit price of transport service in the planning period. Therefore, the agreed utilization is incorporated into the optimization constraints.

3.2 The model structure

The model consists of the four subsystems: Ordering and inventory management, Transport ordering, Transport, and Reports. Inventory management subsystem is developed on IOBPCS (*Inventory and Order Based Production Control System*) models basis. Temporal nature of daily demands is described by using techniques such as time series decomposition and exponential smoothing α_a. Transport ordering subsystem is a collector of orders generated in both sales and procurement, and it transforms all transport demands in supply chain into orders. In a real system, it is a dispatching centre. Transport subsystem describes behaviour of used fleet from available transport sources. Generated techno-economic transport indicators are systematized and presented in the form of reports in the fourth subsystem.

Three variants of basic model were developed as combinations of temporal characteristics of transport demands and limitations related to the contract carrier tariff model, as follows:

- Variant V1 – stationary demand model and single-stage tariff model for contract carrier
- Variant V2 - stationary demand model and two-stages tariff model for contract carrier
- Variant V3 – seasonal model and two-stages tariff model of contract carrier.

For all three variants common constraints are listed in the part 3.1. Constraints are related with available number of vehicles per sources, as well N_{own} and N_{cc} fleet utilization. Latter assumes variations in carrier contract clauses related with his freight rate and fleet utilization. V1 includes constraints for minimum fleet utilization of N_{own} and N_{cc} (α_{own} and α_{cc} respectively). V2 assumes more sophisticated hired carrier contract. Carrier's fleet utilization is not limited, but if the dedicated fleet is less utilized than it is determined by contract, oil company pays penalty, that is higher service price than in case of good fleet utilization. More precisely, it is assumed that if carrier's fleet utilization is less than 50%, his price is 85% of market price. Otherwise, it is 70% of market service price, like in case V1. Thus, both sides take opportunities and responsibility for planning and assignment transport capacities in given planning horizon. The own-account fleet utilization is a constraint only in V1 (0,8). The carrier's price is lower than transport market price, while his capacities are constrained as well as the own-account ones. Stationary demand model (applied in V1 and V2) is more common in theoretical models, while the combined trend-seasonal demand time series, used in V3, is more suitable for analysis of real systems (Disney & Towill, 2005). To summarize, V1 and V2 have common time series demand model, while V2 and V3 have common constraints regarding the conditions of usage of available sources. We also varied selected parameters at intervals σ[50; 200; 50] and exponential smoothing α_a[0.1; 0.3; 0.02] for each variant, to determine the impact of temporal characteristics of transport demand throughout supply chain on the optimal number of vehicles on a whole and per sources.

3.3 Fleet sizing and sourcing

The tool *GoldsimPro Optimizer* calculated the optimal number of selected vehicles from each source, according to constraints given in Tab. 1. Actually, it uses the heuristic "complex" method for maximization or minimization the objective function, based on Box's "complex" method, and so provide the solutions near the optimum (GoldSim, 2007: *User's Guide*, p. 365). By varying input parameters σ and α_a, as described earlier, we have got 44 combinations of input parameters values per each variant. For each combination, 100 repeats have been realized to obtain Monte Carlo probability distribution of output variables, which gave 4400 repeats per variant or 13200 repeats in total. Application of Monte Carlo method in addition to the mean value provides output results with probability higher than 95%. Several iterations with different initial values of daily engaged own-account vehicles, contract carriers' vehicles and vehicles from transport market (respectively N^d_{own}, N^d_{cc} *i* N^d_{tm}) resulted ultimately with almost optimal number of vehicles in planning horizon N_{total} with a maximum precision (Goldsim Guide 2007, 372). Therefore, in the rest of the text, we will use the term "optimal solution" for the obtained results.

The objective cost function *T* for all variants is the same (Eq. 1.), but the constraints are different (Tab. 1.):

$$\min T(T_{own}, T_{cc}, T_{tm}) \tag{1}$$

Subject to:

Constraints in V1	Constraints in V2	Constraints in V3
$N^d_{own}+N^d_{cc}+N^d_{tm}>=N^d max$	$N^d_{own}+N^d_{cc}+N^d_{tm}>=N^d max$	$N^d_{own}+N^d_{cc}+N^d_{tm}>=N^d max$
$t_{own}<t_{cc}$	$t_{own}<=t_{cc}$	$t1_{own}<=t_{cc}$
$\alpha_{tcc}>=0.65$	$N_{own}>= N^d_{own}max$	$N_{own}>= N^d_{own}max$
$\alpha_{town}>=0.8$	*if* $\alpha_{tcc}<=0.5$ *then* $t_{cc}=t_{tm}*0.85$, *else*	*if* $\alpha_{tcc}<=0.5$ *then* $t_{cc}=t_{tm}*0.85$, *else*
$0<=N_{own}<= N_{own}max$	$t_{cc}=t_{tm}*0.7$	$t_{cc}=t_m*0.7$
$0<=N_{cc}<= N_{cc}max$	$0<=N_{own}<= N_{own}\mathbf{max}$	$00<=N_{own}<= N_{own}\mathbf{max}$
	$0<=N_{cc}<= N_{cc}\mathbf{max}$	$0<=N_{cc}<= N_{cc}\mathbf{max}$

Table 1. Constraints for the same objective function *T* and different variants

4. RESULTS

The main model outputs are an optimal fleet size and demand assignment to the different transport sources in the planning horizon. Additionally, reports give all requested annual indicators – e.g. fleet utilization, unit and total costs per transport source, etc. The share of own account, contract carrier and transport market vehicles in the optimal fleet mix depends on input parameters, but in all variants and runs, all three sources made the optimal sourcing mix. Table 2 shows the average fleet size obtained from three sources and their share in optimal fleet to fulfil transport demands. The results are average and extreme values in 44 cases per variant, obtained by varying σ and α_a parameters, as explained. The average values of total annual transport costs per variant are ranked in the last column in Table 2. With the same demand characteristics in supply chain, the average annual costs in V2 are almost 7% less than the ones in V1. Compared with V3, V1 and V2 has 3% and 9% less average annual transport costs, respectively.

Average values	$\mathbf{N_{total}}$	$\mathbf{N_{own}}$	$\mathbf{N_{cc}}$	$\mathbf{N_{tm}}$	**Transport costs ranking***

	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	
V1	52	47	61	16	15	17	1	1	3	35	31	41	2
V2	**53**	**48**	**59**	**23**	**21**	**25**	**20**	**20**	**20**	**9**	**7**	**14**	**1**
V3	81	72	94	28	28	28	30	30	30	23	14	36	3

* Total average transport costs for the Variant *i* are ranked from 1-3, whereby 1 are the least costs and 3 are the highest costs in the column.

Table 2. The average and extreme values of vehicles N for V1, V2 and V3

It can be noticed that the number of vehicles may significantly differ not only between the variants, but also within the same variants in 44 simulated cases. It is additionally highlighted in Table 3.

Average values (vehicles)	N_{total}		N_{own}		N_{cc}		N_{tm}		N_{tm}/N_{total}
	Mean	ΔN_{total}=Max-Min	Mean	ΔN_{own}=Max-Min	Mean	ΔN_{cc}=Max-Min	Mean	ΔN_{tm}=Max-Min	(%)
V1	52	14	16	2	1	2	35	10	65
V2	53	11	23	4	20	0	9	7	17
V3	81	22	28	0	30	0	23	22	28

Table 3. The ranges of N per source and variant

5. DISCUSSION

Three main observations arise from the results. Firstly, research results confirm the initial hypothesis that own-account fleet is justified in certain businesses and industries, if a decision is based on economic principles. The numerical experiment shows that, in relatively developed market, a combination of multiple transport sources - customized solution - gives better results than use of any of available single transport sources. Requested utilization of own-account fleet, transport contract details with carrier and demand characteristics have a significant impact on share of vehicles from particular sources. Secondly, the difference between the variants in costs are up to 10% in average, which on the annual level in big companies may be related with significant savings. In our example, they are related with annual savings of several hundred thousand euros. The savings are even higher in case of extreme solutions, as was recorded in some previous period in the same company (Cakić, 2009). Thirdly, in all three variants, mixed solutions assumed different sourcing mix. According to obtained results, particular available sources cannot be solely favoured in advance. For cost savings, and consequently the profit, sourcing mix is shown to be the best solution. Still, it is the most challenged for transport management.

In V1, it was recorded the biggest share of N_{tm} and the least share of N_{own}. This might be partly related with high requested high utilization of own-account fleet in constraints. The total transport costs are least in V2, where we have the stationary demand model and more complex contract with carrier. The biggest share of N_{own} in N_{total} is also related with V2 (43%). V3 output is the biggest N_{total} in the planning horizon. This could indicate that the best own-account fleet utilization may not be always related with the most cost-effective solution. Some unexpected results indicate the problem complexity and possible room for further research. Further, in the seasonal model (V3), daily oscillations and exponential smoothing do not have impact on N_{own} and N_{cc}, although the maximum of vehicles allowed by the model has not been reached. We feel that further analysis is needed to better explain these outputs for both observations.

As expected, the biggest fleet and the biggest range of N_{total} was found in V3. Obtained optimal solutions show that this significant range of N_{total}, strongly influenced by the seasonal demand variations, was pushed toward transport market in given conditions. V2 outputs the smallest fleet, smallest costs and the least calculated range of N_{total}. That is certainly related with both temporal demand characteristics and fleet constraints.

Common for all variants is that all available transport sources are used. Temporal demand characteristics throughout supply chain can significantly affect the optimal distribution of transport tasks between different sources in a multi-source system. However, the main conclusion is that it is always better to use a flexible, customized multi-source approach, than "either-or" approach and widespread "one size fits all", i.e. total transport capacities outsourcing decision.

Complete outsourcing of transport practically transfers the whole problem of transport efficiency on carriers. This allows almost unlimited transport capacities and demands oscillations; the impact of supply chain dynamics on transport is also not the problem of primary parties in supply chain anymore. Further, it is easier to manage only one transport source, or at least one contract type, instead of more ones. It is a good solution if the company has not enough capabilities and expertize in the field of transport management. However, if the knowledge about transport management is missing, the company would probably have the problem with making appropriate contracts with carriers. This is the one of recognized, so called "paradox of logistics outsourcing" (Stojanović, 2012).

5.1 Simulation model constraints

In the simulation, only one vehicle type with payload capacity of 22.7 t and medium transport distance is considered. Mostly following the real system behaviour, the possibility of unloading at several locations, as well as the possibility of return trips realization are not taken into account. Additional including of return trips in further research is likely to increase the economic justification for own-account fleet and potentially increase a share of N_{own} and N_{cc} in the optimal fleet sourcing mix.

Although we gave our best to find out all the reasons for obtained results, there is always a possibility that some unexpected outputs may be related with the model characteristics. Using the data from other companies and other industries may contribute to reveal possible weaknesses in developed model, if they exist. The model can be relatively easily modified and applied in companies which require additional investments into own-account transport fleet. The developed simulation model assumes that the focal company has one contracting carrier or more contracting carriers which offer transport service under the same conditions. Introduction of more than three transport service sources is also possible in proposed model.

5.2 Implications

Theoretical implications
Obtained results may be inspiring to continue research in several directions. Presented model can be improved in the sense of testing different contract details with the carrier, or to include decision about investment in own-account fleet. It could also include several types of middle-term contracts with more contract carriers. In that sense, varying parameters included in constraints could finely indicate significance of particular constraints related with own-account fleet size and management, as well as the contract clauses.

For more complex decisions, like management responsibility and risk sharing with contract carrier(s), more sophisticated methods and techniques are needed. Further research may also include not only ranges, but also the nature of data set probabilities of N and T. The particular impact of temporal demand indicators, like oscillation, variability or amplification on *N, T* and optimal fleet mix, seems also to be a very promising research topic.

There are still a significant number of very successful companies which own transport fleet, and the presented results provide economic justification of such approach. However, it does not mean that other reasons are less important in driving companies to keep the fleet in-house. Many companies keep in-house services to keep control and service quality and this aspects should be more carefully considered in future research on normative models and procedures about transport fleet sizing and sourcing.

The model is developed according to the real historical data of an oil company. Further development and improvement of model could go toward its wider applicability and, consequently, increasing its practical value and utility. Supply chain strategy and transport market characteristics have a strong impact on transport demands characteristics, available options and selected criteria for transport outsourcing. Further research may include companies from other industries, with different temporal characteristics of demand, e.g. hi-tech industry, food industry, etc.

Practical implications
Supply chains in already developed markets may provide an economic rationale for own-account fleet. In such cases, any "either-or" solution is a simplification of the problem. The set of the most satisfactory solutions, including optimal solution, is related with a customized transport sourcing mix. Different sourcing options may give different cost savings even with similar temporal demand characteristics. Transport sourcing mix, and, consequently, transport costs are mostly related with available capacities/sources and contract clauses with external carriers. The simulation results underpin the idea that all satisfactory options include mixed sourcing. This is not consistent with often highlighted wide spread praxis of outsourcing transport capacities in the literature, which practically indicate to the managers that outsourcing should be the best solution for all enterprises.

It may be concluded that company management which wants to develop cost-effective and efficient transport solution in supply chain, should incorporate the permanent process of planning and decision-making on transport fleet sizing and sourcing related with supply chain management strategies, network characteristics and transport market. This concept is more complex than simple outsourcing, and consequently requires more efforts and expertize at all levels of transport management.

6. CONCLUSION

Results of presented numerical experiment show that standard *make-or-buy* decision making may be considered as outdated, rigid and inadequate approach for transport resource management. The simulated dynamic conditions, which are related with a realistic environment, proved that *make-and-buy* is the most convenient and flexible solution. It is not consistent with wide spread theory and practice which support transport outsourcing for decades. Therefore, it is necessary to develop more sophisticated methods and techniques, to implement them at strategic level of transport planning and to permanently implement them in a company management system. The results reveal that, instead of traditional rigid decision *to outsource or not*, a kind of "soft resourcing" should be implemented in the modern transport sourcing decision-making mechanisms. Although the costs are the most cited reason for outsourcing, experimental research based on the real data showed that combinations of different transport sources represent the best solution in terms of cost-effectiveness and flexibility. Companies should use different transport sources with respect to both dynamic characteristics of supply chain and selected strategies of supply chain management. It is confirmed that outsourcing concept must evolve together with company business in order to be dynamic and flexible (Moschuris, 2007).

Therefore, it is necessary to partly redirect the focus in contemporary literature on transport outsourcing from "how to choose the best carrier on the market", a step backward to the question "how to design transport sourcing procedures and mechanisms".

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Section 6: Maritime and port logistics

TOWARDS GREEN PORT MINDFULNESS: DRIVING FROM INSTITUTIONAL FORCES AND MEDIATION OF TOP MANAGEMENT

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Abstract

Purpose of this paper- The paper attempts to fill the literature gap and the much desired industry needs by researching on green port from the management perspective. Therefore, this study aims to develop an original framework of green port mindfulness to explore the driving forces from institutional environment on green port mindfulness through the mediator top management.

Design/methodology/approach-This study summarizes the concepts of institutional theory and green port management to develop an initial framework to enhance green port mindfulness. Structural equation modeling (SEM) is applied to verify the research framework.

Findings-This study utilizes SEM to explore the influences of three forms of institutional forces (mimetic, coercive, and normative) and top management on green port mindfulness. The empirical results of this study demonstrate that institutional forces have positive effects on green port mindfulness via top management.

Value-This study integrates the institutional theory and top management to develop an initial conceptual model of green port mindfulness to explore its managerial implications and determinants. The analytical framework and results investigated in the paper would be useful references for green port development.

Keywords: Institutional Theory; Top Management; Green Port Mindfulness

1. Introduction

There are an increasing attention on the environmental impact of port operations and development in the past years (Notteboom, 2012). The importance of environmental issues and "Lean and Green" concept has become a cornerstone in the strategy of port administrations, terminal operators and transport service suppliers globally. These new challenges affect enormous corporations in the form of institutional pressures, such as regulatory, market, and social pressures that have driven port corporations toward more environmentally responsible operations (Bansal and Roth, 2000). Nowadays, few organizations don't promote their "Green" and "Sustainable" policies. However turning words into action, especially when it involve a complete re-think of established methods and systems, requires real commitment throughout an organization, realistic planning – and a certain degree of stubbornness!

Bansal and Roth (2000) asserted that corporate environmental response has the potential to improve long-term profitability. Resource-based view scholars think firms.' environmental responses like eco-labeling and green marketing are sources of competitive advantage (Russo and Fouts, 1997; Shrivastava, 1995). Reducing

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your exposure to environmental risk and creating new opportunities for profit are both important in building competitive advantages, and if your competitors are doing these things better, your company is losing ground (Lash and Wellington, 2007).

Institutional pressure (such as media attention and regulation from green building programs) is also an important concept to consider given the strategic changes that firms are undergoing in order to remain competitive. This concept draws upon institutional theory, which posits how organizations become more aligned with the institutional environment over time and come to resemble each other in structure and practice (Starik and Marcus, 2000). Edelman et al. (2001) had emphasized the potentially key role of Top Management in adopting new practices within the institutional perspective, they claimed that managers' perception and modify the meaning of institutional pressures. However, while Edelman et al. (2001) explicitly recognized the functional importance of Top Management, they did not examine whether or how Top Management affects organizational members' perceptions and behavioral intentions. This remains a key gap in the institutional theory. The above gap in the literature drives the research question: how does TM lead to mindfulness of "organizational members" towards the select issue- Green port programs?

2. Literature Review and Hypothesis Development

The foundation of our theoretical framework comprises of two elements: institutional theory and the influence of transformational leadership (see Figure 1). Organizational Researchers have identified a number of sources of institutional pressures that organizations faced. Based on institutional theory (Zucker, 1987), the adoption of new practices by firms is influenced by institutional pressures, which are in turn related to various aspects within the firms. As matter of fact, the pressures that exist within external environments may be a critical factor for driving transformations of the firms and people within them. Since firms in similar environments tend to behave in similar ways, 'institutional change' may be said to occur when the majority of firms in such similar environments try to substitute their existing practices with new ones. Institutionalism suggests that when the key persons (i.e., the Top management) in a firm recognizes and reacts to pressures, rather than proactively seeking opportunities, he/she would initiate 'institutional change'. Along this line of thought, port corporation initiate green port projects can be treated as a sort of institutional change by which port corporation cope with recognized institutional pressures.

2.1 Institutional theory, Top management and Mindfulness

Almost the last three decades, institutional theory (DiMaggio and Powell 1983; Meyer and Rowan 1977) has become a powerful explanation to account for the influence of external institutions on organizational decision making and outcomes (Mizruchi and Fein 1999). We contend that institutional forces have effects on the adoption of new practices and then evolve continuously (Gosain 2004; Swanson and Ramiller 1997). However, external forces, no matter how strong they are, will have no effect on the perceptions and behaviors of organizational members unless affecting the perceptions and behaviors of key person the organization. Therefore, we further argue that external institutional forces affect the perceptions of new practices through the agency of key organizational members (top management). Here the theoretical framework of this study is grounded in the proposition that institutional forces affect organizational members' perception and behavior after being mediated by the top management.

When concerning the influence of external macro-environments on organizational behavior such as adopting and improving environmental performance, institutional theory is especially salient. Institutional theory (Meyer and Rowan, 1977; DiMaggio and Powell, 1983) suggests that there is a need to obtain legitimization from their institutional environment (Scott, 1987). Organizations show their conformity to institutional environments by incorporating environmentally embedded (Granovetter, 1985; Stinchcombe, 1965) and institutionally rationalized rules into their structures (Ibarra and Andrews, 1993). By complying with institutional environments, organizations maximize their legitimacy, stability, and chance of survival (Zucker, 1987). While institutional theory predicts institutional isomorphism, in reality, members inside the organizations may exhibit diverse perceptions and behaviors toward new practices even under a similar institutional environment. Here we apply the human agency perspectives to explain the diversity, and also posit that the top management members are the leading human agency that translates external pressures into managerial decisions such as changing organizational operation processes and establishing policies based on their perceptions and beliefs of institutional forces(Liang et al., 2007). Behavioral theories of organizations are aware of the important role played by the "dominant coalition" (March and Simon, 1958) or top management team in determining organizational activities.

Institutional theory statement how external institutional forces create the homogeneity of organizations within an organizational field. Organizations gain legitimacy and reduce uncertainty through isomorphism, which consists of three mechanisms: coercive, normative, and mimetic mechanisms (Scott, 1995). *Coercive mechanisms* refer to the organizations behaver legitimately to the extent that it conforms to rules and laws (Scott and Davis, 2007). *Normative mechanism* is morally grounded, to which organizations will adhere based on social obligation, appropriateness, and common values (Scott, 1995; Scott and Davis, 2007). *Mimetic* or *imitative mechanism* represents a firm's tendency to adopt the successful elements of other firms' actions in the face of uncertainty.

A common criticism against institutional theory is that it presents a "passive and over socialized" view of how organizations respond to institutional pressures without considering the role of actors and agency (Fligstein, 1991; Friedland and Alford, 1991; Green, 2004). For filling up this gap, and explaining why some organizations shown diverse responses under a similar institutional environment, we apply a human agency perspective and postulate that the top management translates external forces into managerial actions. In this study the new managerial actions is to initiate a new practice "green port projects" based on top management perceptions and beliefs of institutional pressures.

Mitchell (2006) indicated the boundary spanning role of top management team has been identified to significantly affect project performance by integrating external and internal knowledge. In the institutional environment, top managers may benchmark the benefits their initiation of green port projects, thus, this study propose that institutional forces may not directly affect perception and behavior intention of inside members without mediation of intervention of top management. To fully explain the extent of organizational members' perception and behavior intention, we must consider the interaction between institutional forces and top management. For adoption a new practices, top management needs to recognize and assume the responsibility for changing the norms, values, and culture within an organization, and in turn, the new norms, values, and culture engendered by the top management permeate to the individual level in the form of procedures, rules, regulations, and routines, which serve as powerful templates that guide individual behavior (Purvis et al. 2001).

Research suggests that mindfulness is associated with life satisfaction, mental health, well-being, and functioning (Brown & Ryan, 2003; Brown et al. 2007; Chiesa & Serretti 2009; Eberth & Sedlmeier 2012; Reb et al. 2015). Inspired by these researches, organizational scholars have started to investigate the role of mindfulness in organizations (e.g., Dane 2011; Glomb et al. 2011; Malinowski & Lim, 2015). To our knowledge, mindfulness has not been applied in the context of shipping /port industry. Chiesa (2012) recommended that rather than referring to mindfulness in general, researcher could refer to the specific aspect or process of mindfulness that they are focusing on in their research. Therefore, "green port mindfulness" used in this study refer to "a state of conscious awareness in which individuals are implicitly aware of the context and content of green port projects information and knowledge, and the willingness to consider alternatives to response to changes"

2.2 Research Model and Hypotheses

Based on our theoretical proposition that top management mediates the effect of institutional pressures on green port mindfulness, we develop a research model (Figure 1) and propose six hypotheses grounded in the adoption of green port project.

However, these hypotheses do not exclude the possibility that other factors may mediate the impacts of institutional forces, a possibility that will be considered during our model testing and subsequent discussion.

To emphasize the key role of top management, we detail the process by which top managements' perceptions and behaviors to support an organizational initiative, namely, attitude and behavior. Following Ocasio's (1997) attention-based view, the first step, the perception aspects of what top managers pay attention to external institutional pressures, and the second step is how they make responsive actions. We use top management perception (TMP) and leadership behavior (LB) to represent these two steps and treat them as two distinct constructs. TMP refers to an individual's positive or negative evaluative effect about performing a particular behavior, such as adopting the green port project, while LB refers to the behavior and actions performed to facilitate the implementation of green port projects. Srivastava (1983) asserts that organizational strategies, decisions, and behavior are guided by top managers' mental image of a desired future organizational state. Hambrick and Mason (1984) suggest that organizational choices are a reflection of the top management's values and cognitive bases. Thus, the positive attitude of top managers about the green port project result in certain managerial actions intended to facilitate such project. For instance, Chatterjee et al. (2002a) state that "through their perceptions, top management can offer visions and guidelines to organizational members. Based on substantial evidence from the management literature, we propose that

Hypothesis 1: Top management attitude toward green port lead to higher levels of top management participation in the implementation of green port.

Top management publicly communicating the new green port is critical relevant to get legitimacy from the outside. Then employees view internal policies and rules changes relevant to the green port as guidelines. Finally, due to the broad impact of an green port implementation on organizational structure and processes, organizational diktats (rules and sanctions) could either facilitate or hinder the adaptation by employees. As an example, it is recommended that top management pay particular attention to designing new performance evaluation system that align individual incentives to implement green port project (Ba et al. 2001). These mechanisms have a significant effect by providing a vision as to what the green port innovation is supposed to achieve and by encouraging organizational members to adapt a new practice toward specific goals. Therefore,

Hypothesis 2: Higher levels of top management participation in green port implementation lead to a higher extent of employees' mindfulness toward green port

We argue that top management mediates the effect of mimetic pressures on employees' mindfulness toward green port when port authorities acquire from examples that have been developed by other ports. Top management of ports monitor the developments in other ports and take inspiration from the most successful strategies implemented elsewhere. Given the inherent uncertainty environment and with bounded rationality, top management succumb to mimicking the actions of their successful peers or competitors since it shields them against potential loss of face and helps to maintain the legitimacy of their decisions (Acciaro, 2013). Hence, top management exhibits the tendency to imitate the action taken by other structurally equivalent organizations perceived as successful (Teo et al.

2003b). Swanson and Ramiller (2004) suggest that the majority of firms may "borrow" mindfulness from a few successful peers by observing what they are doing and what they have to say about an innovation's benefits. As a rational response to uncertainty, top management tends to develop positive attitude toward an new practice's benefits and then translate their attitude into actions. Hence, we propose that both TMA and TMP are influenced by mimetic forces.

Hypothesis 3a: Higher levels of mimetic pressures lead to positive attitude of top management toward implementation green port project.

Hypothesis 3b: Higher levels of mimetic pressures lead to higher levels of top management participate in implementation green port project.

Coercive pressures have been identified to be significant in the adoption of new systems (Hu et al. 2006; Mezias 1990). Coercive pressures mainly arise from government authorities, key suppliers and customers and industry associations (Teo et al., 2003; Park and Luo 2001). In Taiwan, Taiwan's international port corporation (TIPC) is a government-wholly-owned company, top management are forced to support new practices. Under such circumstances, we infer that there is no need for top management to cultivate a positive attitude toward green port project, and they have no choice but just have to do. Thus, we argue that coercive pressures directly stimulate TMP aimed at initiating green port project without affecting TMA.

Hypothesis 4: Higher levels of coercive pressures lead to higher levels of top management participate in implementation green port project.

The role of normative pressures is the institutional norms shaping by professional affiliations, such as European Sea Ports Organization (ESPO), and American Association of Port Authorities (AAPA) in port sectors. For example, institutional norms regarding eco-port promoted by ESPO are guiding top managers in making decisions to initiate green port project. Although normative pressures usually permeate through the channels of professional affiliations, we believe that the networking of top managers along the port service chain comprising a group of stakeholder is a critical normative influence to drive TIPC to comply. Hence, top managers as the boundary spanners who are inevitably influenced by the institutional norms in port service chain network. We contend that top management is likely to automatically accept institutional norms and take part in implementing the green port projects. Hence,

Hypothesis 5: Higher levels of normative pressures lead to higher levels of top management participate in implementation green port project.

3. Research Design

Based on the postulated hypotheses, the questionnaire is then designed as an instrument of data collection. To insure content validity of the scale used, the questionnaire items were developed from literature reviews and modified to fit the context of the port sector specific when necessary. Three Items for measuring TMA and TMP derived from the Chatterjee et al. (2002), mimetic, coercive, normative pressures were taken from Teo et al. (2003), and used six items to measure the employees' mindfulness toward green port porjects modified from Chen *et al*.(2014).

This study uses questionnaire survey method to verify the hypotheses and focuses on the port sector in Taiwan. In addition, the sample is randomly selected from the TIPC. Respondents are organizational members except top managers.

4. Empirical Results

4.1 Sample characteristics

166 valid questionnaires were used for analysis after screening invalid ones by using reverse questions and identifying illogical answer patterns. Table 1 presents the demographics of the respondents.

Table 1 Sample characteristics

Demographics	Frequency (%)	Demographics	Frequency (%)
Age	~22 (1%) 23~28 (5%) 28~33(17%) 33~40 (16%) 40~49 (46%) Above50 (16%)	Sex	Male (61%) Female (39%)
		Marriage	Unmarried (78%) Single (22%)
		Department	Primary (46%) Supportive. (54%)
Seniority	~2 yrs.(10%) 3~5 yrs.(26%) 6~10 yrs.(6%) 11~14 yrs.(2%) 15~ yrs.(56%)	Monthly Income	~NT35K (12%) NT35~50K (28%) NT50K~100K (46%) NT100K~200K (11%) 200K~ (2%)
Education	Senior High(14%) Undergraduate(41%)		Graduate(40%) Ph.D.(5%)

Source: this study

4.2 Measurement model

Measurement model tests using AMOS 20 software to assess the reliability, convergent validity, and discriminant validity of the latent constructs between three institutional pressures, mimetic, coercive and normative, top managements' attitude and participation and employees' mindfulness toward green port projects. Table 2 listed the results of standardized factor loadings, convergent validity, and internal reliability criteria (Cronbach's alpha). Internal consistency was examined using Cronbach's alpha. The Cronbach's alpha values for all constructs ranged from 0.768 to 0.911, exceeding the acceptable threshold value (0.7) suggested by Nunnally and Bernstein (1994). Composite reliability of every construct used in this study ranged from 0.852 to 0.956, higher than the benchmark value (0.80) recommended by Fornell and Larcker (1981). With respect to the quality of the measurement model, the loadings (λ) of all items of the six constructs reported in Table 2 are significant. The average variance extracted (AVE) for each construct ranged from 0.661 to 0.850, exceeding the standard value (0.5) suggested by Fornell and Larcker (1981). On the basis of the analyses on item reliability, composite reliability and AVE, we concluded that convergent validity was assured.

Table 2 Confirmatory factor analysis results

Latent and Observed Variables	St. loading	CR	AVE	α
Mimetic pressures		0.919	0.792	0.821
Have greatly benefitted	0.784			
Favorably perceived by other ports	0.793			
Favorably perceived by partners	0.890			
Coercive pressures		0.852	0.661	0.768
Pressures from government r	0.637			
Pressures from industry association	0.699			
Pressures from competitive conditions	0.842			
Normative pressures.		0.921	0.796	0.860
Normative expectation from partners	0.842			
Normative expectation from stakeholders	0.876			
Normative expectation from professionals	0.756			
Top management attitude		0.935	0.828	0.902
Green port is a good idea	0.740			
Green port should being supported	0.886			
Green port is a visionary plan	0.921			
Top management participation		0.944	0.850	0.911
Work together with employees	0.916			
Encourage the employees	0.844			
Reward the employees	0.841			
Mindfulness		0.956	0.787	0.926
Feel free to discuss green port issues;	0.887			
Encouraged to express different views	0.902			
Pay attention to what is happening	0.884			
Inclined to report green port info.	0.834			
Rewarded if they share green ideas	0.745			
Know what should be done	0.650			

Goodness-of-fit**:** $\chi 2/df$ =1.932, RMSEA=.075, CFI=.950, GFI=.860, AGFI=.808 NFI=.903, RFI=.879, IFI=951., TLI=.938, Note: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Model fitness was checked by commonly used goodness-of-fit measures, model-fit indices ($\chi 2/df$ =1.932, RMSEA=.074, AGFI=0.808, CFI=.950, NFI=0.903, IFI=951., TLI=.938) meet the recommended levels and only GFI=.860 slightly lower than the recommended value, thus showing that the fitness of the model is acceptable.

4.3 Empirical results of structural model

This study applied structural equation modeling (SEM) to verify the hypotheses and adopted AMOS 20 to obtain the empirical results (Table 3). The hypotheses testing results show that partial hypotheses (H1, H2, and H3a) postulated in our study are supported and the rest are not supported shown in Figure 1. The hypothesized positive relationship between Top management attitude and participation (H1) was supported (β_{21} = .903, $p < .001$). Hypothesis H2, which predicted a positive relationship between top management participation and employees' mindfulness, was supported (β_{32} = .948, $p < .001$). Hypothesis H3a, which predicted mimetic pressures lead to positive attitude of top management, was also supported (γ_{11} = .684, p < .001). As predicted by hypotheses H3b, H4 and H5, mimetic, coercive and normative significantly impacted on top management participation (γ_{21} = -.268, p > .05; γ_{22} = .573 p > .05; γ_{23} = -.22, p > .05) show insignificant results. The predicted relationships, standardized path loadings, and hypotheses test outcomes are provided in Table 3. In addition, since H3a is supported in this study, we find out only mimetic pressures influence the mediator, top management attitude, which in turn influences top management and then final have impacts on the employees' mindfulness toward green port projects. We prove that top management (attitude and participation) mediating the relationships between institutional pressures and employees' mindfulness toward green port projects.

The mediation model in this study is used to clarify the mechanism which underlies specific relationships among institutional pressures and employees' mindfulness toward green port projects via top management, known as mediators. Based on the above research results, we suggest that top management team should pay more attention to their own attitude and participation to inspire their employees, then the project performance will increase automatically.

Table 3 Structural model evaluation indices and hypotheses test outcomes

Hypothesis	Predicted Relationships	Standardized Path Coefficient	Hypothesis Test Outcome
H1: TMA→TMB	+	0.903***	H1 is supported
H2: TMB→GPM	+	0.948***	H2 is supported
H3a :MP→TMA	+	0.684***	H3a is supported
H3b: MP→TMB	+	-0.268	H3b is not supported
H4: CP→ TMB	+	0.573	H4 is not supported
H5: NP→ TMB	+	-0.223	H5 is not supported

Here TMA= Top Management Attitude, TMB= Top Management Behavior, MP= Mimetic Pressures, CP= Coercive Pressures, NP= Normative Pressures, GPM=Green Port Mindfulness, Note: * *p* < 0.05; ** *p* < 0.01; *** *p* < 0.001

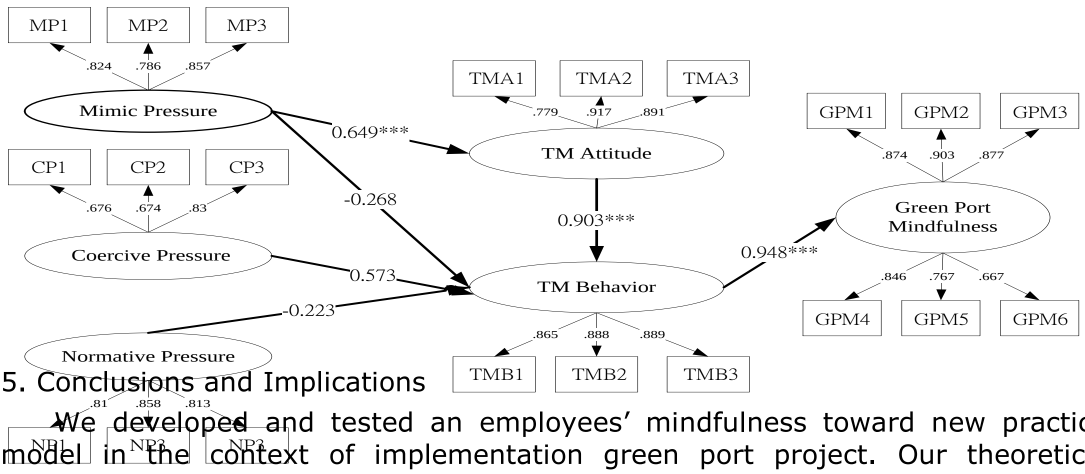

Figure 2. The results of the structural model.
GFI=0.852, RMSEA=0.064; NFI=0.912, CFI=0.963, Note: * p < 0.05, ** p < 0.01, *** p < 0.001

5. Conclusions and Implications

We developed and tested an employees' mindfulness toward new practice model in the context of implementation green port project. Our theoretical framework merges the impacts of top management and institutional pressures to explain the mindfulness of port corporation employees. We attempt to explicate how top management mediates the influence of institutional forces on employees' mindfulness.

Analyses based on 166 samples from Taiwan International Port Corporation partially support the hypothesized relationships in the model. This research contributes to the initiation of new practices which is forced mainly from the institutional pressures within an organization. It confirms that institutional pressures, which have been shown to be important for new practices adoption and implementation, are proven to be mediated by top management also significant in the assimilation stage. It highlights the importance of top management in facilitating employees' mindfulness toward green port project by complying with institutional pressures. Although institutional pressures are accused of giving rise to mindlessness in new practice adoption, this research suggests that such mindlessness might be beneficial to organizations if top management well play the key agency role in guiding and participating in projects implementation process, then it will eventually achieve sustainability. This research results are beneficial for managers, researchers, and practitioners of port sectors and contribute to future research as reference.

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CONTAINERISED EXPORTS FROM JAVA: THE IMPACT OF POLICIES TO REDUCE GHG EMISSIONS

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Abstract

Purpose of this paper:
The purpose of this paper is to analyse the impact of policies to reduce GHG emissions from containerised exports from Java using stated preference data of exporters and freight forwarders.

Design/methodology/approach:
A stated preference (SP) study is used to examine the preferences of exporters and freight forwarders in Java relating to port and inland mode choice. The experimental design generates 8 (eight) alternative combinations of port and inland mode, and 4 (four) of which are presented in each SP choice task. Each alternative presented is described using 2 (two) port attributes (port cost and number of ship calls), and 4 inland mode attributes (inland mode cost, inland mode time, inland mode reliability and GHG emissions). The SP-only and joint SP-RP data are used to estimate the model using Multinomial Logit (MNL), Nested Logit (NL), Mixed Multinomial Logit (MXMNL), and Mixed Nested Logit (MXNL). The best estimation results are used to simulate impacts of a range of potential policies.

Findings:
The best model is MXNL for SP-only data, and MXMNL model is the best model for estimation using joint SP- RP data. The results showing that increases in inland mode cost, inland mode time, inland mode GHG emissions, and port cost all have very significant negative effects on choice utility. On the other hand, inland mode reliability and frequency of ship calls have positive influence on the decision maker when choosing between inland mode and port alternatives.

Simulation results from these two models show that two policies of reducing fuel subsidies for road transport and giving incentives to reduce rail freight rates would provide the most significant encouragement to modal shift from the road mode to the rail mode. However, the largest reduction in GHG emissions can be obtained through policies of reducing fuel subsidies for road transport and placing restrictions on times and routes permitted for the freight road transport operations.

Value:
The main contribution of this research lies in its analysis of the exporters' and freight forwarders' attitudes related to GHG emissions, and the potential affects of policies that may be implemented to reduce GHG emissions. The novelty of this research is in its development of a joint model of inland mode and port choice from the exporters' or freight forwarders' perspective using SP-only and joint SP-RP data collected for this purpose.

INTRODUCTION

Indonesian containerised exports are primarily shipped from three ports in Java, namely Jakarta Port (Tanjung Priok), Semarang Port (Tanjung Emas) and Surabaya Port (Tanjung Perak). These three ports account for almost 70% of total container throughput in Indonesia, with Jakarta Port being the biggest of the three. Issues relating to containerised exports from Java relate not only to the port, but also to the inland transport system for the movement of containers from the origin region to the chosen port. Inland mode choice for transporting the container from the shippers' plant or warehouse should not be separated from the port choice itself. Most shippers and freight forwarders in Java choose truck as their preferred mode for delivery of containerised exports from the origin region to the three ports above.

This situation leads to various environmental impacts including greenhouse emission (GHG) effects (emission of gases such as CH_4, CO_2 and N_2O), acidification, toxic effects on ecosystems, toxic effects on humans, land use, noise and resource consumption (IFEU, 2011). One of the most important impacts, GHG emission, significantly contributes to global warming, almost a quarter of the worldwide CO_2 emissions coming from the transport sector (IEA, 2009). Between 1990 and 2008, CO_2 emissions in Indonesia increased from 140.54 million tonnes to 385.38 million tonnes – an average growth rate of 9.7% per year. Whilst the biggest CO_2 emitter in Indonesia was the manufacturing sector (which uses coal or peat as the main source of energy) with a volume of CO_2 emissions of 131.03 million tonnes and the second largest was the energy sector (with 108.10 million tonnes of CO_2), the transportation sector (75.91 million tonnes of CO_2) was the third largest contributor (IEA, 2010).

According to the Presidential Regulation of Indonesia (PP-RI, 2011) and the report from International Transport Forum (ITF & OECD/ITF, 2010), Indonesia has a commitment to reduce GHG emissions by 26% in 2025 relative to 2010. To reduce GHG emissions from road freight transport, a plan to increase the role of rail in freight transport has been launched by the Indonesian Government. The plan consists of re-opening 2 dry-ports that were closed due to low demand from the shippers, and developing a double-track rail network in Java to enhance passenger and freight transport capacity on the rail transport system.

In order to reduce GHG emissions from container freight transport on Java, shifting of container movement by truck to movement by rail is an appropriate choice due to the lower GHG emissions per ton-km of rail transport compared to road transport (Kruse, Protopapas, Olson, & Bierling, 2009; IFEU, 2011). To encourage shippers and freight forwarding companies to use rail transport, the government of Indonesia needs to implement appropriate policies that will accord with the preferences of shippers and freight forwarders with respect to inland mode choice. Hence the success of the plan for shifting containerised freight from road to rail will depend partly on the behaviour of the shippers and freight forwarder in choosing inland mode and port. This paper investigates how shippers or freight forwarders choose inland modes and ports to move their goods from origin regions to the chosen port of departure. Using a model of inland mode and port choice, this research examines the potential impacts of various policies that can be implemented to reduce GHG emissions during the inland transportation leg used for containerised export movements.

The main contribution of this research lies in its analysis of the shippers' and freight forwarders' attitudes related to GHG emissions, and the potential impacts of policies that may be implemented to reduce GHG emissions. The novelty of this research is in its development of a joint model of inland mode and port choice from the shippers' or freight forwarders' perspective using Stated Preference (SP) data collected for this purpose.

DATA

Due to a lack of data about inland mode and port choice in Java, we decided to conduct a SP survey to collect preference data from exporters and freight forwarders relating to inland mode and port choices. The SP survey method was adopted for this research because it is able to provide data on hypothetical situations and on choices for alternative options (such as new ports) which do not exist at the time of study.

Alternatives

Alongside the 3 (three) existing main container ports in Java, this research also considered 1 proposed port (Cilamaya Port). Hence there are 8 possible alternative combinations of port and inland mode, as follows:
1) Alternative A1: Tanjung Priok Port (Jakarta) – Truck (JKT-ROAD)
2) Alternative A2: Tanjung Priok Port (Jakarta) – Train (JKT-RAIL)
3) Alternative B1: Tanjung Emas Port (Semarang) – Truck (SMG-ROAD)
4) Alternative B2: Tanjung Emas Port (Semarang) – Train (SMG-RAIL)
5) Alternative C1: Tanjung Perak Port (Surabaya) – Truck (SBY-ROAD)
6) Alternative C2: Tanjung Perak Port (Surabaya) – Train (SBY-RAIL)
7) Alternative D1: Cilamaya Port (Cilamaya) – Truck (CMY-ROAD)
8) Alternative D2: Cilamaya Port (Cilamaya) – Train (CMY-RAIL)

Attributes of inland mode and port

To determine the attributes of inland mode and port choice, an investigation of relevant literature was carried out. This suggested that the prominent factors influencing decision making on inland mode and port choice are;
1) *Mode Cost* (Garcia-Menendez et al. 2004; Beuthe & Bouffioux 2008; Ravibabu 2013; De Jong & Ben-Akiva 2007; Windisch et al. 2010; Abdelwahab 1998),
2) *Mode Time* (Garcia-Menendez et al. 2004; Beuthe & Bouffioux 2008; Ravibabu 2013)
3) *Mode Reliability* (Shinghal & Fowkes, 2002; Beuthe & Bouffioux, 2008; Norojono & Young, 2003) and
4) *Mode Frequency* (Shinghal & Fowkes, 2002; Garcia-Menendez et al., 2004; Feo-Valero et al., 2011).
5) *Port Cost* (Tongzon, 2009; Nir et al., 2003)
6) *Frequency of ship calls* (Tongzon, 2009; Nir et al., 2003)

This research uses 5 of the 6 key factors above and also considers GHG emission (Magala & Sammons, 2008) instead of inland mode frequency in order to investigate the preferences of exporters and forwarders with respect to the global warming issue. Table 1 displays the attributes, their units, definitions, and the expected direction of impact.

Table 1: Factors, attributes, units, definitions and the expected signs for this research

Factor	Attributes	Unit	Definition	Expected Sign
Port	Cost	Thousand IDR/TEU[1]	The port cost is represented by the cost of handling of 1 TEU Full Container Load (FCL)	-
	Ship Calls	Ship calls / week	Ship calls is the number of international container ship calls per week from each port, including indirect calls (i.e. with need for transshipment)	+
Inland Mode	Cost	Thousand IDR/TEU-Trip	Inland mode cost to transport 1 TEU container from the origin to the port (including haulage by truck from the shipper location to the consolidation station for alternatives using rail mode).	-
	Time	Hours/trip	The transport time between the mode departure from the origin and arrival at the port, including waiting time if any.	-
	Reliability	Percentage (%)	Percentage of on-time delivery	+
	GHG emissions	(Kg CO_2e / TEU-Trip)	Emissions from the alternative inland modes for a trip from the origin region to port	-

[1] 1 GBP ≅ 20,000 IDR (Indonesian Rupiah)

Respondents and data collection

The potential participants are the decision makers in exporter or freight forwarder companies who select inland mode and port. The survey was carried out in two steps: Pilot Survey and Main Survey. The candidate respondents for the survey were selected from two main sources: (1) The database of exporters in Java was obtained from the Directory of 8000 Indonesian Exporters book[2], (2) the database of freight forwarder companies was derived from the Directory of Indonesian Logistics and Guide book[3].

Respondents were recruited from 16 cities in Java: Jakarta, Bandung, Bekasi, Tangerang, Cirebon, Bogor, Karawang, Semarang, Surakarta, Yogyakarta, Jepara, Surabaya, Malang, Gresik, Sidoarjo and Pasuruan. Respondents were asked to state their preferred choice between the 8 hypothetical situations regarding inland mode and port choice. The respondents were also requested to state their current choice of inland mode and port and characteristics of their exports, in order to provide data that could be used in Revealed Preference (RP) analysis, most particularly to be used in the simulation process.

During the survey (conducted between July 2013 and April 2014), attempts were made to contact 4593 companies via fax, mail and email. Of these, 3340 companies (73%) were successfully contacted. A relatively low response rate of around 7% was obtained. Some 225 companies responded to the pilot and main survey, of which 180 respondents completed the questionnaire adequately. The online survey tool reveals that the average time to answer the questionnaire was 27 minutes with a standard deviation of 21 minutes. Data cleansing led to the exclusion of 17 respondents whose answers suggested data inaccuracies or who had completed the survey in less 10 minutes. As a result, data from 163 respondents was deemed eligible for use in the next steps of the research.

MODEL ESTIMATION AND SIMULATION

Model estimation

The data obtained from the pilot and main surveys has been used to estimate Multinomial Logit (MNL), Mixed Multinomial Logit (MXMNL), Nested Logit (NL) and Mixed Nested Logit (MXNL) models (Ben-Akiva & Lerman, 1985; Train, 2009) for the choice between the 8 port/inland mode alternatives presented in the SP. Bierlaire's *Optimisation Toolbox for General Extreme Value Model Estimation* (BIOGEME) version 2.2 (free software for estimation of various discrete choice models) was used for estimating the parameters of the model (Bierlaire, 2009). In addition to model estimation using the SP-only data, estimation was also undertaken using joint SP and RP data for which results can be expected to accord more closely to the actual observed situation. The MXNL and MXMNL models with the inland mode cost coefficient normally distributed have been chosen as the best models, the criteria for this choice being based on the value of final likelihood, likelihood ratio test, ρ^2, adjusted ρ^2, the sign, and the significance of the estimated parameters. The comparison of estimation results of the best MXNL model from SP-only data and the MXMNL model from the joint SP and RP data is shown in Table 2 below:

2 The Directory of 8000 Indonesian Exporters published by The Indonesian Statistics and Indonesian Exim Bank in 2011.

3 Indonesian Logistics Directory and Guide book was published by the Indonesian Logistics Association (ALI) and PPM Management School

Table 2: Comparison of estimation results for MXNL (from SP data only estimation) and MXMNL (from joint SP and RP data estimation)

Utility Parameters	MXNL			MXMNL		
	Value	Corrected ASC	Robust t-test	Value	Corrected ASC	Robust t-test
ASC A1 (Jakarta - Road)	0			0		
ASC A2 (Jakarta - Rail)	-1.3	-6.35	-5.33***	-2.93	-8.27	-3.75***
ASC B1 (Semarang - Road)	0.69	-7.15	2.14**	0.131	-18.12	0.3
ASC B2 (Semarang - Rail)	-1.99	-11.36	-4.5***	-3.78	-20.72	-3.3***
ASC C1 (Surabaya - Road)	0.01	-2.90	0.03	-0.74	-7.65	-1.39
ASC C2 (Surabaya - Rail)	-0.84	-7.39	-2.65***	-3.29	-14.33	-3.3***
ASC D1 (Cilamaya - Road)	-0.78	-1.67	-3.25***	-1.71	-2.61	-3.32***
ASC D2 (Cilamaya - Rail)	-1.74	-8.88	-3.85***	-3.35	-10.10	-3.66***
B_M_COST				-0.88		-3.73***
B_M_COST_S				0.77		3.1***
B_M_COST_PerShip_More2	-0.41		-6.02***			
B_M_COST_PerShip_Upto2	-0.31		-4.9***			
B_M_COST_S_No_PerShip_Upto2	-0.33		-3.19***			
B_M_GHG_Vol_More10	-1.08		-5.01***	-2.46		-3.31***
B_M_GHG_Vol_Upto10	-0.75		-3.79***	-1.94		-2.99***
B_M_RELI_Exporter	1.99		5.28***	4.48		3.3***
B_M_RELI_Forwarder	4.17		4.09***	10		3.11***
B_M_TIME				-3.07		-3.77***
B_M_TIME_HSCode44_94	-1.08		-3.9***			
B_M_TIME_HSCode_Others	-1.06		-4.74***			
B_P_COST_Freq_More5	-0.88		-4.73***	-1.66		-2.9***
B_P_COST_Freq_Upto5	-0.41		-2.73***	-0.59		-1.71*
B_P_SHIP_Exporter	0.68		2.36**	1.34		2.19**
B_P_SHIP_Forwarder	1.54		2.78***	3.04		2.62***
Nesting parameters						
Cimalaya Port	0.62		3.71***			
Tanjung Priok Port	0.75		4.84***			
Tanjung Perak Port	1					
Tanjung Emas Port	0.52		7.08***			
Scale parameters						
Scale for SP data				1		
Scale for RP data				0.385		-6.39***
Number of estimated parameter			23			19
Number of Observations			1287			1450
Null log-likelihood			-1784.16			-1989.44
Final log-likelihood			-1352.99			-1412.27
Likelihood ratio test			862.34			1154.33
r^2			0.242			0.29
Adjusted r^2			0.229			0.281

Note: * Significant at the 90% level, ** Significant at the 95% level, *** Significant at the 99% level. The values of ASCs in parentheses are the corrected ASCs.

Corrected alternative-specific constants (ASCs) are used to calibrate the simulation results and have been calculated by adjusting the current estimated ASCs by the natural logarithm of the ratio of the real share to the sample share (Louviere et al., 2000), this process being iterated until the simulation results were found to be very close to the actually observed shares. The corrected ACSs are then used in the policy simulation process in the next step, instead of the estimated ASCs.

Policy scenarios for simulation

Five policy scenarios have been simulated using the MXMNL model to examine the impact of each policy on GHG reduction for the inland transportation leg of containerised exports from Java. These policies are:

1) Route and time restrictions for Truck/Road, on an assumption that the truck/road cost will increase by 5% and truck/road time will increase by 10%.
2) Reduced fuel subsidies will increase fuel price by 50%, leading to an increase in the truck/road cost of 25%.
3) Develop double-track rail network between Jakarta and Surabaya will reduce the rail transport time by 20%.
4) The expansion of Tanjung Priok Port will increase its capacity from 6 million TEUs/year to 9 million TEUs/year. It is assumed that this expansion will increase the international container ship calls at Tanjung Priok port by 30%.
5) Provision of subsidy to rail freight transport to reduce the rail tariff by 20%.

The RP data collected in the survey was used in the simulation, and the simulation results are presented in Table 3.

Table 3: Simulation results for all policy scenarios using RP data

Alternatives	MXNL - SP Data only						MXMNL - Joint RP and SP Data					
	BAU*	Policy 1	Policy 2	Policy 3	Policy 4	Policy 5	BAU	Policy 1	Policy 2	Policy 3	Policy 4	Policy 5
JKT-ROAD	54.30	53.04$^{\downarrow}$	*52.95*$^{\downarrow}$	54.16$^{\downarrow}$	**56.36**$^{\uparrow}$	54.13$^{\downarrow}$	54.14	*51.82*$^{\downarrow}$	52.31$^{\downarrow}$	53.28$^{\downarrow}$	**56.72**$^{\uparrow}$	53.82$^{\downarrow}$
JKT-RAIL	2.07	2.29$^{\uparrow}$	2.37$^{\uparrow}$	2.36$^{\uparrow}$	*2.22*$^{\uparrow}$	**2.46**$^{\uparrow}$	2.07	3.68$^{\uparrow}$	3.31$^{\uparrow}$	**4.00**$^{\uparrow}$	*2.48*$^{\uparrow}$	3.76$^{\uparrow}$
SMG-ROAD	4.00	4.71$^{\uparrow}$	**5.08**$^{\uparrow}$	3.94$^{\downarrow}$	*3.83*$^{\downarrow}$	3.85$^{\downarrow}$	4.01	4.71$^{\uparrow}$	**4.89**$^{\uparrow}$	3.81$^{\downarrow}$	3.89$^{\downarrow}$	*3.37*$^{\downarrow}$
SMG-RAIL	0.15	0.19$^{\uparrow}$	**0.24**$^{\uparrow}$	0.16$^{\uparrow}$	*0.14*$^{\downarrow}$	0.18$^{\uparrow}$	0.15	0.28$^{\uparrow}$	**0.55**$^{\uparrow}$	0.18$^{\uparrow}$	*0.15*$^{\#}$	0.29$^{\uparrow}$
SBY-ROAD	24.92	**25.14**$^{\uparrow}$	24.77$^{\downarrow}$	24.73$^{\downarrow}$	*24.42*$^{\downarrow}$	24.58$^{\downarrow}$	25.11	24.54$^{\downarrow}$	*23.50*$^{\downarrow}$	24.18$^{\downarrow}$	**24.61**$^{\downarrow}$	23.53$^{\downarrow}$
SBY-RAIL	0.95	1.13$^{\uparrow}$	**1.29**$^{\uparrow}$	1.05$^{\uparrow}$	*0.93*$^{\downarrow}$	1.20$^{\uparrow}$	0.96	1.37$^{\uparrow}$	**1.92**$^{\uparrow}$	1.17$^{\uparrow}$	*0.93*$^{\downarrow}$	1.64$^{\uparrow}$
CMY-ROAD	13.10	12.94$^{\downarrow}$	12.72$^{\downarrow}$	**13.04**$^{\downarrow}$	*11.64*$^{\downarrow}$	13.01$^{\downarrow}$	13.06	**12.68**$^{\downarrow}$	12.53$^{\downarrow}$	12.45$^{\downarrow}$	*10.79*$^{\downarrow}$	12.50$^{\downarrow}$
CMY-RAIL	0.50	0.55$^{\uparrow}$	0.58$^{\uparrow}$	0.56$^{\uparrow}$	*0.45*$^{\downarrow}$	0.59$^{\uparrow}$	0.50	0.93$^{\uparrow}$	0.99$^{\uparrow}$	0.93$^{\uparrow}$	*0.43*$^{\downarrow}$	1.08$^{\uparrow}$
Combined Alternatives												
Tj Priok Port	56.37	55.33$^{\downarrow}$	*55.32*$^{\downarrow}$	56.52$^{\uparrow}$	**58.58**$^{\uparrow}$	56.59$^{\uparrow}$	56.22	*55.50*$^{\downarrow}$	55.62$^{\downarrow}$	57.29$^{\uparrow}$	**59.19**$^{\uparrow}$	57.58$^{\uparrow}$
Tj Emas Port	4.15	4.91$^{\uparrow}$	**5.33**$^{\uparrow}$	4.10$^{\downarrow}$	*3.98*$^{\downarrow}$	4.03$^{\downarrow}$	4.16	4.98$^{\uparrow}$	**5.44**$^{\uparrow}$	3.99$^{\downarrow}$	4.04$^{\downarrow}$	*3.66*$^{\downarrow}$
Tj Perak Port	25.88	**26.27**$^{\uparrow}$	26.06$^{\uparrow}$	25.78$^{\downarrow}$	*25.35*$^{\downarrow}$	25.78$^{\downarrow}$	26.06	**25.91**$^{\downarrow}$	25.42$^{\downarrow}$	25.35$^{\downarrow}$	25.54$^{\downarrow}$	*25.17*$^{\downarrow}$
Cilamaya Port	13.60	13.49$^{\downarrow}$	13.30$^{\downarrow}$	**13.60**$^{\#}$	*12.09*$^{\downarrow}$	**13.60**$^{\#}$	13.56	**13.61**$^{\uparrow}$	13.52$^{\downarrow}$	13.38$^{\downarrow}$	*11.23*$^{\downarrow}$	13.59$^{\uparrow}$
Road mode	96.33	95.83$^{\downarrow}$	*95.52*$^{\downarrow}$	95.87$^{\downarrow}$	**96.25**$^{\downarrow}$	95.57$^{\downarrow}$	96.32	93.74$^{\downarrow}$	93.23$^{\downarrow}$	93.72$^{\downarrow}$	**96.01**$^{\downarrow}$	*93.22*$^{\downarrow}$
Rail mode	3.67	4.17$^{\uparrow}$	**4.48**$^{\uparrow}$	4.13$^{\uparrow}$	*3.75*$^{\uparrow}$	4.43$^{\uparrow}$	3.68	6.26$^{\uparrow}$	6.77$^{\uparrow}$	6.28$^{\uparrow}$	*3.99*$^{\uparrow}$	**6.78**$^{\uparrow}$

Note: * Business as usual. The numbers in italic format are the minimum shares, and the numbers in bold are the maximum shares. The $^{\downarrow}$ signs indicate that the market shares decrease, the $^{\uparrow}$ signs indicate that the shares increase compared to the 'BAU' condition. The $^{\#}$ signs indicate that the results are constant from the previous shares.

GHG emissions from the two models above are calculated based on emissions factors of 66 grams CO_2e / tonne-km for the road mode and 21 grams CO_2e / tonne-km for the (diesel) rail mode (Mckinnon & Piecyk, 2011). The GHG estimation results from each model are compared in Table 4 below.

Table 4: MXNL and MXMNL models: comparison of estimated GHG emissions reductions for each policy compared to 'business as usual' (BAU) case

Policy	MXNL – SP data only				MXMNL – joint SP and RP data			
	CO_2e Emissions - Tonne		Emissions reduction		CO_2e Emissions – Tonne		Emissions reduction	
	BAU	With policy	Tonne	%	BAU	With policy	Tonne	%
1	4,368	4,172	-196	-4.5%	4,144	3,817	-326	-7.9%
2	4,368	4,140	-227	-5.2%	4,144	3,893	-251	-6.0%
3	4,368	4,355	-13	-0.3%	4,144	3,998	-145	-3.5%
4	4,368	4,422	54	1.2%	4,144	4,162	18	0.4%
5	4,368	4,349	-19	-0.4%	4,144	4,046	-98	-2.4%

DISCUSSION

Factors affecting port and inland mode choices

As can be observed from Table 2, most of the utility parameter coefficients are highly significant at the 99% level, and others are significant at the 95% level. All of the attributes of inland mode and ports have the expected signs. Generally, the parameter values from the MXNL model are smaller than those from the MXMNL model. The MXMNL model has been estimated using the joint SP and RP data, which better describes the real situation because the RP data is included in the simulation.

Inland mode cost is highly significant at the 99% level and has a negative effect on the utility of the inland mode and port alternative. In the MXNL model, the direction of this effect does not depend on size of shipment (number of TEU per shipment), but the values of the inland mode cost coefficients reveal the effect to be smaller for smaller shipment sizes (2 TEUs per shipment or less). In the MXMNL model the inland mode cost is also found to be very significant at the 99% level.

In both MXNL and MXMNL models, the GHG emissions factor has a negative sign and coefficient values are significantly different for bigger volumes of exports (more than 10 TEUs per month) and smaller volumes of exports (less than 10 TEUs per month). Larger volumes of exports are more sensitive to the change of GHG emissions than are smaller volumes of exports. This suggests that bigger companies tend to pay more attention to GHG emissions than the smaller companies.

The reliability of inland mode and the frequency of ship calls are factors that have positive signs, as expected. They are found to be more important to consider for the freight forwarders than for the exporters when choosing between alternative port/inland mode combinations. These findings relate to both the MXNL and MXMNL models.

The inland mode time variable is also highly significant and shows a negative coefficient as expected in both MXNL and MXMNL. The MXNL also estimated separately the inland mode time for those products with HS code number 44 and 94 (wood products and miscellaneous manufactured products) and for all other products, but no significant difference between these two groups was found.

From the MXNL and MXMNL, we can see that companies with more frequent shipments (more than five shipments per month) consider port cost as a more important factor than companies that make less frequent shipments (up to five shipments per month). This finding suggests that port cost is one of the key factors for exporters or freight forwarders when they are selecting their preferred port.

The frequency of container ship calls in the port is found to be an important factor both for freight forwarders and exporters. Ship calls have a positive impact on the utility of an alternative.

Policy impacts

From Table 3, it can be seen that policy simulation using the MXMNL model produces larger changes in the port and mode market shares compared to the MXNL model. The same findings are also apparent in Table 4, where the percentage reductions in CO_2e reductions in the MXMNL model are much greater compared to those from the MXNL model.

Policies 2 and 5 lead to the most significant increments in the rail mode shares. In the MXNL model, the rail mode share increases from 3.67% to 4.48% (policy 2) or 4.43% (policy 5), and in the MXMNL model the shares rise from 3.68% to 6.77% or 6.78% respectively. Unfortunately, in the MXNL model policy 5 does not significantly contribute to GHG reduction (only -0.4%). This may be because most of the switch from the road mode to the rail mode occurs for shorter distance inland transport legs for which the reduction in GHG emissions is comparatively small.

Policy 1 and Policy 2 have a considerable influence in reducing GHG emissions in both the MXNL and MXMNL models. These two policies are directly related to the alternatives with the road mode, whereas policies 3 and 5 are related to the alternatives using the rail mode. The findings indicate that policies impacting directly on the road mode have greater impact in terms of GHG emissions reduction than policies targeted at the rail mode.

Policy 3 will raise the rail mode share by 4.13% and 6.28% according to the MXNL and MXMNL models respectively. Furthermore, this policy does not have an important impact on GHG emissions in the MXNL model, but in the MXMNL model it will reduce emissions by 3.5%.

According to the MXNL and MXMNL analysis set out above, the expansion of capacity at the Tanjung Priok port (Policy 4), and an associated increase in the frequency of ship calls, will result in a very small increment in the rail mode share. However, this policy does not reduce GHG emissions; in fact emissions will increase slightly as some forwarders or exporters switch their preferred port to Tanjung Priok Port from Tanjung Emas Port, Tanjung Perak Port or Cilamaya Port.

CONCLUSIONS

This paper has presented simulated results of the impact of a range of policies aimed at the reduction in GHG emissions related to containerised exports from Java, using the MXNL and MXMNL models. From both of these models we can summarise that increases in inland mode cost, inland mode time, inland mode GHG emissions and port cost all have significant negative effects on choice utility. On the other hand, inland mode reliability and frequency of ship calls at ports have positive influence on the decision maker when selecting between inland mode and port alternatives.

To determine the impact of various potential policies relating to port and inland mode choice, simulations of policy implementations have been performed. Five policies have been examined in such simulations: (1) time and route controls for trucks, (2) reduction of fuel subsidies for road transport, (3) establishing double-track on the Jakarta to Surabaya rail (north Java) route, (4) the expansion of Tanjung Priok Port, and (5) providing incentives for the use of rail freight.

The simulation results show that the two policies of reducing fuel subsidies for road transport and giving incentives to reduce rail freight rates would provide the most significant encouragement to modal shift from road transport to rail transport. However, the analysis suggests that the largest reduction in GHG emissions can be obtained through policies of reducing fuel subsidies for road transport and placing restrictions on the times and routes permitted for road transport operations. Overall, the MXMNL model gives the greater impact than the MXNL model both in the modal shifting from the road mode to the rail mode and in the GHG emissions reductions.

Currently, further simulations are being conducted to examine the combined effects of applying two or more of the policy options simultaneously, to identify which policy combinations are most effective in reducing GHG emissions. Simulations using other standard emissions factors are also in progress.

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A STUDY ON THE ANCHORING SITES SELECTION FOR LAYING UP VESSELS

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ABSTRACT
There are two major approaches a carrier can use to deal with the oversupply of container ships: slow steaming and laying-up ships. Laying-up vessels during market recession and reactivating them when the market is recovering is a regular practice in the shipping industry. Two types of lay-up are generally considered by shipowners: lay-up to overcome the market downturn, and lay-up of ships on the seasonal basis. Shipowners care much more about the former than the latter. How to decide the lay-up anchorage site is a matter of importance to the ocean carriers. The research aims at finding the degree of importance of various constructs/criteria influence carriers' laying-up sites selection for their unemployed vessels in the short term and medium term, and evaluating the degree of attractiveness of four popular vessels laying-up sites in Asia.

INTRODUCTION
The lay-up of surplus box ships since the end of 2008 has been the most severe in the industry's history (JoC, 2013). According UNCTAD (2014), the number of container ships laid up had reached almost 11 per cents in 2009, but this number was about 3.4 percents at the end of 2013. Idle container fleet at end December in 2013 is 779,230 TEUs, and this figure is quickly decreased to 227,862TEUs at end of December in 2014 (Alphaliner, 2015). Ocean carriers' reluctance to lay up surplus ships has continued making freight market depressed in 2015.
There are plenty of examples showing the need for laying up under-utilized and unemployed vessels in the dry bulk and container shipping market. Enterprises Shipholding Corporation (Business editors, 1999) decided to lay-up all its vessels trading in the pessimistic spot market. Large amount of deadweight tonnes of dry bulk ships were ordered amid the 2002-2008 shipping boom had been delivered in the last several years. At the same time, the demand for the iron ore is greatly fell in Chinese steel mills who are the main iron ore buyers. Thus the daily revenue of the bulk ship cannot cover her daily operating cost. Ship owners are increasingly looking at laying-up vessels to avoid non-profitable journeys and financial losses during the market recession (Anonymous, 2009a).Wright(2009) estimated there are now more than a quarter of 1,000 Capesizes were laid up in late 2008, and the largest container shipping company, Maersk Line, was reported to lays-up 8 vessels (Anonymous, 2008). Barnard(2008) also indicated more than 80 containerships laid up, including many 5,000-8,000 TEUs ships at anchor off the port of Singapore, Hong Kong and Shanghai. Larger size of vessels have lower transport costs per unit of cargo, thus the smaller vessels are generally firstly driven into lay-up at anchorage during a market recession(Chow & Lau, 2014).The Philippine Ports Authority (PPA) expects about 625 vessels to be idled in the next three years (Asia News Monitor, 2009). The Journal of Commerce (2014) reported, 175 vessels with a combined capacity of 516,000 TEUs were idled, accounting for 3 percent of global capacity in the beginning of 2014. Thus laying up ships in a period of tonnage oversupply is a common solution across the recent shipping history to avoid occurring extra loss for

both dry bulk ships and container vessels, and for the largest and small shipping company as well.

LITERATURE REVIEWS ON THE VESSELS' LAY-UP

Types of vessels' lay-up

Ship lay ups have been fast increased because of low demand and depressed freight rates (Anonymous, 2009a). Laid-up vessels are defined as vessels which have been decommissioned or otherwise unemployed and idle while waiting for better business prospects for their operations (PPA, 2009). "Laid-up" can also be defined as any vessel is not under repair or not actively employed (PMB, 2015). Generally speaking, there were two types of lay-ups: cold lay up and hot lay up. According to Kumar(2009), in cold lay up, there is a possibility that the ship will not be used for the long run, while in hot lay up, a skeleton crew will be put on board, who ensure that the machinery is kept working, occasionally, so that the vessel can be put to service in a short notice. To be more precisely, in a hot lay-up scenario, shipowners have to keep a reduced crew but with some element of the ship's machinery, like generators, still working during her lay-up in an anchorage site. It's normally a short term measure (a minimum of 30 days per P&Is) without cargo on board and easy to get the vessel up and running again fairly quickly when needed. A cold lay-up is a vessel that doesn't have any machinery running while it's laid up. This requires a safe and secure place and a full shut down. Normally, only a very limited number of crew (2~3 persons) remain on board. Re-commissioning a vessel that's been laid up long term (even up to 5 years, or more) can be much harder and can take some time (t. ward shipping, 2015; Ntovas, 2014). The last possible type of classification on the lay-up is the warm lay-up (Ntovas, 2014) and under such situation the owner has a reasonable expectation that demand will quickly recover (BIMCO, 2015) during a medium term of market recession when the supply of ships exceeds demand (Howley and McCabe, 2015). more complicated taxonomy of lay-up by DNV(2009) is listed as fowllows: (1) hot lay-up: hot lay-up for up to one month, hot lay-up for up to three months, hot lay-up for up to twelve months, hot lay-up with cargo (2) cold lay-up: cold lay-up up to five years, and long term cold lay-up for over five years.

Vessels' lay-up stakeholders

A good vessel lay-up plan required various aspects of attentions from both shipowners and ship management companies which at least should include security, technology, depth of water, climate condition, and etc. The "laid-up anchorage" means the harbour designated for the laying-up of ships. Philippine's Maritime Industry Authority (MARINA) has employed an Integrated Security Response Action Plan (ISRAP) to ensure the security of vessels laid-up at the Malalag Bay in Davao Gulf in the Mindanao Island (Asia News Monitor, 2009).Under the GAC Ship Lay-Up Solutions (GLUS) service partnership, UK-based Bibby Ship Management handles technical management and crew management, while Swedish DehuTech covers the dehumidification aspect of laying-up of vessels, including sale and rental of dehumidifiers(Anonymous, 2009b; TradeArabia, 2009). Philippine port authority requires any ship wanting to use the country's lay-up site should employ the services of an authorized lay-up agent. The GLUS services also includes ship agency, supply services, FRS (fire, rescue and safety), logistics and a range of lay-up specific services from lay-up preparation and documentation to maintenance and inspection.

Regulations on vessels' lay-up

Amojelar(2009) reported the public-operated Philippine Ports Authority (PPA) intends to assign 'lay-up areas' for ocean carriers looking to anchor their unused vessels during the global shipping market slowdown. Meanwhile, the PPA will also charge foreign-vesselsshipowners$91 a day if their ships are anchored in lay-up areas regardless of the ship size. The Philippines has four major lay-up areas --Malalag Bay in Davao, Manila Bay, Subic Bay and Pulupandan in Negros(Asia News Monitor, 2009). Vessel lay-ups in some key ports are affecting domestic ship managers, manning agents and seafarers.

Saleem(2010) reported a cold lay-up anchorage for ships which will result in cost savings of over $20,000 per month in terms of crew wage savings and the Dubai Maritime City Authority (DMCA) has set up two lay-up anchorages near Jebel Ali Port, called Jebel Ali Lay Anchorage (JALA), and another near Port Rashid. Both are about 20 nautical miles from the port in 20 metres of water. When a ship is in hot lay-up, the skeleton crew has to remain on board and to keep all systems running on minimum power to take the ship out of anchorage if necessary. A warm lay-up ship requires more crew on board than a ship in the cold lay-up condition. A cold lay-up can have just two crew members, cutting shipowners' costs to the minimum.

Another problem for ports is the safety point of view. If any ship is laid up in the port or anchorage and simply keeps a skeleton crew on board and in the event of an accident like a fire or anchor dragging, the port has to man and retrieve the ship from the particular situation (Kumar, 2009). Lay-up ships with skeleton crews in unsecure anchorages might be also prone to be attacked by armed robbery, such as the vessels laid-up off the Johor Port. (Wu& Zou, 2014).

The lay-up facility will not be financially viable for ports and there will be additional burden to monitor these ships round-the-clock (Kumar, 2009). Thus Kochi port authority rejected the request from Zim Line, a shipping firm in Israel, that has sought permission to idle their vessels off Kochi. Not all ports welcome warm lay-up and cold lay-up vessels, vessels should leave the Sharjah waters/anchorage areas after 21 days in compliance with the UAE Federal Law (ISS-Shipping, 2013).

LAY-UP SITES SELECTION – AGENTS' VIEWS

Traditional lay-up sites and anchorages remain congested. How to choose a potential lay-up anchorage for different types of lay-up demands is urgently required by the shipowners. Reviewing the websites of the shipping agents providing lay-up services, a good lay-up anchorage should include the following factors: anchorage is in a secure sheltered water area, it has good holding ground in 16m - 27m of water in a current of no more than a knot, weather is moderate tropical, trading vessels are moored to a single anchor~rigs and drills ships to spread of anchor, and the lay up anchorage can accommodate up to 10+ vessels at one time (Gaperi, 2015). A secure and sheltered anchorage specifically approved by the Malaysian Government for the layup of ships and rigs, the lay-up anchorage location is off the coast of Sabah and a short boat ride from the International Shipcare base in Labuan, The anchorage enjoys favourable weather conditions as it is to the south of the typhoon belt, ships are anchored in 22m-30m of water with good holding conditions, the currents are no more than one knot allowing vessels to be moored safely to a single anchor, layup anchorage can accommodate more than 80 vessels at any one time, ships are safely anchored with a minimum distance of one nautical mile in any direction to the next vessel, the town of Labuan also provides a base for the Malaysian armed forces, including the Navy and Air Force. This strong local presence of military personnel and patrols means the area is widely considered to be highly secure and safe from the threat of piracy, there have been no acts of piracy since International Shipcare launched its business in 1975, Labuan also has a modern airport and regular flights provide convenient connections to international airports in Kuala Lumpur and Kota Kinabalu, a shipyard in Labuan and an extensive maritime centre servicing the offshore oilfields of Sabah, a wealth of shipping agents, equipment suppliers and engineering facilities to provide services for the vessels under lay-up care (International Shipcare, 2015). Graig Ship Management (GSM) indicates one reasonable fixed monthly fee covers a safe mooring, port dues, dehumidification, 24/7 watchmen, routine tasks and maintenance, reporting and record keeping is a critical factor to shipowners to choose their vessels' lay-up anchorage (EnergyAsia, 2010). Tsansizis(2015) indicates Maliakos Gulf is an ideal place for lay-up vessels because of its anchorage is safe and wide throughout the year, the availability of getting provisions or changing crew or minor repairs.

Safe Haven Maritime Pte Ltd. (2009) promotes Indonesian Batam anchorage with the following attractions to shipowners: Batam's highly developed marine supply and ship yard industry, its closeness to Singapore ensures professional low cost supply of provisions, spare parts, fuel, fresh water, launch boat transportation, etc. The prices for the anchorage services are overall cheaper. The anchorage's ideal location weatherwise, good holding ground, and security arrangements provided lay-up service agents which gives the vessel Owners an opportunity to sign off crew below minimum safe manning as per flag state regulations in a safe and controlled manner hence offering ship Owners further savings of manning and insurance costs. A short summary on the qualified lay-up site reported from different shipping websites are shown in the table 1.

Table 1 Summary of the lay-up site selection

Constructs	Lay-up Agent Websites / Criteria	Energy Asia (2010)	Gaperi, (2015)	International Shipcare (2015)	Safe Haven (2009)	Tsansizis, (2015)
Anchorage Surroundings	Seabed composition	✓	✓	✓		✓
	Under keel clearance	✓	✓	✓		✓
	Sea water temperature	✓				
	Wind, wave, current & tide	✓	✓	✓		✓
Climate Condition	Humidity	✓				✓
	Not Typhoon, cyclone & hurricane		✓	✓		✓
	Adequate Shelter		✓	✓		✓
Routings	Close proximity to the sea cargo area.			✓	✓	
	Close proximity to bunker port			✓	✓	
	Close proximity to ship repairing facilities	✓		✓	✓	✓
Port Administration	Anchorage charge (Port Dues)	✓			✓	
	Availability of qualified local lay-up agent	✓	✓	✓	✓	✓
	Good port security			✓		✓
	Adequate contingency facilities					

Source: compiled by the authors.

DESIGN/METHODOLOGY/APPROACH

The research firstly carries out a semi-structure interview with executives of ten ocean carriers and marine insurance brokers to summarize the factors influencing carriers' laying-up site selection, followed by an AHP questionnaire survey to understand the degree of importance of laid-up sites selection criteria and the degree of attractiveness of the four major Asian laying-up sites in this study.

FINDINGS

Using four major constructs with fourteen criteria, four popular vessel lay-up sites are evaluated by operation executives of eleven ocean carriers. Port administration (0.474), climate condition(0.241), and anchorage surroundings(0.177) are perceived to be the top three important constructs in terms of vessel lay-up site selection decision-making. Anchorage charges (0.232); typhoon, cyclone & hurricane (0.140); and port security(0.117) are the top three important criteria influencing ocean carriers' lay-up sites selection (see Figure 1). Among the four sites in this study, LaemChabang Port, Hong Kong Port, Port of TanjungPelepas, and the Manila port are perceived to be the best, second best, third best, and fourth best lay-up anchorage sites(see Figure 2).

Figure 1 Degree of importance for the Construct/Criteria influencing lay-up sites selection for unemployed ships – Owners' Views

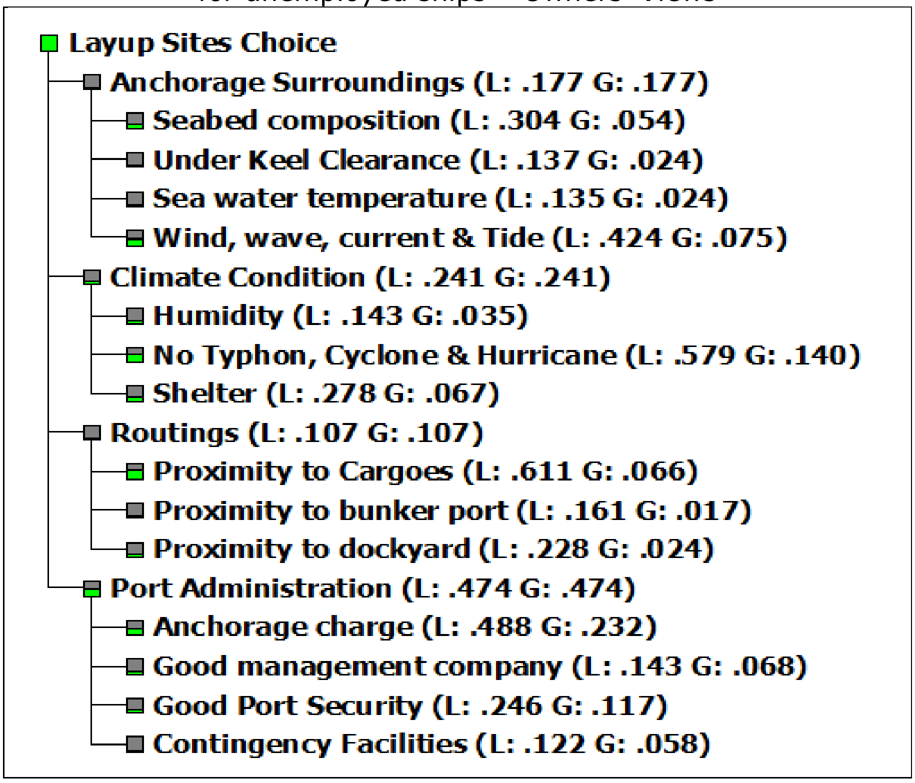
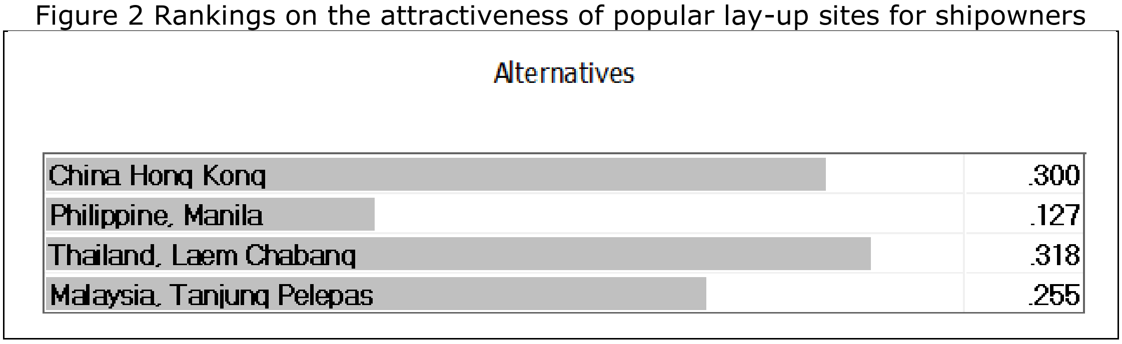


Figure 2 Rankings on the attractiveness of popular lay-up sites for shipowners



VALUE OF THE RESEARCH

According to the authors' knowledge, this is the first research using a quantitative technique to evaluate the attractiveness of different vessels lay-up sites. Ocean carriers can use these research findings to objectively choose the best lay-up site for their unemployed vessels during a recession in the shipping market.

RESEARCH LIMITATIONS/IMPLICATIONS

This research surveys Taiwanese shipowners' opinions on factors influencing their vessels' possible lay-up sites selection. Of the eleven carriers responded, only one of them has a 12-monthes warm lay-up experience for one of its ship. Another container carrier executive mentioned his company simply has a vessel lay-up experience for a very short period of time which is about only a week. Thus the responses from these shipping executives are mostly their stated preferences, not their revealed preference. There might be a big gap between their stated preferences and their actual decision-making behaviour (Gaperi, 2015).

PRACTICAL IMPLICATIONS

Although attracting unemployed vessels to lay-up outside the port area is not a usual practice for a port authority, yet this research reveals the 'port administration' construct has the highest degree of importance influencing shipowners' decision-making concerning their vessels lay-up site selection. Most ports authorities do not prefer too many unemployed vessels laid-up in the anchorage area outside their ports. Thus charging adequate anchorage fees on the warm and cold lay-up vessels might have a great effect to deter these shipowners to arrange too many of their employed vessels outside a port.

ACKNOWLEDGMENTS

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THE PANAMA CANAL AND THE RACE AMONG U.S. EAST COAST VERSUS WEST COAST PORTS

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Abstract

The widening of the Panama Canal, scheduled for completion in 2016, may fundamentally change the flow of Asian goods imported to the US. Ports all over the East Coast of the US are racing to upgrade their infrastructure to be ready for the bigger ships that will be coming through the Canal. These ports will then be better equipped to compete with the larger West Coast ports for goods from/to Asia. This struggle between US West Coast and East Coast ports will redirect some of the flow of cargo from Asia and so reallocate economic opportunities. Here we examine this struggle from the points of view of transportation cost and conclude that not all ports are affected equally. Some ports are thrown into very particular struggles and may be surprised to find out who their competition is. We show the west-east divide for cargo from Asia under various pricing scenarios and conclude that although price is an important factor for the attractiveness of the maritime route through the Canal, the safety and reliability of this route are key elements to enable its sustainable growth.

Introduction

The widening of the Panama Canal, scheduled for completion in 2016, may fundamentally alter the costs of transport and so potentially change US trade routes from Asia. This has frequently been described as a struggle between US West Coast ports and East Coast ports as these ports try to broaden their areas of dominance and redefine the west-east divide for cargo from Asia. The question of where exactly the US west-east divide lies has been the object of numerous studies, debate and speculation [1, 2, 3]. We show how the dividing line for cargo from Asia changes under various land/sea pricing combinations. We conclude that although price is an important factor for the attractiveness of the maritime route through the Canal, the safety and reliability of this route are key elements that will result in sustainable growth.

We consider two types of shipments, that sent by the cheapest route and that sent by the fastest route.

Commodity cargo and cost-shortest routes

Commodity cargo is of relatively lower value , and transportation represents a significant portion of the total investment. Such cargo is typically shipped by the cheapest route.

Consider shipments from Shanghai to the US. Figure 1 divides North America into regions[1] according to which port provides minimum cost transport for shippers to/from Shanghai: *Tacoma/Seattle, Oakland, Los Angeles/Long Beach, Houston, Miami, Jacksonville, Savannah, Charleston, Baltimore, Norfolk, or New York/New Jersey*. Each region contains one port, and that port lies on the least expensive path of goods movement from Shanghai to any point within the region. Figure 1 shows that it is cheaper to serve most of the Midwest through the ports of Tacoma/Seattle and Los Angeles/Long Beach than through any of the other ports.

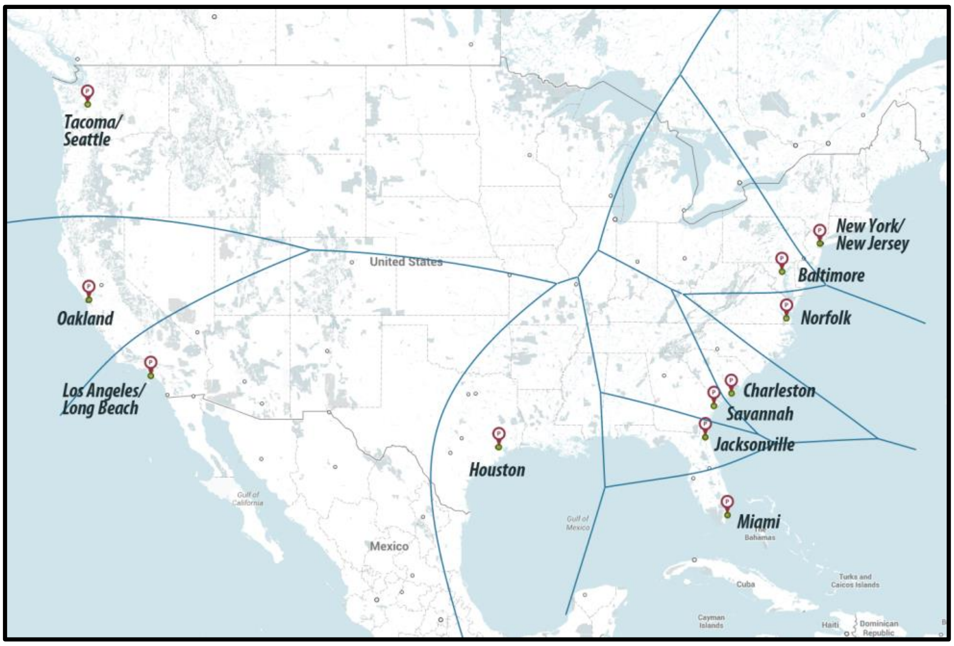

Figure 1: North America divided into regions according to which port should be used for least-cost travel from/to Shanghai.

To construct this figure we have assumed that moving freight overland is nearly six times[2] more expensive than moving it by ship and we assumed travel "as the crow flies".

Of course this figure is only approximate. Land transportation prices will vary by port based on volume, and because freight is transported on trucks and rail the boundaries will not really be smooth lines. But the important thing for us is not the exact shape of a boundary, nor the size of a region. The important fact is that there is a boundary; therefore any port will be cost-preferred for locations that are close enough. What is important is the "topology" of the region and in particular which other regions are immediate neighbours. The boundary between two regions represents the front line in an economic struggle between two ports contending for business.

An interesting feature of the topology is that it scarcely changes for any realistic value of the relative costs of ship and truck/rail, as can be seen in Figure 2 where the land travel price from Tacoma/Seattle was increased by 15%. In all such cases, the natural market region of the ports of Los Angeles and Long Beach borders that of the port of Oakland.

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[1] This is a construct known as a Voronoi diagram.

[2] Based on the November 2013 Shanghai Container Freight Index, the cost of moving a 40' container to US East Coast or US West Coast port was approximately the same at a rate of $0.26 per mile while the spot market intermodal land price was about $1.50 per mile

The red line in Figure 2 indicates the divide between regions for which inland transport is cheaper to/from a West Coast port and those for which it is cheaper to/from an East Coast port.

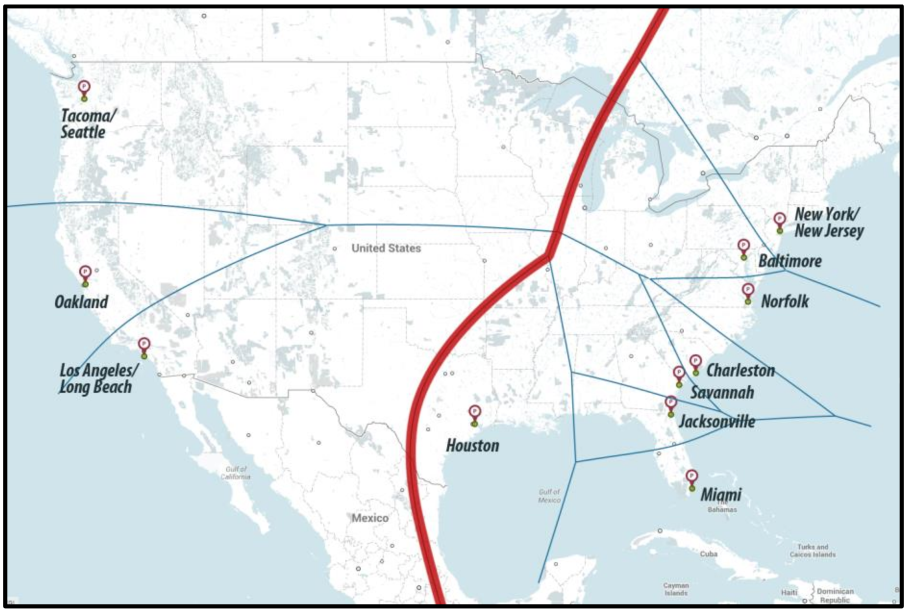

Figure 2: The red line separates that portion of North America closest to a west coast port from that closest to an east or Gulf Coast port.

The race to upgrade capacity can be seen as an attempt by Western ports and Western rail to push the red boundary further east, while the Eastern ports and Eastern rail are attempting to push it back west. Each wants a bigger region, with more business for itself.

From Figure 3 it can be seen that ports directly contend where their natural regions abut. From this point of view, to the extent that there is a struggle between coasts, it is really a struggle between Los Angeles/Long Beach on the West Coast and Houston on the Gulf Coast, and between Tacoma/Seattle on the West Coast and Baltimore on the East Coast. All other ports compete more directly with their neighbour ports on the same coast. For them, any improvement in cargo-handling or hinterland transportation would likely take business from their neighbours and not from the opposite coast. This is most clear for Miami, which competes only with Jacksonville, and is thus removed from any East Coast-West Coast competition.

It can also be seen that Oakland and Norfolk occupy similar positions on their respective coasts. Each is caught between neighbours to the north and south that hem in its competitive region. This means that these ports need to be much more efficient than their neighbours and/or have better hinterland connectivity to increase their natural competitive regions.

Each port has incentive to expand its competitive region, but the costs and benefits are not symmetric. If a port such as Los Angeles/Long Beach reduces its costs, it takes business from four neighbours over a very large area. In contrast, cost reductions at the port of Miami would win increased market only from Jacksonville and only along the Floridian peninsula. For Miami, winning an extra hour’s travel worth of business is not likely to amount to much.

The more neighbours a region has, the more competitors for the business within that region. For example, Oakland has only two natural competitors (Tacoma/Seattle and Los Angeles/Long Beach) while Savannah has five (Jacksonville, Houston, Los Angeles/Long Beach, Baltimore, and Charleston). In general, competition among ports is fiercer on the East Coast, where ports typically have more competitors and where large metropolitan areas lie close to boundaries.

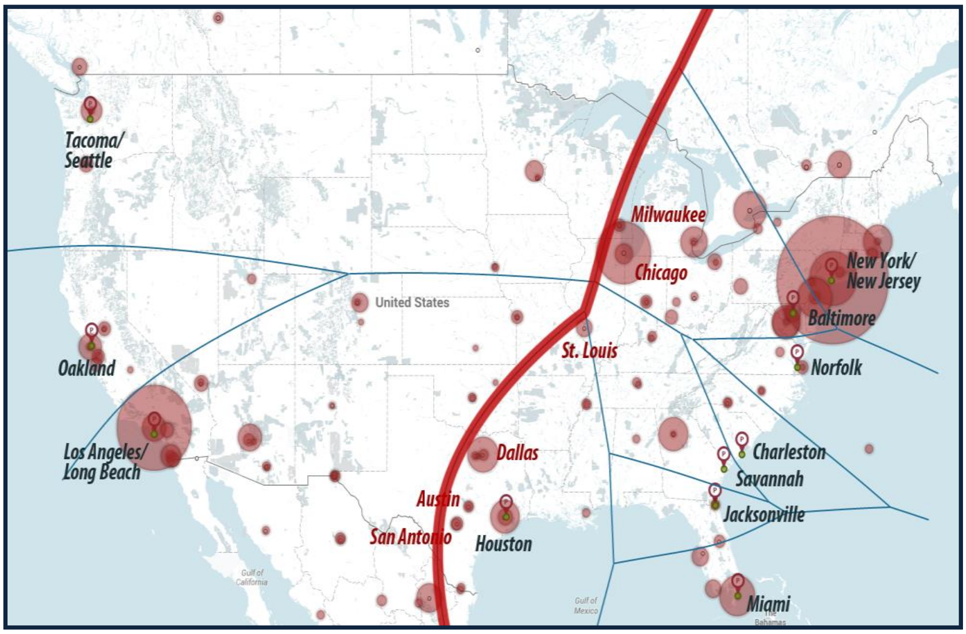

Figure 3: Chicago is a large market that falls close to the boundaries of four ports: Tacoma/Seattle, Los Angeles/Long Beach, Baltimore, and Savannah. The red circles are proportional to city populations.

When considering the population within each region we can again understand the greater intensity of competition among ports on the east coast where moving a boundary only a short distance can encompass a much greater population and so more freight. From this point of view (see Figure 3), Tacoma/Seattle and Los Angeles/Long Beach have a greater incentive to improve operations than East Coast ports. If they can push the red line eastward it will be into areas of greater population density, including the metropolitan areas of Dallas, San Antonio and Austin. In contrast, if Baltimore, Savannah, and Houston push the red line farther west, it will be into sparsely populated regions of the US and so will not bring much return. Houston and Savannah need to extend their area of dominance northwards possibly by improving port efficiency and developing cheaper rail/truck transportation alternatives, whereas Baltimore needs to assert its dominant position in its natural catchment area.

Chicago has a large population and so is an attractive market. Figure 3 shows that it is contested by four ports whose regions meet nearby; the ports of Tacoma/Seattle, Los Angeles/Long Beach, Savannah, and Baltimore. Even Norfolk could make a play for it. Similarly, St. Louis lies close to the regions of Los Angeles/Long Beach, Houston and Savannah. Table 1 shows the potential contenders for the major cities that are close to the west-east divide.

Cities	Contenders
Austin, Dallas, San Antonio	Los Angeles/Long Beach and Houston
St-Louis, Chicago, Milwaukee	Los Angeles/Long Beach, Tacoma/Seattle, Baltimore, Houston, Norfolk, Savannah

Table 1: Potential contenders for major cities close to the west-east divide

Other observations:

- Many large distribution centers are located within a corridor along the mid-Atlantic that includes Memphis, Lexington and Cincinnati, for which Savannah could be the preferred port for East Asian freight.
- Despite its smaller area of natural dominance, Norfolk does move a lot of goods to the Midwest because of a good intermodal connection to that region. It is an excellent example of a port that has successfully overcome its distance handicap to attract and distribute higher volumes of goods than its neighbours (see Table 2).

Although their dominant area extends to the west of the Mississippi River, East Coast ports currently cannot be price competitive throughout that region because of pockets of higher inland transportation costs and/or inefficient hinterland connectivity. In that sense, the area east of the red line in Figure 2 and Figure 3 currently represents the ultimate region that could be competitively served by the US East Coast Ports through the all-water route for trade with Asia.

Impact of the Panama Canal Expansion

The race to upgrade the ports on the East Coast of the US is a direct consequence of the expansion of the Panama Canal. Once the expansion is completed, ships up to the New-Panamax class with roughly 12500 TEUs will be able to sail through the Canal. It has been conjectured that these bigger ships will reduce the price per TEU along the all-water route, increasing the area served by the East Coast ports and pushing the west-east divide further to the west. Figure 4 shows the new divide assuming a 15% reduction in the sea portion of the travel[3]. As can be seen, most of the region gained is sparsely populated and therefore inconsequential. In reality, the East Coast ports are currently not competitive in serving the entire area east of the blue divide, especially in regions closer to the dividing line mainly due to higher inland transportation prices or inefficient land connectivity. Any reduction in the price per TEU along the all-water route will help the East Coast ports to better assert their dominance over this area. This in turn will preserve and may even increase the traffic through the Panama Canal to the US East and Gulf coasts.

Shipping lines are now receiving many of the newer and larger vessels that were ordered in the heyday before the crash of 2008−2009[4], and it is certain that these larger vessels will be introduced on the all-water route from Asia to replace the older Panamax

[3] An 8000 TEU vessel has operating costs up to 17% lower than a 4000 TEUs vessel according to the Proposal for the Expansion of the Panama Canal (2006).

[4] Post-Panamax vessels make up 48% of the cellular fleet capacity today and as of January 2013, they represented 77% of total capacity on order.

vessels[5]. In spite of the new vessels being more energy efficient, they will have to carry more cargo and it has been conjectured that (for a given rotation) this consolidation may result in fewer stops (possibly only one or two) along the East Coast ports to be more cost effective. This would mean that some ports, especially those that are not yet ready for the big ships, will lose out.

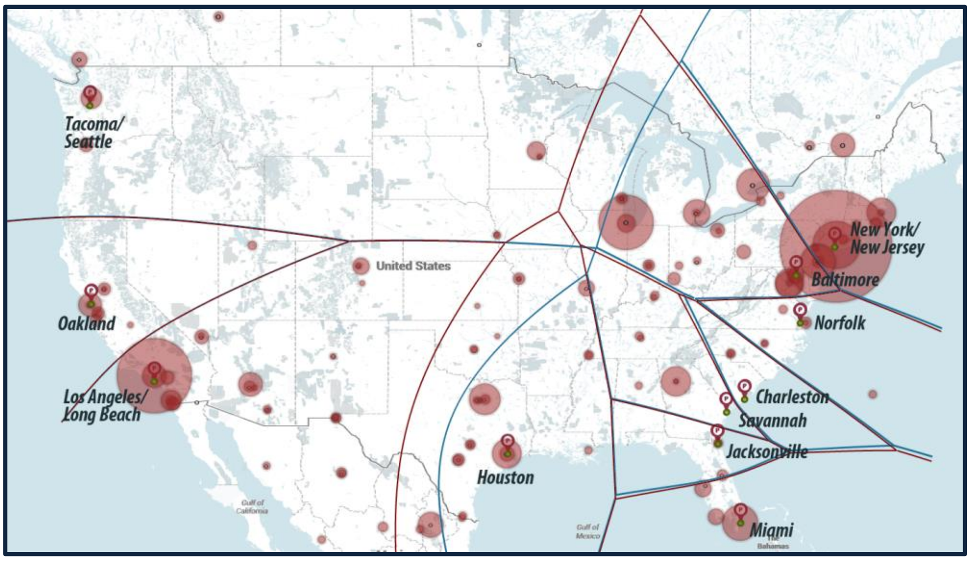

Figure 4: New East-West divide assuming a 15% discount on the sea portion of the all-water route through the Canal (red line).

Analysis of Table 2 reveals that, except for Jacksonville, all of the East Coast ports have at least one service with a 9200 TEU Post-Panamax vessel. Furthermore, these 9200 TEU vessel services make at least three stops at different East Coast ports and one service (MSC Golden Gate) stops at six of the seven East Coast ports under consideration. Although in general it is true that larger ships tend to make fewer stops, the above observations seem to alleviate the risk of making only one or two stops for ships up to the New-Panamax class. Furthermore, the high number of services from Asia to most of the East Coast ports indicates that there is room for some service consolidation without any significant degradation of service level to these ports.

To receive the New-Panamax class vessels, a port must have a depth of at least 50 feet and be equipped with Super Post-Panamax cranes capable of loading and unloading these ships. All the West Coast ports are ready for the bigger vessels whereas the race is on for the East Coast ports, with only Norfolk ready and Baltimore soon to follow. As can be seen from Table 2, Charleston, Jacksonville and Savannah may not be ready to accommodate the larger New-Panamax class vessels coming through the Canal when it opens in 2016 and, once again it is feared that these ports might lose cargo to the New-Panamax ready ports. This will be most damaging for Savannah as it is the East Coast port with the most services from East Asia (15) and is one of the main contenders in the west-east struggle as well as a contender for goods to the Chicago area. However, Savannah already handles 9200 TEU vessels[6] and if the larger vessels coming through

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[5] A Panamax ship is the largest container vessel that can traverse the Panama Canal today and has a capacity of about 4500 – 5000 TEUs.

[6] Which is double the size of the current Panamax limit.

the Panama Canal on its services do not exceed this limit, it will continue to thrive and may even benefit from the lower price per TEU on the all-water route.

Port	Coast	2012 TEU	Port Readiness for New Panamax	Num of Service From Asia - 2013	Max Vessel From Asia (TEU)
Los Angeles / Long Beach	West	14,123,376	Ready	31	13092
New York - New Jersey	East	5,529,913	2015	14 (3 Suez)	9200
Tacoma / Seattle	West	3,577,584	Ready	17	9449
Savannah	East	2,966,213	After 2015	15 (4 Suez)*	9200
Oakland	West	2,344,424	Ready	24	13092
Norfolk	East	2,105,586	Ready	12 (4 Suez)	9200
Houston	Gulf	1,922,529	2014	2	5095
Charleston	East	1,514,585	After 2015	7 (2 Suez)*	9200
Jacksonville	East	923,660	After 2015	4 (1 Suez)	6350
Miami	East	909,607	2014	4 (1 Suez)*	9200
Baltimore	East	677,876	2013/2014	2 (1 Suez)	9200

Table 2: US Ports throughput, readiness and number of services from Asia. The 'Number of Service from Asia' as well as 'Largest Ship From Asia' as listed in Compair Database as of January 2013.
*** Since the data was obtained, the TP7 service from Maersk has moved to the Suez Canal.**

All of the ports on the East Coast have at least one service from Asia coming through the Suez Canal and usually these services use larger Post-Panamax vessels. As the ports on the East Coast upgrade their capacity, the Suez route becomes more attractive since it can accommodate larger vessels over the New-Panamax limit. This could be the single biggest threat for the Panama Canal as not only larger vessels mean potentially a lower price per TEU, but this route offers more potential for filling up the larger vessels as they can consolidate goods from Asia to US, Europe, Middle East and North Africa and pick up more en route.

From Shanghai, the distance to the East Coast ports along the Suez Canal is 15–25% longer than through the Panama Canal and hence a 25% reduction in price per TEU via the Suez Canal would completely wipe out the cost advantage of the Panama Canal even if the latter remains faster.

As production in Asia moves towards South China, Malaysia, and Vietnam, the Suez route becomes even more attractive. Hence it is vital that the pricing of the routes through the Panama Canal remains competitive not only with respect to the intermodal routes through the West Coast ports, but also with respect to the routes via the Suez Canal. An expanded Canal will also offer more capacity and hence potentially reduce the variances in waiting times for ships transiting through the canal thereby increasing the reliability of this route. This together with the added safety when compared to the Suez Canal will enable sustainable growth of the traffic through the Panama Canal. The Suez threat can be further mitigated by establishing Panama as "the" logistics hub for the Americas, where products are stored, configured and relabelled for the US market and dispatched on a 'Just-In-Time' basis.

Conclusions

It should be emphasized that this analysis is only suggestive. We assumed that cost tends to be proportional to distance or to time and that freight travels directly, without detour or interruption. Despite these simplifications, some general insights hold true, in particular it is too broad to say that the competition is between ports of the West Coast and ports of the East Coast. First, the competition will be for commodity product only. When speed is important, the West Coast ports win.

Furthermore, some ports will be affected more than others. In particular, Los Angeles/Long Beach and Tacoma/Seattle will feel it most on the West Coast, Baltimore and Savannah will feel it most on the East Coast. And this competition will focus on winning business in the Chicago area.

The expanded Canal promises to be more efficient, with plenty of capacity to maintain its competitiveness to capture future demand. However, cargo growth through the Canal has been relatively flat in recent years mainly due to the 2008–2009 recession. But cargo from/to US East Coast still represents 54% of all cargo going through the Panama Canal. While the Panama Canal expansion triggered the race for the East Coast ports to be New-Panamax ready, this race could turn out to be disadvantageous to the Canal as it opens up more opportunities for the Suez Canal to US East Coast bound cargo. Larger vessels will require more cargo, and shipping lines could deploy new services that consolidates cargo to the US East Coast from several ports starting from Shanghai to ports further south such as Singapore, which lies at the inflexion point for routes through the Suez Canal or Panama Canal, wiping out the distance advantage of the Panama Canal.

To thwart all threats from the Suez Canal, authorities for the Panama Canal must ensure that the all-water route remains competitive through flexible and adequate pricing schemes. Also, transhipment between Panamanian ports should be fast, efficient and reliable so that the country can operate as one big virtual port serving two oceans with easy access to the free trade zones. These will ensure that the Panama Canal is still the preferred way for Asia-US East Coast ports and enable the country to establish itself as the logistics hub of the Americas, allowing sustainable long-term economic growth for Panama.

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ANALYSING RISK IN SHIP FINANCE

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1. INTRODUCTION

In earlier eras much of ship finance was provided through individual owners funding their own companies. However, more recently ship owners have sought finance from the capital markets. Starting from the 1990s, shipping companies began to turn to the global capital markets to raise finance, through either equity or debt. During the period 2004 – 2007, it can be observed that there was an increased number of Initial Public Offerings (IPOs), secondary offerings, and issuance of high-yield bonds related to the shipping industry. However, since the financial crisis of 2008, bankruptcy amongst firms operating in the shipping industry has been a familiar theme. Corporate finance is therefore an important consideration within the shipping industry which remains in a precarious situation. This has brought additional pressures in terms of shipping companies establishing sound and rigorous, as well as transparent, financial practices. While previously there would have been limited access to financial data about shipping companies, now it has become available through public databases and market information. While the financial data is still to some extent limited, valuable insights can be obtained from analysing that, which is available, e.g. the Bloomberg Database.

While issues such as corporate failure and financial performance have been well researched amongst those in the accountancy and finance field, its consideration within the shipping industry has been limited. The spotlight has been on loans (Kavussanos and Tsouknidis, 2011; Mitroussi et al, 2012), high-yield bonds (Grammenos, et al, 2008) or IPOs (Grammenos and Papapostolou, 2012). To the best of our knowledge, no study discusses the insolvency of shipping firms at a company level, leaving a significant research gap. There remain many unanswered questions, for example, how do shipping firms reach the point of failure/bankruptcy? How can the financial performance of shipping firms be best evaluated?; and what can they do in the future to avert financial crisis?

2. LITERATURE REVIEW

2.1. Financial distress and corporate failure

A significant threat for many businesses, irrespective of company size or the business field in which they operate is corporate failure. Business failures are economically costly and the market value of distressed firms generally declines in the period leading up to collapse (Warner, 1977; Charalambous et al, 2000). In such circumstances not only are the company and its employees directly affected but so more broadly are the suppliers of capital, investors and creditors (Charalambous et al, 2004). The identification of companies which are likely to fail is thus of interest to a range of stakeholders, and predicting corporate failure has been a theme of economic research for several decades (Aharony, 1980; Morris, 1997). Corporate failure indicates that resource misallocation is likely to have occurred which is undesirable, and identifying if it is likely to occur would enable measures to be taken to prevent such an occurrence (Lev, 1974). Further, financial distress as a concept has been used to explain how some companies have an increased probability of failure in situations where they cannot meet their financial obligations (Chan and Chen, 1991; Fama and French, 1996; Campbell et al, 2008).

2.2. Financial distress in shipping

The shipping industry is known for its family run business in favour of traditional financing tools. The industry is fragmented and consists of a large number of smaller firms with concentrated ownership (Stopford, 2009; Tsionas et al., 2012), lack of transparency and limited access to the capital markets. Only since the 1990s have ship owners sought financing from the global capital markets (Grammenos et al., 2007; Merikas et al., 2009). As maritime companies have increasingly turned to the financial markets to raise capital they have come under closer scrutiny by investors and shareholders. They have strengthened their corporate structure, and they have become larger in size, due to their growth strategies through mergers and acquisition. A generation of younger shipowners began to raise finance by itilising international capital markets, particularly during the 1993–1997 and 2004–2007 periods. There are many ways of financing ships, from traditional bank lending to private placements and public issues of debt and equity. They are all associated with different risks and the investor/lender has to make a decision based on the return in order to justify exposure to the risk.

In relation to equity finance, Grammenos and Marcoulis (1996) were the first to document that an increasing number of shipping companies were accessing the capital market. Grammenos and Marcoulis (1996) and Grammenos and Arkoulis (1999) were amongst the first papers to analyse the performance of shipping IPOs in the equity capital markets. Cullinane and Gong (2002) studied IPOs underpricing in the transportation sector in the Chinese mainland and Hong Kong markets. Merikas et al. (2009 &2010) studied global shipping IPOs underpricing using US-listed Shipping IPOs. Grammenos and Papapostolou (2012) were the first to test the different theories that explain the underpricing phenomenon. They examined the impact of market information on US shipping IPOs through analysing 51 shipping US IPOs that took place in the period 1987–2008. They indicated that there is no asymmetry of information between participants in shipping IPOs and the probability of underpricing can be predicted by employing variables available to all IPO participants prior to the issue.

In relation to debt finance, Grammenos et al (2008) argued that bankruptcy and default on a debt instrument represent different phases of financial distress. Grammenos and Arkoulis (2003) studied debt finance for shipping companies for the first time. They investigated determinants of the primary pricing of shipping company high yield bond issues. In line with Fridson and Garman (1998), they argued that when studying the pricing of new high yield bonds, it would be better to categorise the bonds by industry in order to avoid biased results. Using 30 high yield bond offerings issued by shipping companies in the US market during the period 1993–1998 they identified a set of potential determinants, with credit rating being the major determinant of the price spread of bond offerings. Financial leverage and shipping market conditions also account for a significant part of the price variability. Grammenos et al (2007) studied factors affecting the dynamics of yield premia on seasoned high yield bonds of shipping companies. They found the explanation factors to be: credit rating; term-to-maturity; changes in earnings in the shipping market, as well as in the yield on 10-year Treasury bonds; and the yield on the Merrill Lynch single-B index. While default against individual financial instruments can represent early phases of corporate failure, predicting overall failure at the firm level is worth investigating.

3. DATA

3.1. Data description

The data were extracted from the Bloomberg database for the period 1992 to 2014. 484 globally listed shipping companies were selected under the marine transportation sector available from the Bloomberg database, of which 158 were delisted. We apply the criteria that the company must have had at least three years of full financial data prior to its formal failure year. The application of this criteria resulted in a sample of 20 delisted shipping companies. We then chose to match these delisted companies with 20 companies that survived in the same periods and with similar size of total assets. The final dataset thus consists of 40 shipping companies that either survived or failed between 2007 and 2014.

A large number of financial ratios were employed and tested to ascertain whether corporate failure of listed shipping companies could be predicted. These ratios can be categorised into six groups: gearing, liquidity, profit, activity, cash flow and market. We further chose three industrial specific variables (dummy variables) in order to reflect the main business of the shipping companies: ship-owning, tramp and wet. Ship-owning is used to describe whether the company owns any ships, Tramp is used to select the companies with tramp trades as their main business, and lastly, Wet is used to select the companies with oil products as their main business. All the ratios are collected through six time horizons prior to failure: half year, one year, one and a half years, two years, two and a half years and three years before the year of failure.

3.2. Financial ratios

Ratio analysis evaluates various aspects of an organisations operating and financial performance, e.g. efficiency, liquidity and profitability. For most ratios, an acceptable level is determined by its comparison to ratios of companies in the same industry. Such ratios are generally of two types: comparison of items between years or a comparison between items in the same year. The number of ratios that can be calculated is large and the multiplicity of available ratios means that it is important that the correct ratios are chosen. For the purposes of this paper the ratios considered covered gearing, liquidity, profit, activity, cash flow and market and are detailed in Table 1. (Tamari, 1978; Investopedia, 2015a).

Table 1. Financial ratios tested in the study

Category	**Variable Definition**
Gearing	*Current liabilities/total assets*
	Total debt/total assets
Liquidity	Current assets/current liability
	Current assets/total assets
	Working capital/total assets
Profit	Earnings before interest and taxes/total assets
	Net income/total assets (ROA)
	Net income/shareholder’s equity (ROE)
Activity	Sales/total assets
	Sales/current assets
Cash flow	Cash flow/total assets
Market	Market value of equity/shareholder’s equity

4. Empirical results

4.1. Trend analysis

The trends of the financial ratios were compared for both active and delisted companies three years prior to the failure of the delisted companies. Figure 1 shows the equally weighted means of three representative financial ratios for the two groups of companies.

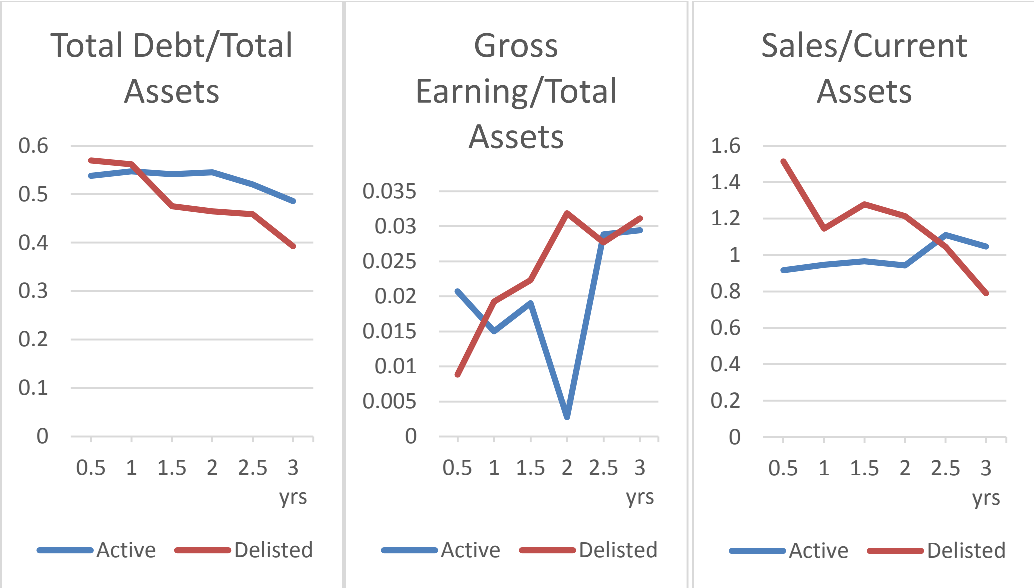

Figure 1. Trend of representative financial ratios

Distinct differences can be observed between the two groups of companies. The total debt/total assets ratio increases for the delisted shipping companies as the year of failure approaches, while it remains relatively stable for the active companies. This observation is in line with the previous corporate failure findings, where gearing is positively related to the probability of failure. The gross earning/total assets ratio shows a decreasing trend for delisted shipping companies, while it doesn't follow any specific pattern for the active companies. This observation is also consistent with the previous literature, where profitability measures are inversely related to the probability of failure. The sales/current assets ratio remains relatively stable for the active companies, while it reveals an increasing trend for the delisted companies. This can be explained by a decrease in the value of current assets before failure which leads to an increasing overall ratio.

4.2. Univariate analysis

To examine the predictive ability of the financial ratios, the significance of the individual variables was tested through univariate logistic regression, to uncover which of these variables might be empirically important in explaining corporate failure before they might be considered simultaneously for multivariate analysis. For convenience only the significant variables in this screening stage are reported.

Among the possible financial variables the only variable that is found to have a significant impact on explaining corporate failure is 'gearing', as measured by the total debt/assets ratio. Table 2 shows that regardless of the choice of the data quoted in terms of the time before the delisted companies are 'dead' (with an exception of the choice of '3 years before' where none of these variables is found to be significant). The estimated coefficients for this variable all have the expected (positive) sign that indicates that a rise in the debt-to-assets ratio tends to imply a higher probability of failure as omened by exacerbated financial burden. The McFadden R-squared and H-L statistics are both within reasonable boundaries for this baseline model to be considered acceptable.

While previous literature shows that financial leverage/gearing variables provide the highest univariate classification accuracy (Charitou et al, 2007), this finding seems to distinguish itself from many existing findings in the literature that corporate failure might also be predicted by many other factors besides gearing, such as liquidity, profitability and cash flow (see Charitou et al, 2004 and Grammenos et al, 2008 for examples). At this point it can be concluded that the gearing ratio shows a consistent and robust significance in prediction corporate failure of listed shipping firms.

Table 2. Univariate regressions

	Time before failure					
Regressors	6 mths	1 yr	1.5 yrs	2 yrs	2.5 yrs	3 yrs
Gearing						
TD/TA	4.408**	3.815**	3.521**	3.423**	4.16**	2.33
	(2.001)	(1.68)	(1.657)	(1.678)	(1.845)	(1.672)
Constant	-1.86**	-1.617**	-1.671**	-1.489*	-2.11**	-1.279
	(0.902)	(0.804)	(0.782)	(0.77)	(0.928)	(0.783)
McFadden R^2	0.153	0.131	0.135	0.109	0.155	0.053
H-L statistic	6.258 [0.618]	7.633 [0.469]	7.697 [0.464]	3.029 [0.933]	5.549 [0.698]	8.8176 [0.358]
Obs:	34	34	35	32	30	29

In order to capture sector-specific factors in the shipping industry, three variants of the baseline model above were tested, by adding to it in each case a shipping industry-specific dummy, representing the main business of the shipping companies, to see if any of these would improve the model's fit. The three dummy variables considered were 'ship-owning', 'tramp' and 'wet', where 'ship'=1 represents the case in which the company owns ships, 'tramp'=1 means the company is involved with tramp trades as their main business and 'wet'=1 means the company is involved with oil products as their main business

Overall, the screening exercise suggests: Firstly, any analysis with data quoted as '3 years' before failure fails to establish a correlation between the probability of corporate failure and normal financial variables. Hence we can conclude that it is difficult to predict failure for shipping companies three years ahead, it would only be sensible to use historical data with shorter time horizon (i.e. less than 3 years) to predict corporate failure in shipping companies. Secondly, the main business of the shipping company, i.e., whether a company owns ships or whether it operates in tramp trades, matters when it comes to financial failure, and they have the potential of improving the significance of some financial variables under the '6 months before' category. Thirdly, gearing, measured as total debt-to-assets ratio is found to be significant and robust in different variants of model and it has the best goodness-of-fit under the '6 months before' category with the inclusion of 'ship'.

4.3. Marginal effect

Having identified five model variants that are robust in predicting corporate failure using the debt-to-assets ratio measured at different times with reference to the bankrupted firms' delisted dates, how the probability of failure varies can be evaluated, in each model variant, along with the variation in the debt-to-assets ratio, i.e., the marginal effect of debt-to-assets ratio on the firms' failure probability.

One important feature of the marginal effect in logistic regression analysis, compared to the usual linear regression analysis, is that the marginal impact of an explanatory variable on the dependent variable, as measured by the 'slope parameter' in linear regression analysis, is not fixed but a function of both the slope parameter and the values at which all the explanatory variables are measured, due to the non-linear relationship between the dependent and explanatory variable(s) as reflected by the logistic model structure. In other words, the non-linear relationship between the dependent and explanatory variable(s) determines that the change in the probability of failure would be different should the same amount of change in an explanatory variable be caused upon different starting levels.

This can be seen clearly from figure 2 below the probability of failure against the significant financial variable is plotted, the debt-to-assets ratio, as identified with data measured at the different reference points. It can be seen that while a higher debt-to-assets ratio leads to higher probability of failure in all cases (as determined by the positive coefficients of TD/TA as reported in Table 2 above), the varying slopes on each response function suggest the responsiveness of failure probability with respect to 'a unit change' in the debt-to-assets ratio varies at different gearing levels. The most obvious of these is when the model is estimated using data reported 6 months before the bankruptcy dates, where, for example, when the debt ratio is close to 0%, a 10% rise in the ratio would only cause a 4% rise in the failure probability, whereas when the debt ratio has reached a 'cautionary' level, say 40%, a 10% rise on top of this would cause the failure probability to rise significantly, by as much as 19%; the sensitive response then slows down again substantially when the debt level has passed a 'critical' point, at about 70% of the total assets. The other model variants, by the nature of the model setting, also display similar properties of varying responsiveness, although compared to the '6-month before' version their responsiveness is much more 'linear'; that is, they imply much less drastic changes in failure probability when the debt ratio varies.

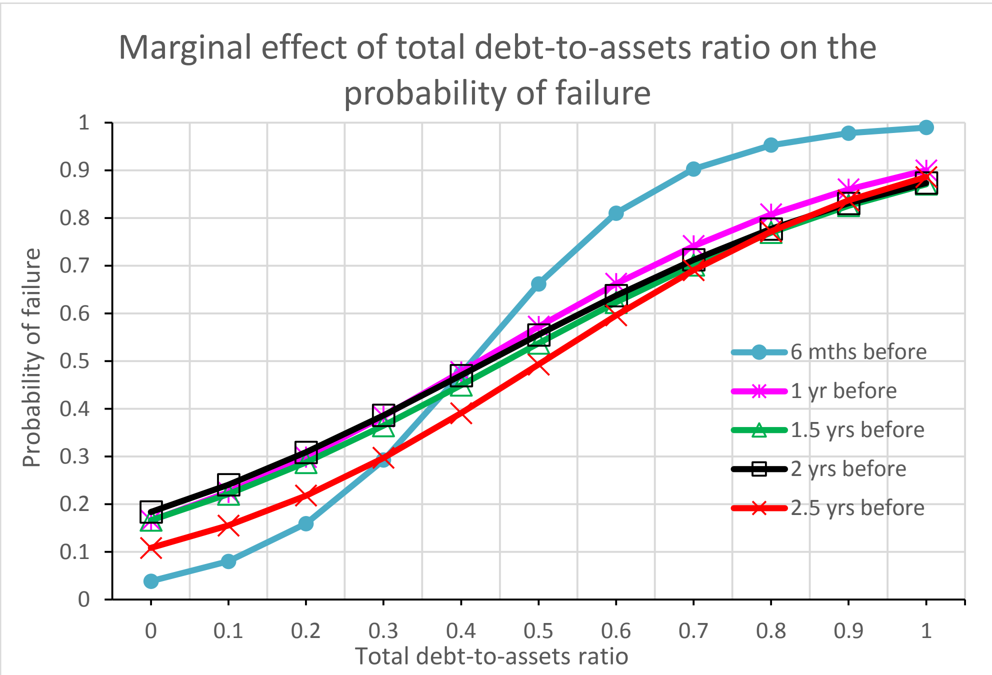

Figure 2. Marginal effect of debt-to-assets ratio on failure probability

Interestingly, Figure 2 shows all but the '2.5-year before' variant suggest a response function that intersects each other when the debt ratio is near 40%; at this level the probability of failure is about 50% which is usually taken as the threshold/critical point in binary logistic analysis. Here, these variants seem to roughly agree that a debt-to-assets ratio at around 40% is notable – this contrasts to our trend analysis (figure 1) where the average debt ratio of delisted firms was mostly kept above 50% while that of active firms was just above 30%. The '6-month before' variant predicts much higher (lower) probabilities of failure beyond (below) this critical point compared to the others whose predictions are not substantially different. The '2.5-year before' variant suggests a somewhat higher critical point, at about 50%; its prediction is otherwise fairly similar to the others' (except for that of the '6-month before' variant), although below such a critical point its predicted failure probabilities are consistently lower by some 8-10%.

While we have identified five model variants that are robust in predicting corporate failure, it should be noted that these logistic models were only estimated with limited observations. Hence we have carried out In and out of sample tests to validate the robustness of our models. The results of In and Out of sample tests can be obtained on request.

5. CONCLUSIONS

In this paper we analysed how financial and industry specific variables can be used to predict corporate failure in listed shipping companies through the use of binary logit model. Through trend analysis, univariate regressions, gearing, profit and activity were found to be useful in predicting corporate failure in listed shipping companies. We also conclude that it is difficult to predict failure 3 years prior to bankruptcy. The best time horizon to predict corporate failure in shipping is 6 months. Our paper further examines the different characteristics of financial risks in shipping through marginal effect analysis. If the gearing ratio increases to above 40% and remains in the 40% to 70% range it would appear that failure is more likely to occur.

In light of the above, these findings will be of interest to traders and investors in shipping markets, as well as banks and shipowners in the ship finance sector. The publicly available nature of the information used to compile this research means that traders and investors (both individual and corporate) are now able to use an easily accessible source of data to make their judgements about investing in the shipping industry. In addition ship owners are able to identify the factors that they need to focus on in order to understand more effectively the financial performance of their company.

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Section 7: Knowledge management and E-business in supply chains

CONTROL AND MONITORING FOR E-FULFILLMENT IN FASHION

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ABSTRACT
More than before fashion is sold through e-channels and this implies an increase in e-logistics. Shop selling stagnates. But as fashion sales handled through e-channels is becoming a substantial part of the business, successfully managing such a channel is a challenge for almost all fashion retailers. This research maps the logistics structures of the different fashion e-tailers, and obtains insight in the patterns how products are distributed and returned. The involved logistics structures differ strongly from the logistics structures towards fashion shops in the High Street, especially for its return flows. We describe which parts of the logistics flows are most vulnerable, and which KPI's are applied to meet these challenges. We found that Dutch fashion e-tailers use a wide variety of distribution structures for e-business and sometimes use different KPI's as compared with regular supply chains. Delivery appears to be an important part of the total customer experience. Controlling, applying KPI's and improving efficiency during the e-fulfilment phase is considered essentially by companies to become more competitive and financially successful. We found that the number of KPIs seems to be related to the width of the product range and the price level. Our research gives a clear view how fashion chains are coping with e-logistics and how this relates to existing theoretical models. Especially the control on goods returned, which has not been done much before in-depth. This is important to know, as fashion chains urgently ask for a better understanding of the questions how to manage e-tailing and which KPI's may suit to what conditions. The research offers several practical recommendations to the industry on this aspect.

Keywords: fashion e-channels, key performance indicators, E-fulfilment, returned fashion goods

INTRODUCTION

Whether fashion products are sold from a store or through a web shop, for every fashion company logistics is a hot topic. A fashion company which fails to get the right items at the right time at the right store or at the right delivery address, will find itself quickly out of customers or out of profit. For decades, all fashion companies are improving their logistics, in order to determine the success of the company. Zara still is the leader in fashion logistics, with a longstanding sales and profit growth of around 20 percent per annum (Inditex, 2013). For the first time, the Half Years Results of 17 September 2014 reported a sales increase of "only" 6% and a profit increase of "only" 4.5%. Few fashion businesses can design a whole new fashion line, produce, distribute and offer it in its stores within 16 days, like Zara does. But in recent years, almost all fashion companies have been able to shorten their lead times considerably. For fashion companies selling via the High Street store still forms the focus for their main logistics concepts.

In the Netherlands since 2008, we see High Street retail sales stagnate. Especially the fashion industry has been hit hard. Some Dutch High Street fashion retail organisations have lost 30% of their turnovers since 2008. Not only independent retailers, but also large High Street retail chains such as De Bijenkorf had to close shops, and some retail chains collapsed, like the Schoenenreus, Hans Textiles and Bandolera. At the same time, overall fashion sales increase - even considerably. Partly driven by new providers or new potential competitors, fashion companies have started to open web shops. These web shops generate not only more turnover for the retail chain, but also increase brand awareness.

PROBLEM SKETCH

The decision to start selling fashion online alongside a physical store, is usually driven by competition - there are more and more competitors on the market - and is aimed at maintaining or increasing a market share. The front of the e-business - towards the

consumer - is generally realized quickly, the back - the logistical structure and the physical realization – has often been no easy aspect for fashion e-tailers. In fact, the logistics of their e-commerce activities has proven to be a major challenge for these companies. E.g. a large fashion retailer like Zalando only made a profit in 2014 after 6 years of continuous losses (Oude Elferink, 2014; Zalando, 2015). But fashion store chains mainly seem to use web shops as a mean for not losing market share and generating brand awareness, rather than using it to generate more profit. But the logistics costs of e-fulfilment are invariably extremely high, so these costs always put profitability under pressure. On average, the logistics costs of a web shop consists for 2/3 of transportation-related costs (last-mile distribution, return transport) and for 1/3 of warehouse fulfilment costs (Lenders, 2014). Many fashion companies wish to organize and control e-fulfilment of web shop sales better. How can this be done best?
We have formulated on the basis of this analysis the following research question:

How do fashion companies in the Netherlands organise the e-fulfilment concerning web sales and how can they improve the control and monitoring of these processes?

By doing this research we want to help the fashion business to understand under what conditions certain KPIs are appropriate, and we want to give our students more insight into the question how the logistics of the Dutch e-fashion fits with existing theories, and how this e-fulfilment can be improved.

For this study, we posed two sub-questions:

1. What are recent developments concerning physical flow of delivery and returns setup in e-fashion in the Netherlands and which logistics basic patterns can be distinguished?
2. What kind of PIs are used by the surveyed fashion companies and what conclusions can be drawn from this?

We were asked to investigate how control of e-fulfilment eventually could be translated into Performance Indicators (PIs). During this investigation, we discovered that the focus of e-fulfilment was on delivering goods towards the customer. This was strange as during the interviews many remarks were made by the respondents on the problems caused by goods returned by the customer. The lack of interest in returned goods also can be found in many publications on managing e-business (e.g. Chaffey, 2014) and even in a book written by professional experts on the new Dutch e-business customer (Van Welie, 2015). In this book returns are discussed as an aspect of customer relationship and a legal EU obligation and not as a profit cruncher.

METHODOLOGY

After an extensive study of literature, we asked 21 fashion chains for this research. 7 fashion chains - who represent the diversity of fashion companies in the Netherlands - accepted. We did a thorough qualitative study, based on in-depth interviews with logistics and supply chain managers. One of these companies only operates on the internet based on a long tradition of direct marketing; 6 are traditional High Street retailers who have setup a new internet distribution channel as a supplement to their main High Street activities. They vary in assortment, market segments and price-levels.

If we look at the type of business we can categorize them as follows:

- 100% e-shop (="clicks") : company A
  - has a brand platform in addition to his own collection
- Wholesale + e-shop and High Street (" bricks" : company E
  - sells its brand collection to other retailers
- Department store (bricks and clicks) : companies B and C
  - carries a wide range of products including fashion
- High Street chain (bricks and clicks) : companies D, F and G

- only sells its own collection

Table 1 below provides a breakdown of the different companies in the number of employees, number of stores (brick-stores) and how long the organization has been active in e-business (set date September 1st, 2014). Finally, we made a classification by the width of the fashion range offered on the company's website: XL for a very large range; L for a wide range; M for a medium range; and S for a limited range.

Company	Number of employees in NL	Number of brick-stores in NL	Years active in e-business	Width fashion range
A	500 – 750	0 – 25	>15	XL
B	7.500 – 10.000	500 – 750	8 – 15	L
C	10.000 – 12.500	50 – 100	6 – 8	L
D	1.000 – 1.250	100 – 200	4 – 6	M
E	1.000 – 1.250	25 – 50	2 – 4	M
F (*	7.500 – 10.000	750 – 1.000	2 – 4	S
G (*	5.000 – 7.500	500 – 750	2 – 4	S

Table 1 breakdown of participating companies in this study

(* Range with a low price density per item

First we needed to identify recent developments and characteristics of e-fashion. This was needed in order to create a basis for understanding the market and its logistics processes. Our field study in fashion companies started with mapping the different fashion retail distribution and return flows. Then investigated which PIs are used in order to monitor and supervise these logistic flows. On the basis of this analysis conclusions were drawn about the current use of PIs in the surveyed companies. We focused on fashion, especially the product groups clothing and shoes. We did not include high-fashion, given that in terms of scale and price category, this forms a special segment of the market. On basis of the findings of these interviews, we also set up an internet survey which was held under students and ex-students which were also asked to forward the survey to acquaintance. We wanted to understand how they valued the logistics of their internet fashion purchases, and how sustainability influenced their approach towards home-delivery and returning goods. In the 3 weeks of the survey 396 persons responded. Some of the questions asked in the survey relate to reasons for customers for returning goods, and provide insight in the question how to prevent goods being send back.

FINDINGS

In order to understand the physical flow of delivery in the e-fulfilment-structures, we used the model of Van Loon, Deketele, Dewaele, McKinnon & Rutherford (2014). This model - as shown in figure 1 below - shows which channels can be used for e-fulfilments.

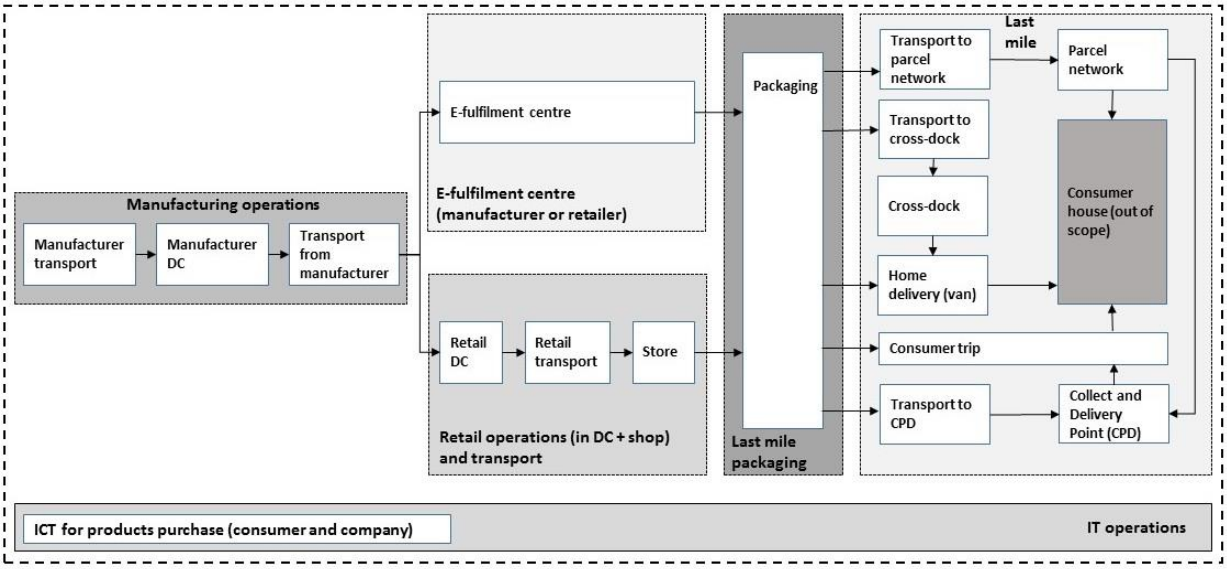

Figure 1 E-fulfillment: the different logistics channels from production to delivery to the customer (Van Loon et al., 2014)

The model depicts the various flows of goods and information for different combinations of bricks and clicks. As we are interested in the control and monitoring of these flows on the basis of PIs, we have to look deeper into the operation. Obviously, PIs should relate to the ordered goods in the right composition, in the desired quantities, at the agreed location, within the agreed time, with the right information and, provided with the correct invoice (Van Mook, 1995; Van Goor, Ploos van Amstel & Ploos van Amstel, 2014), and at least submit an image to deliver the reliability, completeness delivery, return policy, and the back office (Kotler & Armstrong, 2014).

Based on our interviews we found that fashion e-flows appeared to take a different routing in business practice than expected, and we had to redesign the model of Van Loon et al. (2014) in order to depict the situation for e-fulfilment of fashion in the Netherlands:

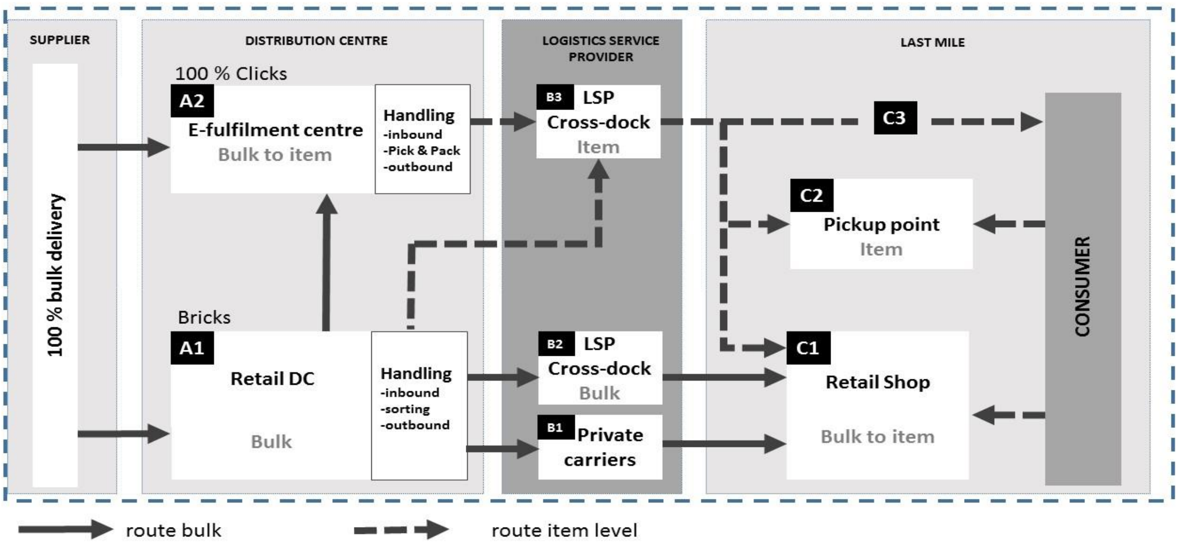

Figure 2 E-fulfilment in business practice for fashion in the Netherlands: the different logistics channels from production to delivery to the customer

On the basis of our analysis of the investigated fashion chains, we distinguish the following different structures for delivering goods to the e-consumer:

1. **Companies that implement e-fulfillment processes in their regular retail DC** (A1 in figure 2). Some fashion companies handle the products in the same way for both bricks as for clicks. The products ordered over the web, are stored individually, or packed as a whole consignment, and delivered via a logistics provider (B3) to the e-consumer (C1 to C3).
2. **Companies that, besides their own DC for the extradition towards shops, use a separate e-fulfillment warehouse** (A2). In this e-fulfillment center, all bulk streams are divided at lot level. After pick and pack, shipments also are delivered via a logistics service provider (B3) to the e-consumer (C1 to C3).
3. **Companies that pick e-commerce orders out of the stocks for the High Street stores** (A1). The logistics provider (B1) or the company's own trucks (B2) comes along at the end of the day to pick up the parcels destined for the e-consumers out of the regular – bulk- deliveries for the chain High Street shops (C1).

For the last mile / the final delivery to the consumer, we found we can distinquish four main variations. The first two options already are included in the model of Van Loon et al. (2014), the other two (c and d) are added by us:

1. **On item level:**
   a) delivery to the home address of the consumer (C3);
   b) or to a pickup point (C2) where the consumer picks up the ordered parcel;
   c) or to a specified High Street store (C1) where the consumer picks up the ordered parcel.
2. **On bulk level:**
   d) or to a specified High Street store (C1) where the consumer picks up a fashion item from the regular store stock. This construction increases the turnover of the store inventory and reduces the chance that clothes should become obsolete and end as a sale item. In this variation, the following problems can occur (Daukuls, Leeuw & Dullaert, 2013):
   - Store staff may lack time, or is not properly trained to handle e-sales;
   - When there is a lack of oversight of the available shop stocks, there is a chance that the product ordered is not in stock at the store and the customer goes home empty-handed.
   - If the company uses a sales bonus system for shop staff, it lacks an incentive to participate in e-sales.

As we saw, many fashion companies fully outsource their e-business to specialized e-fulfillment companies. Outsourcing the whole process, including handling and transport, can be noticedespecially at fashion companies that have a national coverage. For a large number of logistics service providers, e-fulfillment is a substantial part of their activities: e.g. Norbert Dentressangle, DHL, CB Logistics, TNT and Belspeed. In addition, a number of service providers in the Netherlands has specialized fully in e-fulfilment, like Docdata, Pondres and Misi. For a fashion business, outsourcing of e-fulfilment is obvious, given the great pressure on the company to lower costs, and its completely different character, compared to the regular flows of large bulk. When outsourced, fashion flows leave the retail DC (A1) in bulk to the fulfilment party's DC (A2), where the pick & pack activities takes place on a unit level, and fashion products subsequently are shipped (B3) to the e-consumer. Here again, we have the ability to deliver the goods to the delivery points C1 to C3.

The physical return flow is partly a reversal of the flow like the ones shown in Figure 2, with a number of modifications. Depending on the chosen "return formula" the product is send back to the DC, or to the store. The fashion chains that participated in our survey use the following formulas to facilitate the return by the consumer:

1. **The consumer returns the clothes to a High Street store** (C1 in figure 3). Thus the company avoids transportation costs. The shop either is re-selling the product in the shop, or destroys it. For the e-consumer this formula is reasonably

accessible. The customer must leave his own home but he/she can swap or match different clothes at the store. In practice, consumers do buy additional items. A number of companies recorded growth in retail sales after the introduction of this formula. Especially fashion retailers with a nationwide coverage offer this formula;

2. **The consumer returns the goods to a pickup point** (C2) being a post office or parcel point. From there on, the products are send (B3) to the DC. As a rule, to the e-fulfillment center (A2), but in some cases also to the – bulk – DC (A1). In both cases, the returned goods are re-evaluated for marketability, repaired if necessary, stored, or destroyed.
3. **A logistics service provider picks up the goods at the consumers home** (C3). After this, goods are send (B3) to the e-fulfillment center (A2) or the retail DC (A1).

On the basis of their sales and marketing approach, fashion chains determine which of these opportunities are offered to consumers. Offering the ability to return products for free, is often quoted as an argument to stimulate online buying. The different options are summarized in Figure 3.

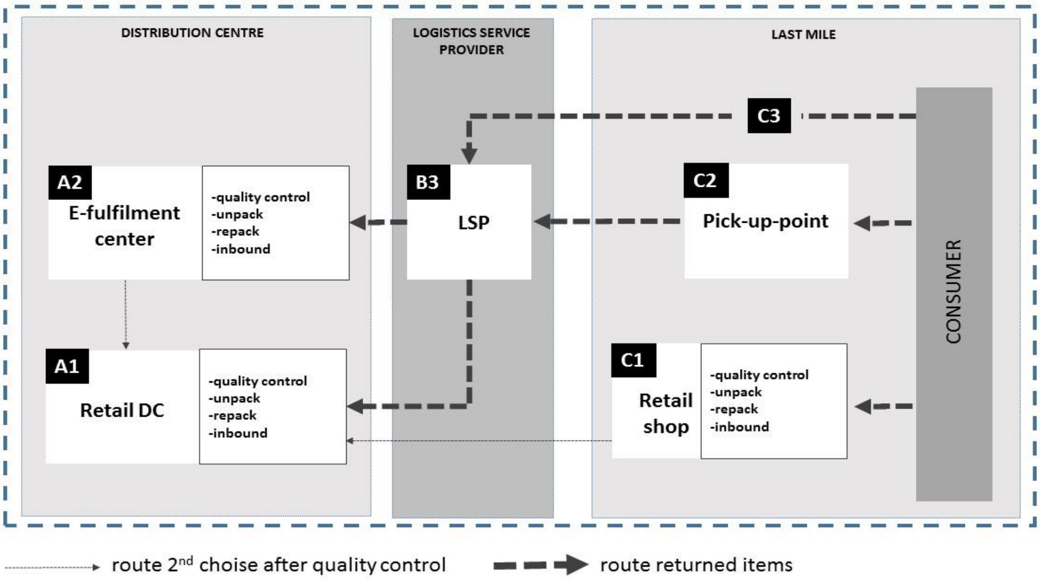

Figure 3 The different return channels for E-fulfillment in fashion, from customer towards DC

In table 2 a total overview is given of the PIs as used for delivery and return:

Company	A	B	C	D	E	F	G
PIs for delivery	17	17	16	16	18	10	10
PIs for returns	13	14	7	11	11	0	2
Total PIs	30	31	23	27	29	10	12

Table 2 Number of PIs used in delivery and return flows per company

Our research showed the following findings for PIs dedicated to monitor e-fulfilment processes:

1. All surveyed companies appear to deploy PIs. Many different ones, we counted a total of 39 different types of PIs.
2. Some companies use a lot of PIs – up to 31 – and some relatively few: 10 to 12.
3. Fashion companies with a narrow range of products and with products in the low price segment seem to apply few PIs, compared to fashion companies with a broad assortment in the higher price array.

4. Companies with an average and a wide product range apply relatively many PIs for the return flows. Companies F and G that are active in the low price segment and have a narrow product range, barely use any PIs for the return flows. At these companies, their High Street stores play a central role for their returns.
5. A number of PIs involve the same business process, but companies use different units of measurement, such as "cost per extradition ',' cost per item" or "cost per order".

Returns have a substantial impact on the profitability in e-business and should be well monitored and controlled. If possible, they should be avoided. Online fashion shops make it very easy for consumers to return any merchandise. Often easier as European legislation requires, which allows consumers to return e-purchased products within two weeks without giving a reason. Zalando in the Netherlands even offers a 100 days window for returning any goods bought with them (Zalando.nl). In business practice return rates amount to 30 to 40% for clothing, and 70% for shoes, as shown in our research. For various reasons a part of these returns no longer can be resold, and has to be discarded or priced down. From a customer's point of view our senses play a greater role in purchasing clothing and footwear than in many other purchase experiences. Even with clothes or shoes well photographed, the actual feel, look and even smell of the purchase prevails. In addition, the fit should be good and last but not least, the article should match other products that the consumer has already in his/hers wardrobe. Together, these elements form a substantial risk for the consumer to be disappointed with his purchase and to take the step to send the product back to the e- shop. Therefore it is interesting to understand the reasons behind the behavior of the e-customer for returning his purchase. The Dutch Knowledge Distribution Centre Logistics Gelderland conducted a survey (autumn 2014) on finding the reasons why e-customers were satisfied or not with e-fulfilment related to their fashion purchases. (Verbeek, 2015). We have found many aspects which do influence the goods being returned by e-customers; some are discussed in this paper, but the bulk will appear in a future article on e-fulfilment, fashion and sustainability. 301 of the 396 people surveyed did buy fashion online. The survey shows that 72 % of online fashion customers in most cases gamble about what size may fit them. And 86% of online-buyers of fashion products return the buying because they claim it does not fit. From the survey, there seems to be a correlation between the way a product is described on the web, and the rate of satisfaction with the purchase as is shown in table 3.

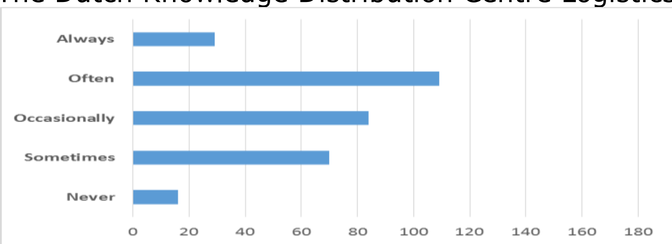

Figure 4 How often do you gamble that the chosen product will suit/fit your size?

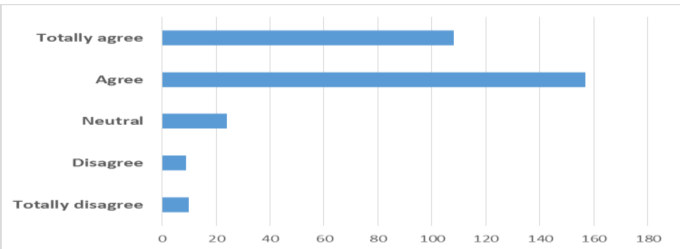

Figure 5 I return products due to the fact that they do not fit

		The information on the website was clear				
		Totally disagree	Disagree	Neutral	Agree	Totally agree
Satisfied with most recent purchase	Totally disagree	6	2	2	1	0
	Disagree	0	6	7	5	0
	Neutral	0	4	10	18	1
	Agree	0	6	22	140	8
	Totally agree	0	0	4	25	34

Table 3 Relationship between information on the website and customer satisfaction

CONCLUSIONS

We did this research to understand how fashion companies in the Netherlands organize their e-fulfilment, and how they control and monitor these processes.

We found that the surveyed Dutch fashion e-tailers have organized their e-fulfilment in a substantial different way as described by earlier – in part theoretical – models. This is due to the nature of the products, the market and the right of customers to return any purchased item.

Dutch e-fashion shops do appear to use PIs in order to monitor and control their e-fulfilment processes. Companies with an average and a wide product range apply relatively more PIs for the return flows, as compared to those companies that are active in the low price segment and have a narrow product range. But as the logistics costs are relatively higher for this low price segment, as compared to the items sold in higher price ranges, returns for the low price range should be avoided even more, as for the higher price range. It is therefore important that the fashion e-tailers operating in the lower price range not only should control and monitor their returns effectively: as all return products may cause enormous return cost, and as some returned products cannot be re-issued for new sales, it is vital that any return should be avoided as much as possible. Proper description and information and appearance on line is vital, as many customers do gamble with sizes, colors, etcetera, when ordering fashion items on line. More research is needed to get a better insight into these aspects concerning e-fulfilment for e-fashion.

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INVESTIGATING E-FULFILMENT IN GULF COOPERATION COUNCIL BUSINESS-TO-CONSUMER MARKETS

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Abstract

Purpose of this paper:
This paper reports on a literature review and research objective development pertaining to a current PhD research project on electronic commerce (EC), specifically e-fulfilment, in Gulf Cooperation Council (GCC) business-to-consumer markets (B2C).

Design/methodology/approach:
The literature investigated three categories of actors and related literature streams: pure player (PP) and multi-channel (MC) e-stores; third-party logistics (3PL) service providers; and consumers within the six GCC countries. Research objectives and semi-structured interview questions were developed and interviews have been conducted with 54 interviewees: 16 consumers, 28 EC firms or retailers and 10 3PL service providers.

Findings:
The literature trawl found different issues in offline and online markets, factors affecting EC and e-fulfilment, food and non-food EC, interactions between EC and logistical processes to achieve e-fulfilment, and the growth of EC in the GCC and its economic impact. The following three research objectives were developed from that review: what are extant electronic commerce (EC) and related e-fulfilment logistics processes in GCC B2C markets; are there significant differences between international and GCC e-fulfilment purchase and delivery methods; and to what extent does culture affect e-fulfilment processes in the GCC?

Value:
The study should provide three important outputs: a solid understanding of various methods in developing and managing e-fulfilment logistics services; an exploration of e-fulfilment in developing countries, particularly the GCC nations which is under-researched; and how they can benefit from other experiences regarding current infrastructure and cultural effects.

Research limitations/implications:
The data analysis is currently being undertaken and hence and findings from the field work and data collection are not yet available.

Practical implications:
The study should provide EC firms or retailers and 3PL service providers with insights into the state of EC and e-fulfilment in the GCC and suggest new strategies to make these practices more efficient, effective and relevant.

INTRODUCTION

This paper reports on a literature review and research objective development pertaining to a current PhD research project on electronic commerce (EC), specifically e-fulfilment, in Gulf Cooperation Council (GCC) business-to-consumer markets (B2C). The increase in the number of Internet users and GCC government investment has prompted this research to investigate how EC firms provide e-fulfilment services and what kind of logistical processes they implement. This research has also been motivated to explore e-fulfilment logistics in GCC countries, which have similar language, religion and beliefs. The overarching aim of this study is to suggest new strategies to make EC and e-fulfilment more efficient, effective and relevant in GCC countries. The study has the following three research objectives:

1. To investigate extant electronic commerce (EC) and related e-fulfilment logistics processes in GCC B2C markets;
2. To explore differences between international and GCC e-fulfilment purchase and delivery methods; and
3. To determine the extent of a cultural effect on e-fulfilment process in the GCC.

This study investigates three categories of actors: pure player (PP) and multi-channel (MC) e-stores, third-party logistics (3PL) service providers, and consumers from different cities within the six GCC countries (Kingdom of Saudi Arabia or KSA, Oman, Qatar, Kuwait, United Arab Emirates or UAE, and Bahrain).

The motivation for this study is to learn more about e-fulfilment logistics service in the GCC countries as EC there is expanding rapidly with growth in the number of PP and MC retailers. More than 200 e-firms are classified as either PP or MC with attendant issues such as transportation choice between road that may be slow or air cargo that is costly; no payment gateways except credit cards; inaccurate postal systems; and hard to return shipments. Further, 3PLs do not recognise customers by only using English language with Arabic native customers. E-firms have thus not developed or provided satisfactory models to fulfil customer needs in the region. Thus, investigating e-fulfilment in the GCC countries offers the opportunity for an in-depth study to provide contributions to literature and practice. Finally, studying the e-fulfilment literature and undertaking this study of a variety of firms' experiences can provide two important outputs: first, the various methods in developing and managing e-fulfilment logistics services; and second, an exploration of e-fulfilment in developing countries and how they benefit from previous experience with regard to current infrastructure and cultural effects. Finally, few previous studies have mentioned e-fulfilment logistics in Arabic countries or the GCC nations, which has also encouraged this in-depth investigation from a business perspective.

LITERATURE REVIEW

Any consideration of e-fulfilment requires an understanding of B2C relationships within which various logistical processes take place. E-fulfilment involves services that interact with various logistics activities from checkout until the shipment arrives. Moreover, the GCC and cultural factors both need to be assessed to reach an in-depth understanding of e-fulfilment element within that scope. Therefore, in this study the EC market has been classified into PP, which are firms that only sell online, and MC firms, which operate both online and have a physical store (Boyer, 2001; Burt and Sparks, 2003). Building trust is important for both types of operation. For example, a PP can be established and build trust to create a strong position in relation to consumers, as the processes are more flexible and more tightly controlled and the process and delivery flow easily to help the continuous development of the business (Elliot and Joseph, 2004). At the same time, MC firms have a way of reaching consumers easily with a smooth delivery process due to their ability to assemble a logistics system quickly and launch a delivery process as they are already in the market; this point can represent a risk for PPs as they have to create an effective logistics system (Gurãu et al., 2001; Maltz et al., 2004). Further, EC has expanded globally and in 2011 the market was estimated to be US $10 trillion, with a $240 million share going to B2C (Veronica, 2012). Nielsen has listed the top products and services sold online globally: books, clothing/accessories/shoes, airlines tickets, electronic equipment, tours/hotel reservations, cosmetics/nutrition supplies, event tickets, computer hardware, videos/DVDs/games and grocery (2010: 2).

Offline and Online Markets

Competition between PP and MC retailers is still growing according to several studies (Kauffman and Walden, 2001; Urbaczewski et al., 2002; Ngai and Wat, 2002). However, this has carried more pressure to fulfil consumers from ordering to processing and ending with minimizing delivery lead time (Lieber and Syverson, 2011). At the same time EC has had significant growth. Figure 1 shows a rapid increase during 11 years from $4.5 billion to $41.5 billion (Ramcharran, 2013). There is still significant competition between PPs and MCs with regard to prices and products; Brynjolfsson and Smith (2000) examined 42 offline and online firms and found online prices to be lower by 9%-16% compared with offline. However, buying online is still a controversial subject. Buying offline has strong points such as not having to wait for a delivery, cost of travelling, and the availability of products with the option to exchange immediately at lower cost, whereas on-line leads time are still critical, consumers are not very sure about the suitability of products, and the challenge of returning products at extra cost and the process taking a long time.

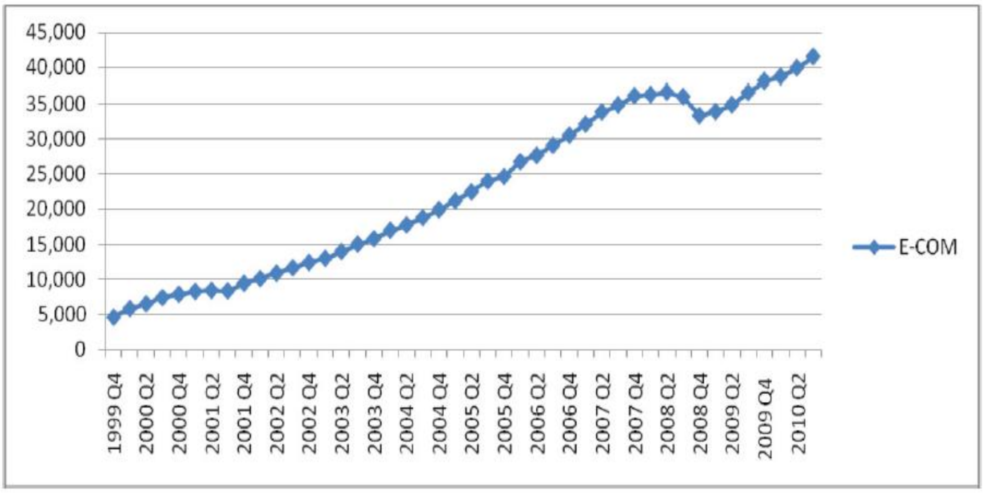

Figure 1: EC sales growth (in $ millions) from 1999 to 2010 (Ramcharran, 2013)

PPs have greater advantages and profitability than MC firms because investment in technology and developing a supply chain provides them with an advantage in the market when looking to develop strong relationships with customers and makes the process faster with lower prices. Amazon.com, the giant PP with a mass product operation model, can still achieve success in sales and customer loyalty. Amazon is valued at more than $79 billion, which is 40% higher than Target and Kohl's that have 2,800 stores (Lieber and Syverson, 2011). Amazon and some pure-player corporations have created distinctive brand names and customer loyalty, and individuals will pay $1.72 extra to buy a product from Amazon (Brynjolfsson and Smith, 2000). Global offline sales in 2008 were considered to be $18.7 trillion, whereas online sales were recorded as $3.7 trillion (Ramcharran, 2013).

Factors Influencing Electronic Commerce (EC)
EC has certain factors that can affect the fulfilment process, whether PP or MC. Consumer culture, for example, is considered an important part of the process as some consumers prefer to deal directly with product so that they can touch them, such as food or clothes. Further, there is differentiation between large and small cities in terms of services; in large cities the extent of sharing pictures and downloading music and movies is still higher than in small cities with regard to the availability of technological tools and population numbers (Hortaçsu et al., 2009). Quaddus and Achjari (2005) classified the drivers of EC success and impediments to it from internal and external factors as shown in Table 1.

Contribution to success	Locus of impact	
	Internal	External
Driver	1. Cost leadership 2. Reputation 3. Market 4. Business entry	1. Product pricing 2. Time spent 3. Convenience 4. External relationship
Impediment	1. Financial 2. Risks 3. Expertise	1. Customer's expense 2. Delivery time 3. Transaction risk 4. Access

Table 1: Internal and external factors that affect EC (Quaddus and Achjari, 2005)

Types of Grocery and Non- Grocery Electronic Commerce Operations
In many developed countries firms sell groceries online and deliver them, but not so much in GCC countries. Delivering groceries to consumers is still a difficult process to accomplish easily, as there are challenges involved that are of greater concern than for non-foods, such as temperature, speed and quality, the ability to exchange, the variety of brands and physical delivery (Sherah, 2008). In addition, launching an online grocery business is considered by PPs and MCs to be both costly and risky. Table 2 shows some of the leading grocery firms throughout the world and highlights the differences in their experience and various services (Tanskanen et al., 2002; Al-Nawayseh, 2012).

Table 2 also reveals various firm strategies throughout the world, whereby each country has a particular economic situation and different sorts of culture. For example, the table begins with a multinational corporation, Tesco, which invested $58 million in e-grocery to provide deliveries of products based on the pick-up model. The table also reveals other and different scenarios that have occurred, as businesses have either succeeded, been bought or have ceased trading, which suggests that selling groceries online is still a critical business. For example, Streamline began as a grocery PP by investing $80 million and was later sold to Peapod. Moreover, Peapod started the logistics process as a delivery service before being bought by the second-largest e-grocer in the world, Royal Ahold. Also, in 1999 Webvan in the US had invested an estimated $120 million to provide a high-tech model of picking groceries from a dedicated distribution centre, more than double the amount of Tesco. However, three years after the project started, Webvan went bankrupt.

Books and clothes appear at the top of the Nielsen list (2010) referred to above. In addition, one study (Ghezzi et al., 2012) analysed the percentages of EC penetration in both the US and Europe. As shown in Figure 2, the US online market still occupies a higher percentage than for the whole of Europe for clothing, followed by books and DVDs, with a low percentage for grocery for both regions. The previous figures increased the demand for 3PL and companies such as FedEx and UPS hired more people for deliveries (Ramcharran, 2013).

	Tesco UK	Sainsbury's UK	Webvan USA	Streamline USA	Peapod USA	Carrefour France	Ito-Yokado Japan
Background	The biggest supermarket chain in the UK	The second largest supermarket chain in the UK	Started as a pure e-grocer in1999	Started as a pure e-grocer in 1992	Started home delivery service before the Internet in 1989	The largest hypermarket chain in the world in terms of size	The largest supermarket chain in the Japan
Investments in e-grocer development (Approx. in US millions)	$58	$40	$120	$80	$ 150	$100	$140
Main operational mode	Industrialized picking from the supermarket	Picking from the supermarket or (DC) in London.	Highly automated picking in distribution centre (DC)	Picking from the distribution centre, reception boxes, value adding services	Picking from both (DC) and stores	Picking from the supermarket	Picking from the supermarket
Current status	The biggest e-grocer in the world. Expanding its operations outside the UK. Partnering with Safeway and Groceryworks.	53 stores occupying 73% of UK	Operations ceased July 2001 Bankrupt	Parts of operations were sold to Peapod in September 2000. The rest of operations ceased in November 2000.	Bought by global grocery retailer Royal Ahold. Second biggest e-grocer in the world.	announced that it was "highly likely" that it would dispense with its Champion fascia, with all stores expected to be rebranded under the Carrefour name	There are 174 Ito-Yokado stores operating in Japan. Expanded to China, where they formed a joint venture with Wangfujing Department Store and China Huafu Trade & Development Group Corp

Table 2: Grocery market leaders and retailers (developed from Tanskanen et al., 2002; Al-Nawayseh, 2012)

	USA	Europe
Apparel	17%	5%
Books, CDs and DVDs	35%	15%
Grocery	2%	1%
Consumer electronics	38%	33%
Tourism	25%	22%

Figure 2: Penetration percentage of EC in Europe and the US (Ghezzi et al., 2012)

Logistics and Electronic Commerce Fulfilment or E-fulfilment

E-fulfilment has a complex relation in many organizations, whether locally or globally, as each logistics element can be affected from the point of despatch. Logistics has a strong effect on an economy and can affect gross domestic product, economic growth and society as a whole. The cost classification of logistics can be divided into four major sectors: transportation, warehousing, inventory and administration (Grant, 2012).

Focusing on logistics activity can lead to more production and enhance efficiency while maintaining the quality of products, which in turn leads to consumer loyalty that comes from speed of delivery with proper shipment conditions. For example, Logistics Manager (2004) reported that Procter and Gamble has 300 variously branded and named products and spent £23 million on restructuring its logistics infrastructure and focusing on its supply chains to keep the flow of products moving while taking into account its relationship with its suppliers. Two distribution centres were placed in the north and south of England, providing global positioning systems and using advanced information technology tools in seeking solutions.

Product delivery from point of origin to the point of consumption (Grant, 2012) is a complex process and combines two fields: marketing services and logistics activity. There are five activities common to both fields: people, processes, place of sale or distribution, power and planning and control. Further, packaging products and then delivering the shipment at a precise time in good condition to the right place and person relies on physical distribution, which in MC delivery systems can be assembled more easily than for PP. However, building a home delivery system or outsourcing outbound activity is considered one of the obstacles, particular for pure players. Amazon and Dell have similar supply chain strategies whereby they outsource the last stage of their delivery service to a 3PL service provider. Physical distribution is one of the processes that deal with finished products and integrates the satisfaction of firm and consumer requirements (Xing et al., 2010). An e-fulfilment physical distribution service quality (e-PDSQ) model was developed by Xing et al. (2010) for non-grocery and contains four constructs - timeliness, availability, condition and return - and 15 variables.

Grocery sales are discussed in the literature to a greater extent than non-foods, which reflects the various challenges in this sector that relate to the differentiation of consumer behaviour. The greater number of e-grocery studies from the business and consumer perspective have the advantage of providing feedback to help adapt e-fulfilment services. For example, Amazon.com has launched a new line to deliver groceries in some states in the US and Germany. There are further factors for consumer e-fulfilment support such as arranging online grocery delivery to avoid congestion, the availability of service 24/7, the ability to choose delivery time and method, the option of various brands with expiry dates, and consumer reviews (Ghazali et al., 2006; Scott and Scott, 2006).

Therefore, EC logistics has been growing and discussed from different angles, from retail to strategy. EC logistics is often involved in B2C and consumer-to-consumer (C2C) transactions and, because sales has a separate delivery channel, it often handles physical distribution (Benjamin and Wigand, 1995; Delfmann et al., 2002). Increased delivery capability has led to an expansion in network delivery to reach consumers and enhance cost efficiency. Bask et al. (2012) did a systematic literature review of EC and logistics and noted that logistics played a minor role in most studies. However, they found three areas of importance that need to be considered together due to their interactions: the retailer’s online strategy, its logistics and delivery infrastructure, and consumer preferences. Tanskanen et al. (2002) noted that developing EC logistics systems should first be done locally and then tested in a wider market.

B2C is considered vital in EC logistics and affects capability and firm strategy, whereas business-to-business (B2B) often follows traditional logistics processes. In addition, EC can be influenced by the location of the inventory and whether the warehouse structure is centralized or decentralized, and if the inventory is outsourced or uses the same producer or retailer. Various logistics capabilities have been discussed (Cho et al., 2008), while others (García et al., 2007) argue that an efficient method would be to choose warehousing. However, some research has added a way of applying outsourcing that comes from two parts of a strategy: capacity with flexibility and a global presence (Delfmann et al., 2002). Another concern is that different segments of customers emerge as a result of the differentiation of logistics strategies. Cao and Zhao (2004) have discussed customers' demands as individuals and as EC consumers, identifying that EC retailers should be aware of the performance of delivery and maintain service in e-fulfilment accordingly. Bask et al. (2012) argued that most EC studies focus on digital channels, which better combine the electronic channel and bricks and mortar. In addition, logistics needs to enhance the study of B2C and C2C trade in order to identify fulfilment solutions for the structures, services and processes of EC. Appropriate delivery has recently been considered in the e-PDSQ model by Xing et al. (2010), and the value of time in the shopping mode has also discussed (Hsiao, 2009) and found to be related. Delivery time is considered a vital factor for customers when choosing between stores (Cao and Zhao, 2004).

The Gulf Cooperation Council (GCC)

The GCC is composed of six countries: Saudi Arabia, Kuwait, Bahrain, Oman, the United Arab Emirates and Qatar. These countries are similar in a number of ways e.g. religion and culture, have a total population of 46.7 million, and inhabitants have full e-government support with plans to link networks. The highest number of Internet users in the Middle East is in Saudi Arabia, followed by Iran (Omari, 2013; Menatech, 2013). In addition, some factors are important to study PP and MC such as transportation, inaccurate postal systems, cash on delivery payments, and how women might receive orders under culture and religion factors. More than 200 PP and MC firms strive to find suitable logistics systems whereas 3PLs are still not considering B2C in GCC as a target market segment. Al-Nawayseh (2012) investigated e-grocery in Jordan and concluded that the collection model is an appropriate one for consumers and might help female customers in GCC countries, especially in Saudi Arabia were women are prohibited from driving. Another important factor is that delivery personnel cannot easily deliver a shipment, as this might be considered suspicious. On the other hand, a number of Gulf countries have been placed among the top 50 countries in a United Nations e-government report (Omari, 2013). Moreover, the World Bank's (2014) Logistics Performance Index (LPI) notes that the quality of logistics services is central to trade efficiency and is strongly associated with the reliability of supply chains and the predictability of service delivery available to producers and exporters. From the list of 166 countries included in the 2014 LPI, the Emirates, Qatar and Saudi Arabia are among the top 50 (at 27, 29 and 49 respectively), which reflects the condition of different factors, among them infrastructure and transportation.

CONCLUSIONS AND CURRENT STATE OF THE RESEARCH STUDY

The foregoing trawl of the literature has noted different issues in offline and online markets, factors affecting EC and thus e-fulfilment, food and non-food EC, the interaction between EC and logistical processes to achieve e-fulfilment, and the growth of EC in the GCC and its economic impact. The review has thus led to the three research objectives noted in the Introduction.

The choice between different paradigms for this study was driven by the exploratory aim of the research and the resultant research objectives. Thus, this research attempts to understand the meaning of an applied interpretive paradigm. The major reason for adopting an interpretivist paradigm is that few data exist regarding logistics activity in e-commerce in GCC firms, whether PP, MC or 3PL logistics services and e-fulfilment between retailer and consumers requires more investigation. In addition, adopting an interpretive paradigm assumes that *"the social world is mostly what individuals perceive it to be, and that reality is socially constructed as individuals attach meaning to their experience"* (Narcisse and Harcourt, 2008) (p. 1156). Further, seeking details regarding such situations allows a researcher to obtain deep understanding of the phenomena of interest. An interpretivist paradigm was therefore considered suitable for this study.

Qualitative techniques for collecting relevant data are relevant to such an inductive strategy and thus semi-structured interviews were used to obtain data about the phenomena of e-fulfilment logistics across all six GCC countries. A total of 54 interviews were conducted in GCC fieldwork from the period May to September 2014: 16 with consumers, 28 with EC firms or retailers, and 10 with 3PL service providers. At present data analysis is currently being done on a within-case basis for each GCC country. Following that, a cross-case analysis will be done to determine similarities and differences among the GCC countries and to compare theory and practice to the literature in order to delineate the theoretical contribution of this study and provide suggestion for EC firm and 3PLs in the GCC.

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THE IMPACT OF INFORMATION TECHNOLOGIES ON LOGISTICS SERVICE PROVIDERS' OPERATIONS – A CASE STUDY

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ABSTRACT
Essentially, logistics provision comprises of the organisation and management of two process flows: the physical flow, concerned with the storage and movement of product, and the information flows, that exist to support the physical flow services. This research focusses on the latter more intangible flow, which is increasingly being focused on and developed by logistics service providers (LSPs) and thus used to support their ambitions to differentiate their business offering from competitors.

The study explores two related questions in this area:

- how can a LSP use its ability to manage information flows to support performance improvement; and,
- why, from a theoretical perspective, should a LSP strive to improve performance through enhanced information management capabilities.

A case study methodology is adopted and through combining primary and secondary multiple methods an in-depth review of the information system that has been developed by a world-leading LSP is focused on for the research. The Resource-based View theory, is used to appraise and assess the competencies and combined capabilities that this LSP has managed to build-up through the development of its information technology systems and processes.

The findings are perhaps somewhat paradoxical in that rather than the LSP using its clear prowess in information technology to "entrap" customers, it instead deploys a layered approach and for some customers allows a "free movement" approach which differentiates itself from competitors. This finding runs against the strategic ambition of developing "stickiness" for customers, thus making it harder for them to leave to take their business elsewhere, leading, in theory, to longer more durable inter-organisational relations and contracts. Instead, by providing more of what some customers may actually want, 'a plug and play' mentality, the LSP is providing an alternative way to differentiate themselves though their development and use of information systems, to attract, retain and develop their business customer base. Thus, we argue that traditional lock-in strategies, while useful for securing repeat business, can have a detrimental effect on customer satisfaction. Instead, enabled by recent ICT advances, flexible information linkage provisions bring new alternative competitive advantages to LSPs.

INTRODUCTION

For companies specialising in logistics provision, known broadly as logistics service providers (LSPs), the marketplace for their services is characterised as being highly competitive, particularly in developed economies. The various factors which have contributed to this include globalisation, deregulation and ever-more demanding customers. In addition, logistics provision has become increasingly strategically critical in recent decades. This is predominantly attributed to the integral role it plays in modern, tightly managed, time sensitive supply chains, which have invariably been extended by global procurement strategies (Zeng and Rosetti, 2003). Given this background, there is continuing pressure on LSPs to constantly reappraise their value propositions (Tian et al., 2009).

Essentially, logistics provision comprises of the organisation and management of two process flows: the physical flow, concerned with the storage and movement of product, and the information flows, that exist to support the physical flow services. This research focusses on the latter more intangible flow, which has traditionally been developed by LSPs to support their ambitions to improve their value proposition with regard to timeliness, accuracy and flexibility (Closs et. al., 1997) and thus to differentiate their business offering from competitors (Aldin and Stahre, 2003). Previous research in this area has mainly focused on individual logistics activities that are facilitated through the application of information technologies to improve performance. Comparatively, little research has been conducted on how a 3PL company integrates various information systems into its routine operation process collectively based around a customer value based perspective. This research will examine how a leading LSP is using its ability to manage information flows to support performance improvement centering on value creation, but it will also explore why, from a theoretical perspective, it is striving to achieve this.

Consequently our research questions are:

- how can a LSP use its ability to manage information flows to support performance improvement that lead to value creation for its customers?
- why, from a theoretical perspective, should a LSP strive to improve performance through enhanced information management capabilities?

The paper is structured as follows. After this introduction, a literature review presents the background to the paper identifying the research gap the study aims to contribute to. It provides an appraisal of the strategic development of logistics service provision by LSPs, summarises the research that has investigated how logistics performance can be defined and presents an overview of how information technology utilisation has been deployed by LSPs. It also reviews the theoretical research, focusing particularly on the Resourced Based View of the firm, asking why technology management competencies have been seen to be so important to LSP’s competitive positioning. A case study methodology is adopted and, through combining primary and secondary multiple methods, an in-depth review of the information system that has been developed by a world-leading LSP is focused on. The Resource Based View theory, is used to appraise and assess the competencies and combined capabilities that this LSP has managed to build-up through the development of its information technology, systems and processes. After the results are presented, an analytical discussion relates the findings to the literature base before conclusions are drawn.

LITERATURE REVIEW

Logistics Service Provision

Over recent decades the demand for outsourced provision of logistics services has grown considerably with LSPs being increasingly accepted by organisations of most sectors. For instance, US-based LSP companies have increased their average yearly earnings from 545 million dollars to 122 billion dollars over a ten year period from 1997 to 2007 (Min and Joo, 2009). With shippers (customers of outsourced logistics) left to concentrate on their core competencies LSPs are also increasing the depth and scope of their activities with decisions connected with what activities are outsourced moving from being taken at a local to a corporate level (Rahman, 2011). The increasing importance of supply chain management and the criticality of logistic's role in this pursuit has also heightened the strategic importance of outsourced logistics provision (Bolumole, 2001).

However, the development of LSPs is not without its significant challenges. With globalisation, competition in the industry has incessantly intensified, as is found in many sectors today. Many logistics activities too have become quite commoditised making it hard for LSPs to differentiate their offering to provide a credible basis for survival. And, customers are continuing to demand more and more for less and less despite many factor prices increasing year on year (perhaps with the exception of diesel and lubricant prices at the end of 2014 and into early 2015). Indeed, many customers of LSPs are reviewing what adding value LSPs are providing for their organisations (Power et al., 2007). The state of the market is such that the shipper can really almost dictate their terms to the LSP. In turn, in order to further improve the values they can provide their shipper customers, which is an important determinant of how customers perceive 3PL companies and can add value to their businesses, the LSPs are looking at dynamic elements of their business (Tian et al., 2009), such as the potential for adopting developments in ICT to improve their logistics performance.

Information Technology in Logistics Provision

It is frequently claimed that organisations can be transformed by the impact of information technologies (Crowston and Myers, 2004). Information technology (IT) can be defined as "any computer based software or hardware systems, telecommunications equipment, and other dedicated technologies for data processing, storage, transmission, and communication that add value to the process" (Lai and Mahapatra, 1997). A firm's IT management capability plays an important role in developing other firm's capabilities for customer management, process and performance management (Mithas et al 2011).

In addition to the traditional material flow, the Council of Logistics Management has since 1988 included information flow in its definition of logistics (Bowersox and Closs, 1996). So, what can be termed broadly as logistics information systems refers to the collection of systems that process the flows of information connected to the physical material flows. Similar to the material flows, supply flows have become more tightly managed. They have also become more integrated with other flows. So, the notion of right information, right time and right place applies just as much to information flows as the core physical flow. One of the keys is to develop abilities to convert data from information flows into appropriate decision making which makes it so valuable and a potential source of competitive advantage for LSPs if they get it right from the perception of their shipper customers.

So, clearly IT is a core component of logistics and thus Closs et al's (1997) point that logistics performance can be improved by enhanced information technologies is self-evident. Examples include, transport and fleet management systems (TMS and FMS), warehouse management systems (WMS), tracking & tracing (T&T), sales systems, customer relationship management systems (CRM), e-Commerce, electronic data interchange (EDI), barcodes, radio frequency identification (RFID), etc. Each category of IT has attracted a research focus in relation to logistics management. So for instance, Stefansson and Lumsden (2009) examined how TMS impacted upon supply chain performance. Also research on the importance of integrating many of these systems together to achieve world leading performance at the time was argued by Closs and Savitskie (2003). Performance has multiple dimensions: see for instance, Johansson et al.'s, (1994) customer value metric where quality, service, cost, and lead-time are four fundamental elements that influence the customer perceived value. IT enhancements have the potential capacity to have multi-dimension benefit boosting the primary goals of logistics such as improved efficiency, such as lower inventory levels, or enhanced effectiveness, such as better on-time delivery rates, or more flexibility, such as faster response to accommodating urgent shipments. When customer values are fully appreciated and completely aligned with logistics decision making, LSPs can make a significant difference to total shipper customer performance in practice (Yazdanparast et al., 2010).

Developing and Sustaining a Competitive Advantage

Developing and sustaining a competitive advantage is an attribute that is desired by all firms in their strategic quest for on-going survival and success. Based on the theory of the Resource-Based View of the Firm, which argues that firms within an industry may be heterogeneous with respect to strategic resources and that these resources may not be perfectly mobile across firms (Barney, 1991), a useful tool to examine the firm in this regard is the VRIO framework: Value, Rare, costly-to-Imitate, Organisationally-supported (Barney and Hesterly, 2005). In summary it poses four questions that should be asked about a resource or capability in identifying whether it forms the basis of a competitive advantage position for the firm. These questions are: is the resource of value, is the resource rare, is the resource imitable and is the organisation organised to support the exploitation of valuable, rare and/or costly-to-imitate resources? Resources can be tangible, intangible or organisational capabilities and a competitive advantage is achieved by implementing a value creating strategy not currently or potentially being imitated by any competitors.

METHOD

Due to the exploratory nature of our research, the case study methodology was adopted and, through combining primary and secondary multiple methods, an in-depth review of the information system that has been developed by a world-leading LSP (hereafter as CaseLSP) was undertaken. In addition, as the day-to-day operations of a LSP company reflect the real phenomena of logistics activities, it further justifies the adoption of qualitative research to reveal social reality. Moreover, Yin (2002) suggests a case study strategy is preferred in research that tends to answer explanatory questions such as "how" and "why", because these questions cope with operational process that required to be observed on a continuous basis instead of sporadic occurrence.

However, a single case study has limitations. Voss et al. (2002) argue that a single case study suffers from not being able to generalise conclusions, as research findings are based on only one object. Besides, it may potentially result in biased judgment and contain representativeness issues, or be prone to an exaggeration of available data. But this does not mean single case study is an invalid research method. Single case studies have become recognized as being reputable as they can provide through context concentration greater in-depth comprehension than multiple case studies and have the capability of providing a powerful description capability Shakir (2002). Yin (2002) points out the content richness that a single case study is able to reveal has formed the foundation that ensures that a single case study is now respected as a valid method. Hence, taking accessibility, richness, and validity into consideration, this research considers conducting a single case study on a third-party logistics company – CaseLSP is appropriate which is chosen because of its global leading position as a 3PL company that represents what is typical of the industry. Indeed, CaseLSP is one of the world's biggest transportation and logistics providers employing more than 95,000 people in 140 countries at around 2,000 locations in the world's most important economic regions. CaseLSP businesses cover rail freight, air freight, ocean freight, warehouse, land transportation, customs clearance and other value-added logistics services. (CaseLSP, 2015).

This research deployed both primary data, via interviews (with five leading members of the company's Ocean, Air General Divisions) and a questionnaire (involving 10 members of the same divisions based in the company's operation in China) supported by secondary data obtained via documents, internet sources and other applicable methods. Denscombe (2007) mentions the use of multiple data source enables data to be triangulated, which therefore strengthens data validity and overcomes the problem of a biased or myopic response from one source. In particular, air freight export and ocean freight export operation are investigated as they represent the core businesses of a 3PL company that coordinate shipper, consignee, carrier, warehouse, truck distribution, customs brokerage, and other logistics activities together.

RESULTS

The findings show a variety of information applications were deployed by CaseLSP to manage its information flows within the company and with its clients and related parties such as carriers and government bodies (e.g. custom clearance, etc.) E-commerce is used as a supplementary platform for handling shipping orders, preprocessing shipments booking, and sending pre-alerts. Customer service teams then need to coordinate with the hub operation team which is in charge of contacting carriers and warehouses to reserve freight space, confirm freight rate, and reserve warehouse space. Once these procedures are settled, a dedicated application is applied to manage shipment information with carrier space, freight rate, and warehouse space to produce working sheet which standardize the shipment data entry in the Freight Management System. The most important system that the entire process hinges on is the Freight Management System. Here documentation teams input mandatory shipment data into the Freight Management System and produce necessary shipping documents including HBL, cargo manifest, and invoices. With regard to physical shipment movement, once necessary documents for custom clearance are ready, trucks are assigned through TMS (truck management system) to pick up shipments from shipper's premises to CaseLSP designated warehouses where WMS (warehouse management system) and bar-coding technologies are adopted. Shipments will then be transported to carrier terminals awaiting loading according to planned shipping date. Customer service teams electronically send shipment arrival details to CaseLSP destination agents. Other systems such as electronic billing and business objects are integrated too.

ANALYSIS

Using Johansson et al.'s, (1994) customer value metric where quality, service, cost, and lead-time are the four fundamental elements that influence the customer perceived value, Table 1 provides an analysis of how the Information Technology system can create customer value for CaseLSP. It is clear how multiple dimensions of enhanced value have been created by CaseLSP for its customers, confirming what was found in the literature.

Quality	Direction	Element	Information technologies implementation	Cost	Direction	Element	Information technologies implementation
	Improvement	Capability of total quality service and integrated process management	Freight managemet system		Reduction	Reducing related operating costs of shipments	Space share consolidation;Co-Load in; Co-Load out (freight management system)
		Accuracy and precision of shipments	Working sheet system; Standard Operation Procedure			Reducing related overhead, charges and fees	Paperless Internal invoice (freight management system)
		Improving customer satisfaction	Customized IT systems (Electronic billing system; OEM invoicing system)				
Servcice	**Direction**	**Element**	**Information technologies implementation**	**Lead Time**	**Direction**	**Element**	**Information technologies implementation**
	Improvement	Reliability	Event entry performance review (Freight management system;Business Objective reporting system; other applications)		Reduction	Reducing lead time of core logistics services	AMS custom clearance (TRAXON freight management system)
		Providing diversity of value-added services	Statistical reports periodical delivery (Business objective reporting system)			Reducing the non-value-adding time	Warehouse data entry (Bar-coding;freight management system; WMS)
						Implementing integrated logistics information system	Cross-docking (RFID)
		Availability	New functions; New modules (Freight management system)			Quick responsiveness	Online quotation & booking (e-commerce)
						Quick responsiveness	Shipment tracing (tracking & tracing system)

Table 1: An analysis of value enhancement (based on the Johannson et al., 1994 metric) via CaseLSP Information Technology systems

For the second part of the analysis the research examines why, from a theoretical perspective, a LSP should strive to improve performance through enhanced information management capabilities. Three principal points can be focused on:

- The information system has driven up standards as data entry is at a single point, accessed by all output services. Emphasis is placed on ensuring data entry complies with all regulatory strictures. The Freight Management System can respond efficiently through either modifying current functions or adding new modules to the system to any market or industrial regulation changes. One example relates to the creation of special air cargo manifest for shipments shipping to the United States.
- The Freight Management system has acted as a catalyst to cross-organizational integration. All functions are now inter-linked together around the information system which in turn is linked to customers.
- The information system has provided improved customer service levels. Fundamentally, service reliability is backed up by the use of this kind of multiple system. Moreover, the business objective reporting system run off the system provides a diversity of value-added services. Key account clients often require periodical statistical reports on for instance, shipment counts, pieces, weight, volume, or invoice amounts, all of which can be sent automatically. This information analysis based service builds on the bundle of value added services instead of just relying on general service that stems from the physical shipment movement.

There are clearly multiple practical benefits that have been derived from the enhancements to the information system. But has the competitive position of CaseLSP been boosted? What is interesting to reflect on in this regard is CaseLSP's approach to the adoption architecture designed into information system by CaseLSP and the consequent layering options presented to customers.

The architecture can be divided into three layers. Layer I is a core level where the information system is integrated through major operational functions to support every aspect of customer value metric involving quality, service, cost, and lead time (e.g. Freight Management System). Layer II can be individually customized functional systems that using data source provided by Layer I via EDI or other means and developed for diversified purposes to support either one or multiple aspects of customer value metric (e.g. Reporting System). Layer III can be standalone system or individual information technology used for a particular operation to support just one aspect of customer value metric (e.g. Barcode).

Depending on the level of service and integration that customers desire CaseLSP can vary the degree of inter-operability between themselves and the customer ranging from highly tailored, very integrated levels of information support to more of a "plug and play" option where there are no tie-ins entrapping customers by the way the system operates at all.

When related to the Resource Based Theory of the Firm what CaseLSP have achieved is a multiple approach. At one extreme they have used the physical resource of the information system to produce highly sophisticated, tailored information services that are valued by certain customers but make it difficult for them to switch allegiance to other logistics providers. At the other extreme, using a different layer of the same information system architecture CaseLSP provide a much less onerous, freer service, where customers can access the basic logistics service of the company supported by key information system support but without the benefit of tailored added value information services or the burden of being "entrapped" by this kind of integration.

CONCLUSIONS

An in depth investigation has been carried out into how a world-beating LSP, CaseLSP, uses information communication technology to differentiate itself compared to the competition it faces. To undertake this, the study has conducted a thorough review in detail of CaseLSP's deployment in IT. Two questions have been addressed: how can a LSP use its ability to manage information flows to support performance improvement and why, from a theoretical perspective, should a LSP strive to improve performance through enhanced information management capabilities? In terms of the first question it has been found that CaseLSP has improved customer satisfaction due to the development of its information technologies provision capabilities. This competence has strengthened the relationship between it and its major customers and the probability of signing long term contracts with those customers is expected to increase due to improved service derived from mutual trust and interdependency.

In terms of the second question though CaseLSP has applied a spectrum of strategies. Improving customer satisfaction through developing tailored systems for key account customers has contributed to the developmemt of customers who are tied in, but also CaseLSP has developed other "layers" where a more "plug and play" policy can be adopted by customers that wish this level of service with no burden of entrapment at all. So perhaps counter-intuitively, the study has found that although CaseLSP has developed an advanced form of information system, rather than using this to create circumstances where all customers become locked into a relationship with them, they have created an alternative option where the customer is free to come and go as they please. This provides an interesting finding for the logistics sector as it suggests a different avenue for creating competitive advantage. The flexibility and agility it provides on information configurations with its customers allows technological infrastructure resources to be re-provisioned when necessary. This is a unique appealing value proposition to its customers. Knowing they can exist when market conditions change will put shippers mind at ease and actually creates more voluntary 'stickiness', other than a bitter feeling of being "locked in". This new way of service provision coupled with recent technological advances such as cloud computing could potentially transform the way supply chains are structured and logistics services are provisioned. In some ways too it continues the trend observed over many years of the commoditisation of the services offered by providers of logistics.

The finding also provides a challenge to the theory of competitive advantage as outlined by the RBV theory. The strategy previously advocated to use competencies to tie all customers in. Although representing an attractive proposition to the provider in reducing the customers who display fickle behaviour and switch providers, in reality this may lead to an inferior service if customers value the ability to work with a LSP with no strings attached and no obligation to continue working with this provider. So it would appear that LSPs should avoid the temptation to provide services which are designed to tie customers in, as many customers would actually prefer more flexible contracts than this. This is just a single case study undertaken on one focal company. Thus there is a clear limitation of the study and our ability to be able to generalise from the research. Nevertheless, the research can be contrasted with the existent literature base. It does appear to challenge the accepted view of the theory of strategy that firms should pursue strategies around being the exclusive provider of goods and services that lock the customer in. In reality in logistics, this kind of strategy is looked on suspiciously by many customers who would prefer to seek a more flexible plug and pay provision of logistics as exemplified by the focus company of this research.

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STUDY ON DELIVERY NETWORKS THAT SUPPORT OMNI-CHANNEL RETAILING, WHICH INTEGRATES ONLINE AND OFFLINE SALES

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ABSTRACT
As sales at bricks and mortar (BM) stores decline as a result of the growth in online shopping, and as the mode of contact between retailers and consumers diversifies as a result of the widespread use of smartphone, SNSs and blogs, a new sales mechanism, called "omni-channel retailing," has emerged since around 2011. A major consideration when introducing omni-channel retailing is how to build two different types of delivery network: one for delivering products sold at online stores and one for replenishing stocks at BM stores. This paper examines the two above-mentioned delivery networks, and proposes different types of delivery networks that minimize product delivery loads.

1. INTRODUCTION

1.1 Background

As online shopping continues to grow, sales at bricks and mortar (BM) stores are declining. The widespread use of smartphone, SNSs and blogs is resulting in a diversification in the modes of contact between retailers and consumers. As a result of these developments, a new sales mechanism, called "omni-channel retailing," emerged around 2011 [1][2]. This integrates online and BM stores, enabling consumers to shop without any concern about how they are buying products. Since around 2013, there have been concerted efforts in Japan to establish this sales mechanism. For example, products sold at BM stores may be sold online and delivered to a BM store close to the customer or directly to the customer's home [3].

1.2 Purpose of this paper

To reap benefits from the integration of online and BM stores, it is necessary to study a wide range of issues, from marketing to logistics. A major issue is how to combine two different delivery networks: one for delivering products sold at online stores and the other for replenishing stocks at BM stores.This paper proposes a method of combining these two delivery networks, evaluates the effectiveness of the proposed method in terms of the product delivery burden, and identifies issues that require further study.

1.3 Main related studies

The following are significant papers that are related to the subject addressed in this paper. Alexander H. Hübner et al.[4] developed a holistic logistics planning framework for last mile order fulfillment in omni-channel grocery retailing. Stephen Mahar et al. [5] developed a mathematical model that examined the cost and value of providing in-store pickup and return and determined the best subset of BM stores to handle the demand for in-store pickup and return. Etsuo Masuda [6] focused on how to improve online supermarkets' product delivery to cope with an increase in the number of customers and proposed a "site handover method," in which products were handed over to customers at specified handover points. Will Lockie [7] identified key considerations in delivering long-term business success, based on the experience of a UK retailer who has recently launched a click-and-collect service. However, to our knowledge, there have been no previous studies that examined the two types of product delivery network, each operating in a different mode, from the perspective of how to integrate and operate online and BM stores effectively.

2. BASIC ISSUES TO BE ADDRESSED IN INTEGRATING ONLINE AND BM STORES

2.1 Integration of online and BM stores

According to Mobile Retailing Blueprint Ver.2.0.0 [1], which was released by the MRI (Mobile Retail Initiative) in January 2011, the contact points between retailers and consumers have evolved from single channels to multiple channels, cross-channels and omni-channels. An omni-channel is a product selling mechanism that integrates online and BM stores in such a way that consumers do not recognize the boundaries between different channels. The objective is to expand retail sales by achieving synergy between online and BM stores.

2.2 Basic issues

Table 1 shows how basic issues concerning the integration of online and BM stores are related to marketing, logistics, IT and the organizational structure of the enterprise concerned. Issues (1) and (3) are closely related to marketing while Issue (2) is closely related to logistics and IT. All the issues are related to the reform of the organizational structure.

<table>
<tr><th rowspan="2">Item</th><th rowspan="2">Description</th><th colspan="4">Relevant field (Note)</th></tr>
<tr><th>Marketing</th><th>Logistics</th><th>IT</th><th>Organizational structure</th></tr>
<tr><td>(1) Determine service mode</td><td>Most effective way to combine customer contact points, i.e., {sites where products are displayed} and {sites where products are handed over}</td><td>◎</td><td>△</td><td>△</td><td>○</td></tr>
<tr><td rowspan="2">(2) Maximize the effectiveness of the service mode</td><td>Most effective ways to centrally manage customer information, to share customer ID between online and BM stores, and to centrally manage information about inventories at multiple sites</td><td rowspan="2">△</td><td>△</td><td>◎</td><td rowspan="2">○</td></tr>
<tr><td>Most effective ways to combine the network for delivering products sold at online stores and the network for replenishing stocks at BM stores, and to manage inventories both with each network and between the two networks</td><td>◎</td><td>△</td></tr>
<tr><td>(3) Implement measures to promote sales</td><td>Most effective way to implement measures to promote sales in such a way that the customers need not be aware of whether they are using online or BM stores</td><td>◎</td><td>△</td><td>○</td><td>○</td></tr>
<tr><td colspan="6">(Note) ◎: strongly related; ○: related; △: somewhat related</td></tr>
</table>

Table 1: Basic issues to be addressed in integrating online and BM stores

3. PROPOSAL FOR A PRODUCT DELIVERY NETWORK THAT SUPPORTS THE INTEGRATION OF DELIVERY NETWORKS

3.1 Characteristics of the two different delivery networks

Fig. 1 shows a network for replenishing stocks at BM stores and a network for delivering products sold at online stores. An issue in integrating online and BM stores is how to combine these delivery networks. The characteristics of the two delivery networks are compared in Table 2. In the stock replenishing network, the delivery destinations and route are more or less fixed, the same type of product is delivered in large numbers, and the delivery time and lead time can be planned in advance. On the other hand, in the online-sales product delivery network, the delivery destinations and routes can vary day by day, a large variety of products are delivered in small quantities to individual destinations, and it is highly likely that products ordered and sent out are not received by the shoppers because a timeslot of more than two hours normally needs to be allowed for handing over products to individual customers.

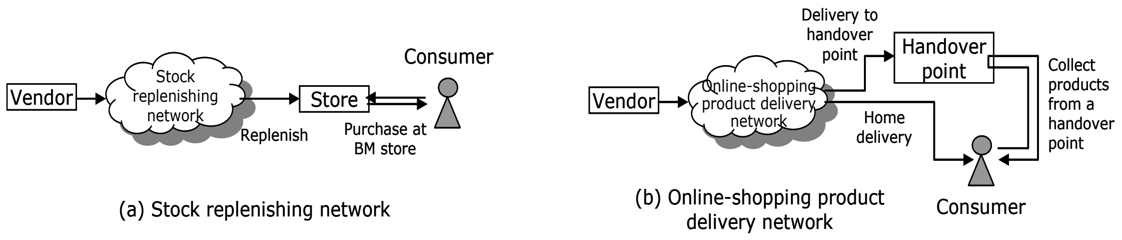


Fig. 1: Two different delivery networks

	Item	*Stock replenishment network*	*Online-shopping product delivery network*
1	Delivery destinations	BM stores (not consumers)	Consumers (normally)
2	Number of delivery destinations	Small	Large (normally)
3	Timing for shipping and delivery	When there are requests from BM stores (normally)	When orders are placed by consumers
4	Numbers of items delivered per destination	Large	Small (normally)
5	Delivery destinations, route, number of journeys	Delivery destinations and routes are more or less fixed. The number of journeys depends on the product demand.	Delivery destinations and route are normally not fixed. The number of journeys depends on the presence/absence of online orders.
6	Permissible lead time, permissible variation in delivery time	Lead time is planned in advance. Permissible variation in delivery time is small.	Lead time depends on individual shoppers. Permissible variation in delivery time is 2 hours or longer.
7	Considerations in delivery	Stringent delivery time	Improvement in delivery efficiency and truck load efficiency. Reduction in the number of delivery failures due to absence of recipients.

Table 2: Characteristics of the two delivery networks

3.2 Proposal for a delivery network suitable for the integration of online and BM stores

(1) Considerations for the study of combining the two networks
The following two issues need to be studied when considering combining the two delivery networks.
(i) Expansion of the online market
The volume of online sales per consumer is expected to continue to grow. This means that the volume of products carried via the online-shopping product delivery network will increase, requiring reinforcement of the equipment and personnel concerned. On the other hand, the utilization of the stock replenishing network will fall, reducing the demand for the equipment and personnel that it requires.
(ii) Increase in the number of delivery destinations
A rise in the proportion of online shopping increases the number of delivery destinations, which can add to the delivery burden. It is expected that the introduction of handover points, at which products purchased online are handed over to purchasers, will be promoted in order to reduce both the delivery travel

distance and the frequency at which the handover of products cannot be completed due to the absence of the recipients [8][9].

(2) Configuration of the delivery network
The use of handover points is assumed in the following. One simple idea of configuring a new delivery network is simply to build two independent delivery networks but operate them in such a way that there will be some coordination between them (Method A). We have studied an alternative configuration in order to cope more efficiently with an increase in the proportion of shopping carried out online. This configuration uses a combination of the network for delivering products to BM stores/handover points and networks for delivering products to consumers' homes (Method B). The two methods are shown in Fig. 2.

In Method B, both products purchased online and stock replenishment products are delivered to handover points or BM stores, as appropriate. Since handover points are included in the truck travel route for replenishing BM stores, the same truck can carry both products purchased online and stock replenishment products. Separate networks (home delivery networks) are used to deliver products purchased online from handover points to consumers' homes for those consumers who want to have products delivered directly to their homes. An advantage of this approach is that the spare capacity of vehicles and personnel for replenishment product delivery, which will arise as consumers shift to online shopping, can be redeployed for the delivery of products purchased online. Each home delivery network needs only to cover a small area surrounding a handover point. These networks can be covered by small trucks. Fig. 2 shows a case where BM stores and handover points never utilize the same sites. If they are always collocated, and if products purchased online are delivered only when replenishment products are delivered, the only additional delivery burden is the delivery of products from those handover points (i.e., BM stores) to consumers.

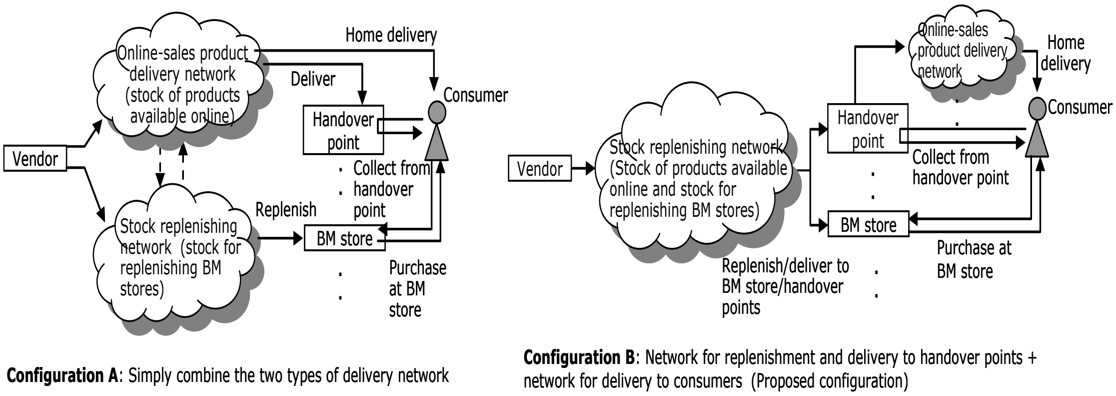


Fig. 2: Two alternative product delivery network configurations

4. EVALUATION OF THE PROPOSED METHOD

This section evaluates Method B in terms of the delivery burden.

4.1 Evaluation item and conditions

(1) The basic indicator of delivery burden is the distance travelled by the delivery trucks, hereafter called the travel distance. So, the two methods mentioned in Section 3 are compared in terms of travel distance.
(2) Since the travel distance for stock replenishment does not differ between the two methods, we will focus on the delivery of products purchased online.
(3) We will focus on a case where the BM stores and handover points are completely separate. Based on the result of this case, we will discuss the case where they are collocated.

(4) A specific value is assumed for the degree of demand for online shopping. The proportion of online shoppers who collect products at handover points is treated as a parameter: δ (0≦δ≦1) (Fig. 3). We consider four cases: δ=0, 0.3, 0.6 and 1. Note that δ=0 is the case where all shoppers receive products at home, and δ=1 represents a case where all shoppers collect their products at handover points.

4.2 Evaluation model

Since our objective is to compare the two methods in terms of travel distance for the delivery of products purchased online, we consider a simple model with the following geographical and delivery conditions:

(1) The delivery area is a circle of 3-km radius from the stock center. There are 7 handover points in the circle (Fig. 4), which are used only for Method B.

(2) In each area served by a handover point, shoppers are uniformly distributed at a radius between 0 and 1 km and around the 360 degrees.

(3) Orders by purchasers arise according to an exponential distribution. The average order interval is 20 minutes.

(4) All products ordered online within a 6-hour interval are delivered by a truck. As shown in a balloon in Fig. 4, the delivery areas are a single 3-km circle in Method A, and seven 1-km circles in Method B.

(5) In Method A, the truck leaves the stock center, and travels counterclockwise to either handover points or consumers' homes. In Method B, one truck leaves the stock center, and travels counterclockwise to handover points using the stock replenishing network. Other trucks travel counterclockwise from each handover point to the homes of the shoppers in that handover area who wish the products they have purchased online to be delivered to their home.

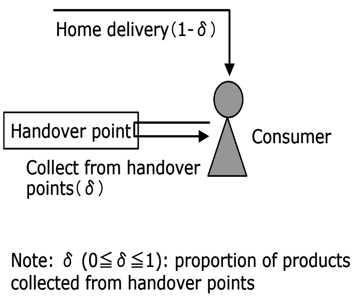


Fig 3: Definition of δ

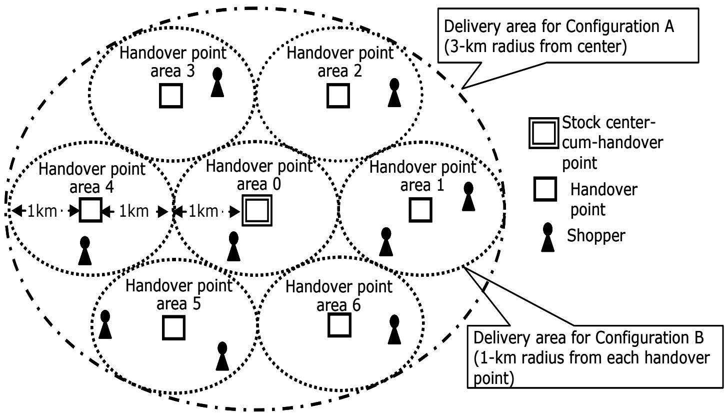
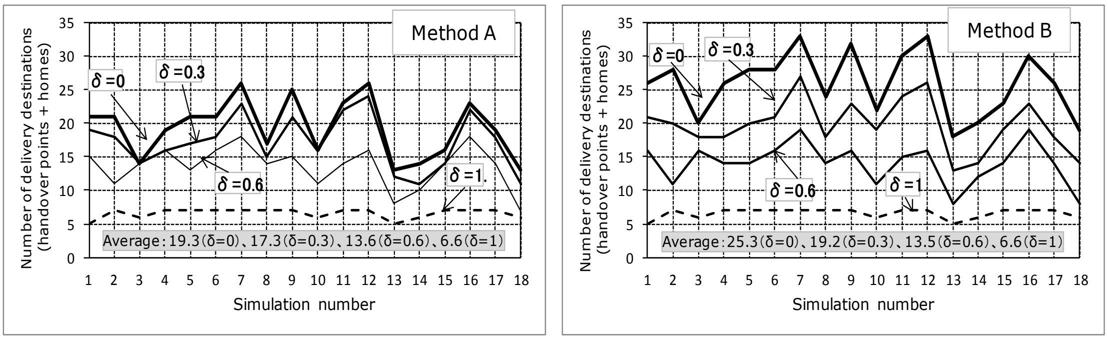


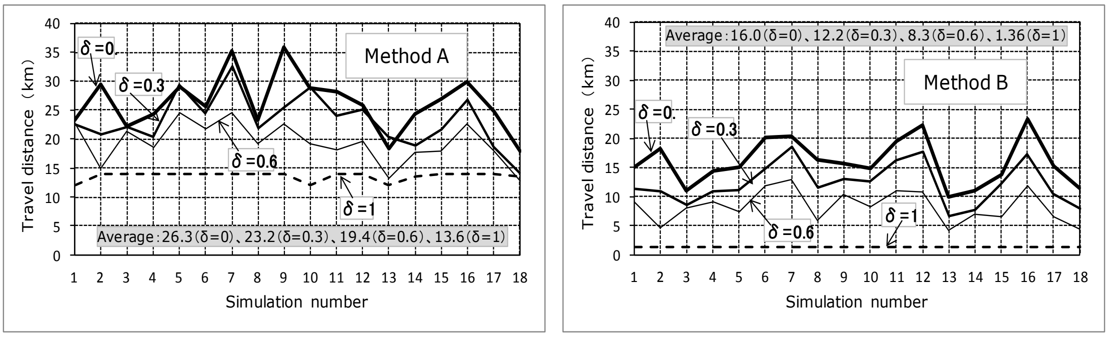
Fig. 4: Geographical model for calculating travel distance

4.3 Evaluation results and discussions

Fig. 5 shows the number of delivery destinations (handover points and consumers' homes), and the total travel distance (km) incurred for each method. Fig. 6 shows how the average number of delivery destinations and the average travel distance of each method vary with δ. The travel distance for Method B is the total of the travel distances of all the handover point areas. Figs. 5(a) and 6(a) show that Method B involves more delivery destinations than Method A for almost any value of δ. The difference between the two methods decreases with an increase in δ and becomes zero when δ=1. This is because, in Method B, products purchased online are delivered to all handover points through the stock replenishing network irrespective of the value of δ. Figures 5(b) and 6(b) show that Method B involves a lower travel distance than Method A. There are two reasons for this. The first reason is that, although Method B requires delivery to both BM stores and handover points, the handover points are incorporated in the replenishment product delivery route, and thus only the marginal increase due to

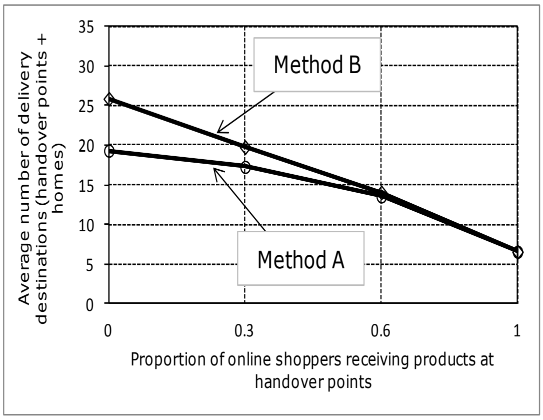


(a) Evaluation in terms of the number of delivery destinations

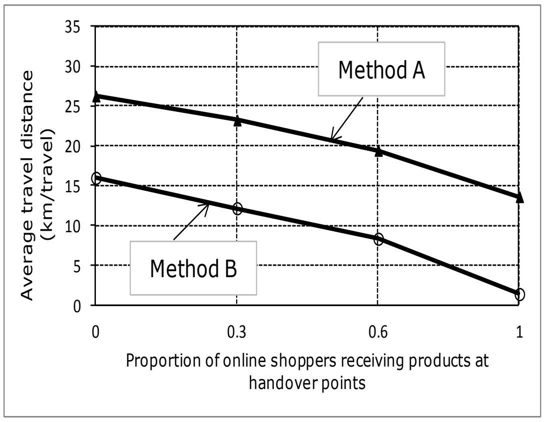


(b) Evaluation in terms of travel distance

Fig. 5: Evaluations in terms of the number of delivery destinations and travel distance



(a) Average number of delivery destinations



(b) Average travel distance

Fig. 6: Variation in the number of delivery destinations and travel distance with δ

visiting the handover points needs to be taken into account for the delivery of products purchased online. The second reason is that the travel to the shoppers' homes for Method B is shorter than that for Method A because the travel is limited to within each handover point area.

The above results have been obtained for the case where the BM stores and handover points are completely separate. If they are fully collocated and if the delivery of products purchased online coincides in time with the delivery of stock replenishment products, the results may be as follows. In Method B, it is, in this case, sufficient to look at only the delivery from handover points to consumers' homes. Therefore, Method B is preferable than Method A in terms of both the number of delivery destinations and travel time for almost all values of δ. To be specific, only when $\delta=0$ do the two methods have the same number of delivery destinations. When $\delta>0$, Method B has fewer delivery destinations than Method A and the difference widens as the value of δ increases. Method B is preferable in terms of travel distance as well. The difference in travel distance between the two methods is more dependent on the difference in size of the delivery areas than on the value of δ.

It can be assumed that some but not all handover points will normally be collocated with BM stores. In such cases, the results will be between the two extreme cases mentioned above. For all cases, Method B (the proposed method) is preferable in terms of travel distance. As mentioned above, Method B is also desirable in that the delivery of products purchased online, which are expected to increase in volume in the future, can make use of the delivery resources of the stock replenishing network.

5. FUTURE ISSUES

This paper has shown that Method B is preferable, by focusing on the contact points between consumers and the delivery network, namely the points where products are handed over to online shoppers, such as BM stores, handover points and homes. In particular, it has evaluated the travel distance from the nearby stock center to these contact points. Looking forward, the following issues require further study:

(1) Improve the evaluation model by adopting more realistic values for truck travel time and cost and a more realistic delivery area model, and by studying the proportion at which people buy products online.

(2) Although this paper assumes that products available for purchase online are stored in a single stock center, they may be stored at multiple stock centers, BM stores and vendor sites. It is necessary to study how to manage stock and move products within the stock replenishing network.

(3) In Method B, products purchased online are delivered with the same timing as the delivery for replenishing the stock at BM stores. For those shoppers who want to receive their online-purchased products more promptly, it will be necessary to run separate trucks.

(4) When a stock replenishing network is also used to deliver products purchased online, the stock center will need to manage both products purchased online and products for BM stores. It is necessary to study how to ship both products purchased online and stock replenishing products from the stock center efficiently.

(5) In introducing new online-shopping product delivery networks that extend from handover points, it will be necessary to study how to assign trucks and drivers for these networks because the demand for them may be small.

(6) If omni-channel retailing is to be implemented nationwide, as is done by Seven & i Holdings and AEON, delivery networks need to cover online shoppers distributed over a wider area. It will be necessary to study where to establish stock centers, and how to manage stock and move products in this situation.

6. CONCLUSIONS

This paper has provided a basic study on a product delivery network that supports the integration of sales at online and BM stores. Specifically, it has studied how to combine two delivery networks: a network for replenishing stocks at BM stores and a network for delivering products sold at online stores. We have proposed to use the existing stock replenishing network for the delivery of products purchased online to handover points (which may include BM stores), and to set up networks for delivering products purchased online from handover points to homes. We have shown that the proposed network is advantageous in terms of truck travel distance. It will be necessary to study the proposed network further by addressing the issues described in Section 5.

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ANALYTICAL FUNCTIONS FOR COMPUTING TIERED DISCOUNT SCHEDULES

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ABSTRACT

Businesses are under constant pressure to cut cost by negotiating price discounts and inducing inter-suppliers price competitions. Discounted prices are determined using Bertrand Nash and related equilibrium paradigms which require mathematically robust discount schedules with continuous derivatives. Our extensive literature searches revealed the unavailability of *analytically* robust and accurate discount schedules, motivating the present work. Volume based price discounts are typically presented in tables. As such, they are non-analytic step functions with discontinuous and infinite derivatives. Frequently, analytically convenient simplifications include highly inaccurate linear or "mildly" non-linear discount schedules. In this paper, we introduce discount functions that have *sigmoidal* analytic forms which become step functions in the limit as their slope parameter μ approaches $\propto$. We demonstrate that such functions have finite and continuous analytic derivatives, a critical feature that renders them highly useful for computing price equilibria in inter-supplier price competitions.

INTRODUCTION

Businesses are under constant pressure to cut cost of raw materials, equipment and supplies, which can account for upward of 40 % of operating expenses in some industries. Such reductions are frequently pursued by negotiating volume-based price discounts, inducing suppliers to enter into price competitions aimed at maximizing market share. Optimally, discounted prices are determined using price equilibrium computations using Bertrand Nash or similar methods.

In order to compute discounted price equilibria, discount schedules need to be mathematically robust. We were surprised when our extensive literature searches revealed the unavailability of *analytically* robust and accurate discount schedules. These findings motivated the present work.

Volume based price discounting literature is prevalent (Axsäter 2000; Choi et. al 2005). Typically, suppliers offer all-unit price discounts for order quantities that exceed a preset volume breakpoint. Such discounts, most commonly presented in tables, can be one-, two-, or multi-tiered as shown in Figure 1. As such, they are non-analytic step functions with discontinuous and infinite derivatives, two features that frustrate their use in multi-objective optimization and in computing price equilibria.

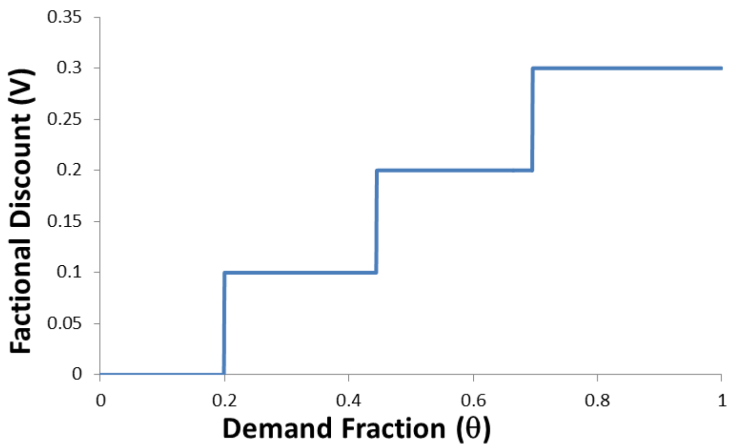

Figure 1: Tiered discount as a function of demand

To circumvent computational obstacles, authors often resort to analytically convenient simplifications such as linear discounts, which offer inaccurate estimates of the tabular discount schedules. In one report, Hu et al. (2012) address the impact of Group Purchasing Organizations on prices of healthcare supplies using game theoretic models in which volume based discounted prices represent the game strategies. Their implementation reverts to linear discounts, whose use they justify based on prior publications.

Schotanus et al. (2009) highlight the conspicuous absence of analytic non-linear discount functions in the vast literature on discounts. They offer the following form as an alternative

$$p(q) = p_m + \frac{S}{q^\eta}, \qquad (1)$$

where p, p_m, q, S and η are price, minimum price, quantity, discount scale factor, and discount exponent respectively. Equation (1) has the same shortcomings as linear discounts. Other discount schedules with simple non-linear forms have been deployed elsewhere (Marvel et al. 2008).

Additional discounting approaches have been pursued in the literature. Zhang (2010) studied a single-period newsvendor problem with all-unit supplier quantity discounts and budget constraints using a nonlinear mixed integer programming model with a Lagrangian relaxation heuristic. Monahan (1984) developed an analytical model for supplier profits by anticipating buyers' response to discounts. In a more recent work, Ke and Bookbinder (2012) found the optimal quantity discount from a supplier perspective, using non-cooperative two-player Stackelberg-Nash equilibrium and joint decision making. These and related proposals suffer one or more of the troika of shortcomings: discontinuous derivatives, lack of practical realism, or inability to accurately represent the industry's step function discounts of Figure 1.

Due to the unavailability of realistic and analytically robust discount schedules, in this paper we develop discount schedules that meet the following critical features:

1. Represent general multi-tiered discounts
2. Analytic with continuous and finite derivatives

3. Easily adaptable for single-tiered and two-tiered discounting
4. Limiting behavior as the "slope" parameter $\mu \rightarrow \propto$ (Eq. 2) is a step function.

SINGLE-TIERED AND MULTI-TIERED DISCOUNT SCHEDULE

To overcome the shortcomings of the commonly-used discount schedules outlined above, we suggest using discount functions that have the *sigmoidal* analytic form. Such functions are commonplace in electrical engineering (Park et al. 1991; Yu 2013; Zhang et al. 2013), where they serve as switching functions that approximate on-off step functions. Using such functions, a supplier's discount schedule V (Equation 2; Figure 2) is an increasing sigmoidal function of the fraction of total demand θ (see Table 1) apportioned to that supplier:

$$V = \frac{V_m}{1+e^{-\mu(\theta - V_0)}} \tag{2}$$

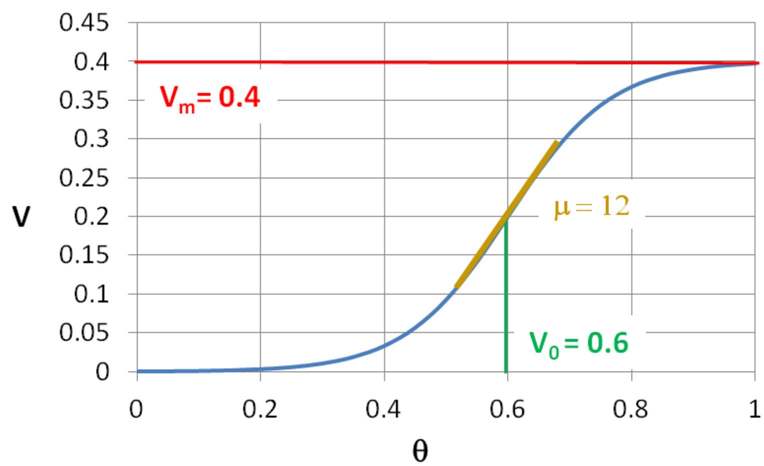

Figure 2: Discount schedule (V) of Equation 2 (V_m = 0.4, V_0 = 0.6, μ = 12)

θ is within [0, 1]. V has three parameters: maximal discount (V_m), discount breakpoint (V_0), and the "slope" parameter (μ). V_0 is the value of θ that delineates the no-discount/discount demand fraction. Discounts are offered only for $\theta \geq V_0$. V_m is the maximal discount as θ approaches 1. The parameter μ controls the slope of V at midpoint. As μ approaches infinity V approaches a step function. In this paper, μ is set adequately high for V to "sufficiently" emulate a step function. The V discount schedule (Equation 2; Figure 2) represents a single-tiered discount schedule and has the following properties;

1. $0 \leq V \leq V_m$ for all θ.
2. Values of $\theta \geq V_0$ trigger higher discounts, approaching V_m as θ approaches 1.
3. Values of $\theta < V_0$ lead to lower discounts, approaching 0 as θ approaches 0.

The discounted price markups (σ_2) are computed by discounting their undiscounted counterparts (σ_1) using volume (θ) based discount schedules (Equation 2). To clarify the discounting rationale, we note that σ_1 is a markup over the unit price that the customer pays for purchasing an item. For example, σ_1 = 1.3 comprises a supplier cost of "1" and a supplier profit of 0.3 that corresponds to 30 % profit. σ_2 is computed by discounting the (σ_1 – 1) profit part of σ_1. That is

$$\sigma_2 = \sigma_1 - V * (\sigma_1 - 1);\ 0 \leq V \leq 1 \qquad (3)$$

For σ_1 = 1.3 and V = 0.2 (a 20 % discount), V * (σ_1 – 1) = 0.2*0.3 = 0.06, σ_2 = 1.24, corresponding to a 24 % profit.

In a special implementation, suppliers can set V_m to be linearly proportional to V_0 with a slope κ (Equation 4) which, when substituted in Equation (2), gives Equation (5). The value of κ is determined by the supplier's business imperatives.

$$V_m = \kappa V_0 \qquad (4)$$

$$V = \frac{\kappa V_0}{1+e^{-\mu(\theta - V_0)}} \qquad (5)$$

The single-tiered discount schedule in Equation 2 is easily generalized to multi-tiered discount schedules using

$$V = \sum_{i=1}^{n} \frac{V_{m,i}}{1+e^{-\mu\left(\theta - V_{0,i}\right)}} \qquad (6)$$

For a 3-tiered discount schedule, n = 3, and the tiers are given by ($V_{m,1}$, $V_{m,2}$, $V_{m,3}$) with the corresponding breakpoints ($V_{0,1}$, $V_{0,2}$, $V_{0,3}$). For n = 3, μ = 100, and the values of the three maximal discounts ($V_{m,1}$, $V_{m,2}$, $V_{m,3}$) = (0.05, 0.07, 0.12) and the corresponding discount breakpoints ($V_{0,1}$, $V_{0,2}$, $V_{0,3}$) are (0.2, 0.5, 0.7). The three individual discount functions in Equation (6) are shown in Figure 3.

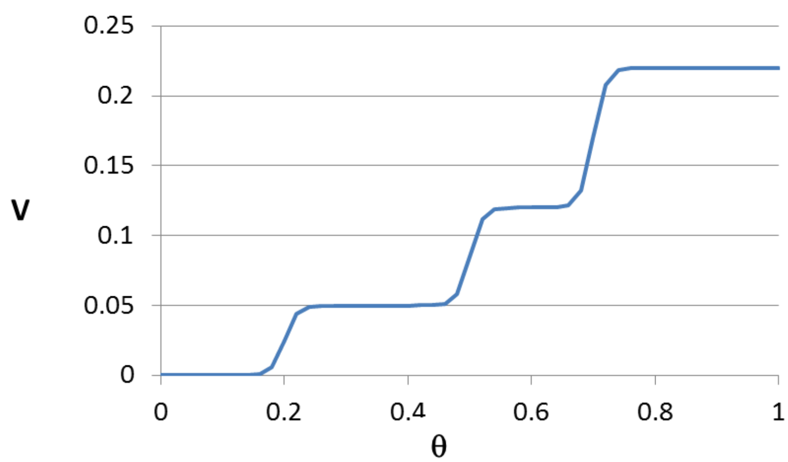

Figure 3: Three-tiered discount schedule (V, Equation 6)
{n = 3; ($V_{m,1}$, $V_{m,2}$, $V_{m,3}$) = (0.05, 0.07, 0.12); ($V_{0,1}$, $V_{0,2}$, $V_{0,3}$) = (0.2, 0.5, 0.7)}

BERTRAND NASH PRICE EQUILIBRIUM INVOLVING DISCOUNTS

A customer has a large demand (D) for a certain item. Two suppliers (V-supplier, W-supplier) compete to meet this demand. Each supplier purchases the items from the manufacturer at a per-unit-price P. The suppliers' undiscounted price markups are (σ_1, ζ_1)

and their per-unit transportation-to-customer costs (η, λ). They offer discounted prices ($\sigma 2$, $\zeta 2$) for corresponding fractional price-based demand splits (θ, $1 - \theta$), computed using Equation 7 ($\beta = 0.5$) (Attanayake 2014).

The two suppliers compete to maximize their respective demand fractions (θ, $1 - \theta$). Their discounted prices ($\sigma 2$, $\zeta 2$) and discount schedules (V, W) are shown in Equations (8) and (9), respectively.

The profit functions (π_V, π_w) are scaled by the price-demand product PD.

$$\theta = \frac{e^{-\beta\sigma_2}}{\{e^{-\beta\sigma_2 + e^{-\beta\zeta_2}}\}} \qquad \theta = \theta(\sigma_2, \zeta_2) \qquad 7\ (a, b)$$

$$\sigma_2 = \sigma_1 - V\{\sigma_1 - 1\} \qquad V = \frac{\kappa V_0}{1+e^{-\mu(\theta - V_0)}} \qquad 8\ (a, b)$$

$$\zeta_2 = \zeta_1 - W\{\zeta_1 - 1\} \qquad W = \frac{\kappa W_0}{1+e^{-\mu(\theta - W_0)}} \qquad 9\ (a, b)$$

$$\pi_V = \{(\sigma_2 - 1)(1 - V) - \eta\}\theta \qquad \pi_w = \{(\zeta_2 - 1)(1 - W) - \lambda\}(1 - \theta) \quad 10\ (a, b)$$

The profit functions in Equation (10) are functions of ($\sigma 2$, $\zeta 2$) and the discount schedules. The competitive markups (σe, ζe) are determined using Bertrand Nash methodology to determine the equilibrium pricing, hence the equilibrium discounts that simultaneously maximize the corresponding profit functions (π_V, π_w).

Using standard Bertrand Nash techniques, the equilibrium point (σe, ζe) is determined by setting to zero the derivatives of the profit functions (Eq. 11). (σe, ζe) is the point in ($\sigma 2$, $\zeta 2$) space for which the two conditions in Equation (11) are simultaneously satisfied.

$$\frac{d\pi_V(\sigma_e,\zeta_e)}{d\sigma_2} = 0 \qquad \frac{d\pi_W(\sigma_e,\zeta_e)}{d\zeta_2} = 0 \qquad 11\ (a, b)$$

The supplier profit function π_V varies explicitly with $\sigma 2$, as well as through V and θ. Similarly, π_w varies explicitly with $\zeta 2$, as well as through W and θ. Thus, the derivatives in Equation (11) are computed in Equation (12)

$$\frac{d\pi_V}{d\sigma_2} = \frac{\partial\pi_V}{\partial\sigma_2} + \left\{\frac{\partial\pi_V}{\partial V}\frac{\partial V}{\partial\theta} + \frac{\partial\pi_V}{\partial\theta}\right\}\frac{\partial\theta}{\partial\sigma_2} \qquad \frac{d\pi_W}{d\zeta_2} = \frac{\partial\pi_W}{\partial\zeta_2} + \left\{\frac{\partial\pi_W}{\partial W}\frac{\partial W}{\partial\theta} + \frac{\partial\pi_W}{\partial\theta}\right\}\frac{\partial\theta}{\partial\zeta_2} \quad 12\ (a, b)$$

The derivatives $\{\frac{\partial V}{\partial\theta}, \frac{\partial W}{\partial\theta}\}$ in Equation 12 are the slopes of the respective discount schedules with respect to the demand fraction. In the standard methodology of publishing discount schedules as tables and steps functions (Figure 1), V (θ) and W (θ) are step functions with discontinuous and infinite derivatives which renders equilibrium computations unwieldy, if not altogether impossible. On the other hand, using Equations 10b and 11b, these derivatives can be easily computed, significantly simplifying the computation of price equilibria.

Variable	***Definition***	***Variable***	***Definition***
V	Discount schedule for supplier V *	$(\sigma e, \zeta e)$	Bertrand Nash equilibrium point
V_0	Maximal discount for supplier V	μ	"slope" parameter
V_m	Discount breakpoint for supplier V	κ	Slope of V_m as function of V_0
W	Discount schedule for supplier W *	θ	Supplier fraction of demand **
W_0	Maximal discount for supplier W	β	"split constant" set to 0.5
W_m	Discount breakpoint for supplier W	λ	Shipping cost of supplier V
σ_1	Undiscounted markup of supplier V	η	Shipping cost of supplier W
σ_2	Discounted markup of supplier V		
ζ_1	Undiscounted markup of supplier W		
ζ_2	Discounted markup of supplier W		
* Discount schedule (V) is defined here as the fractional discount. For example, for V = 0.2, the original price is discounted by 20 %. ** Vendor fraction is the fraction of the total demand that is satisfied by this vendor. For θ = 0.3, the supplier in questions satisfies 30 % of the demand.			

Table 1 – Variables and their definitions

CONCLUSIONS

In this paper, we have demonstrated that the typical tabular discount schedules with discontinuous and infinite derivatives as well as the inaccurate analytic analogs thereof can be replaced by analytic discount schedules that accurately reflect tabular discounts and that have finite and continuous derivatives. We demonstrated that these improved features are critical for computing price equilibria in inter-supplier price competitions.

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APPLYING 3-DCE FOR VALUE CREATION IN SECOND-HAND CLOTHING CHAIN: A SWEDISH STUDY

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ABSTRACT

The paper explores the antecedents of value creation in second-hand clothing value chains in Sweden along 3-DCE perspective. It identified the value generating stages as collection, sorting, refurbishing, reselling of used clothes and redesigning. These stages have various enablers and challenges at the intra-organizational and value chain levels. At the intra-organizational level, key antecedents are strategic logistics infrastructure for collection, sorting, transportation as well as creative retailing. Effective merchandise planning is another critical enabler for reuse and redesign, while right market knowledge is yet another essential enabler. At the value chain level, key antecedents are process integration, well-designed collection network and collaborative collector-sorter partnerships along with product design for durability. Further, supporting sustainability communication also enables higher value generation in the organization. These antecedents were further mapped in the paper along 3-DCE drivers to identify their foci. Design for durability, sustainable communication and creative redesigning with users were the key antecedents demanding 3-DCE attention.

Key words: Reverse value chain, three-dimensional concurrent engineering, second-hand clothing, Sweden

INTRODUCTION

In majority of the second-hand clothing value chains in western countries the extended responsibilities of various involved actors are limited to voluntary involvement with low levels of strategic collaboration thus making the system fragmented and complex (Ekström and Salomonsson 2014, Brooks 2013). As in the case of Sweden, only around 20% of consumed clothing are collected in channels for reuse and recycling through various individually run take-back schemes by retailers and charities for creating value through post-retail initiatives (e.g. by H&M, Kappahl, Boomerang, Red Cross among many others) (Ekvall et al. 2014, Hvass 2014). Further majority of these collected garments are not kept for value creation in the country of collection but are exported by charity organizations for commercial use in developing countries (Palm et al. 2013), leading to low realization of potential value in the system.

Overall, the current system leads to low value creation (in terms of financial performance and resource efficiency) even though many organizations have already adopted two main strategies, viz. product take-back schemes and resell/reuse over various platforms for prolonging the life of the garments and to capture the resell value (Hvass 2014). Further the responsibility of supply of second-hand stock lying in the hands of the private consumers introduces uncertainties in the quality, quantity and timing of product returns (Anderson and Brodin 2005, Halldorsson et al. 2009).

In this context, various attributes of product design, process and supply chain decisions are essential to enhance return rate, generate higher profits, improve product durability and end-of-use (EOU) quality, in short result in higher value creation (Subramanian et al. 2009, Savaskan et al. 2004). More specifically these design attributes can be deemed to be essential to counter loss of value from "value outsourcing" to "local value generation". For example, new product take-back schemes can result in more resource efficient and consolidated collection through process reengineering (Savaskan et al. 2004). In addition, effective schemes for reuse and redesign would result in higher reuse/resell value (Ekström and Salomonsson 2014), thus redesigning the existing product architecture. In addition, close coordination among various actors in the network can be also crucial to complement in skills and expertise (Hvass 2014). Thus these activities need to be synchronized to redesign products, processes and associated value chains independently and more necessarily simultaneously thus calling for three-dimensional concurrent engineering (3-DCE) as a critical lens to explore the existing value creation activities. Thus the paper explores how designing of products, processes and supply chains offers an interesting lens to explore the antecedents of value creation in second-hand clothing value chains.

LITERATURE REVIEW

The conceptual framework of the paper is based on (i) value creation activities in second-hand clothing network, and (ii) 3-DCE in reverse value chain.

Value creation activities in second-hand clothing network

A 'source of value' is defined by Amit and Zott (2001) as *any factor that enhances the total value created* by a business. The notion of stakeholder value comprises of responsibilities and commitments in terms of value creation towards a broad spectrum of stakeholders, ranging from owners and investors, employees, suppliers, customers, to society and the environment (Mathur and Kenyon 1997).

A commercial chain for used garments requires several steps of value creating activities. According to Jayaraman and Luo (2007), the reverse logistics system enhances the value of returned products through upgrading and/or maintenance. It consists of collection strategies as well as recovery processes such as sorting, cleaning and mending or reuse of the material (van Hillegersberg et al. 2001). Once an unwanted garment has passed through collection, sorting, and possibly further steps of labour practices, it has regained exchange-value and re-entered the commodity form. Thus, it can be sold or exchanged either as a reused item or as a redesigned product. While on the other hand, used garments those still having potential exchange-value to their first owners are directly redistributed in the market and thus do not need reproduction processes (Brooks 2013). Besides reuse in terms of second-hand retailing, some charity organizations perform small-scale redesigning or remaking of used garments. The residues those cannot be exported, sold or redesigned are consequently incinerated (Ekström and Salomonsson 2014). However, Kumar and Putnam (2008) have researched cases where the recovery of used product is economically more attractive than disposal or incineration.

3-DCE in reverse value chain

Two main problems in the reverse logistics are in terms of difficulties in predicting the amount and quality of returned products (thus affecting the resell/reuse potential), and issues related to the collection- and transportation process, more specifically how to control and plan inventory and production (Jayaraman and Luo 2007). To handle these problems both expertise and specialization is required, alongside cooperation with suppliers holding the right capabilities for managing the complexity of the system (Kumar and Putnam 2008).

Various processes involved in reverse logistics rely on the logistics architecture; how products are collected, separated or sorted, remanufactured and later distributed to customers (Rogers and Tibben-Lembke 1998, Fleischmann et al. 2004). Depending on where the products are collected, from the consumer or another member of the value chain, the reverse logistics system is planned accordingly. Hence, this is an important factor to determine the subsequent reverse logistics activities. Fleischmann et al. (2004), in this context, argues that the main distinction between forward and reverse logistics is the network design; the former consisting of separate structures between production and distribution and the latter, encompassing both separate and connecting links in a highly complex structure. By considering network design when planning for reverse logistics, great benefits in terms of reduced costs and use of new resources can be achieved

(Ellram et al. 2008). However, this complexity may also give rise to issues concerning strategy and logistics operations (Jayaraman and Luo 2007).

In addition, companies working with reverse logistics identify integration with other actors in the value chain as an another important factor to make the operations profitable (Jayaraman and Luo 2007). Further, Blumberg (1999) and Debo et al. (2004) acknowledge coordination between the different actors involved in the reversed value chain as a critical task, which directly affects the efficiency of the whole system. This result in lower price and higher total profits in a coordinated channels compared to decentralized channels (Savaskan et al. 2004). Key factors related to coordination in the reverse logistic system is the flow of information between the network actors to enable efficient planning of returned products with regards to timing and quality (Kumar and Putnam 2008, Debo et al. 2004, Fleischmann et al. 2004).

The management of product within the supply chain for optimized recovery is yet another subject of many research papers pertaining to reverse logistics (Pilar et al. 2004, Fleischmann and Kuik 2003). Most of these papers highlight a strong linkage between product designs and reuse options. For instance, Abraham (2011) has mapped how the reconditioning processes comprising of minor-major deconstruction of the used garments resulted in value addition through product development in the apparel aftermarket in India. In this context, design for durability and design for EOU activities are also essential activities those alter the product architecture and supply chain responsibilities of the actors through extended product stewardship (Hvass 2014). Table 1 summarizes the deductive framework for reverse value chain attributes in connection to 3-DCE.

Reverse value chain attributes	Key supporting authors	3-DCE linkages
a. Supply chain network, Supply chain planning for reverse logistics	Ellram et al. (2008), Fleischmann et al. (2004)	Process-supply chain- or Supply chain-focussed
b. Logistics architecture: of collection, sorting, remanufacturing and distribution	Tibben-Lembke and Rogers (2002), Fleischmann et al. (2004), Jayaraman and Luo (2007)	Process- or Process-supply chain-focussed
c. Product architecture: Design for durability, EOU	Ekström and Salomonsson (2014), Ekvall et al. (2014), Pal (2015),	Product- or Product-process- or 3-DCE-focussed
d. Product architecture: Refurbish/Remanufacture/Redesign	Pilar et al. (2004)	Product-process- or 3-DCE- focussed
e. Network collaboration, Cooperation and sharing of expertise, Information integration, Supplier partnership	Jayaraman and Luo (2007), Blumberg (1999), Debo et al. (2004), Savaskan et al. (2004), Kumar and Putnam (2008)	Supply chain- or Process-supply chain-focussed
f. Collaboration with end-user	Ekström and Salomonsson (2014), Tojo et al. (2012)	Supply chain- or Process-supply chain-focussed

Table 1: Deductive framework for reverse value chain activities in connection to 3-DCE

In summary, reverse logistics enable firms to attain a closed-loop system and thereby reclaim value from the returned products along the processes of collection, inspection, processing, consolidation and remanufacturing (Ellram et al. 2007, Jayaraman and Luo 2007, Kumar and Putnam 2008). Numerous studies have addressed and advanced the research and practice in the area of reverse logistics, while some have specifically addressed reverse logistics in the textile and clothing industry (Tibben-Lembke and Rogers 2002, Svensson 2007, Sinha et al. 2012). However, its explicit connection to value creation, in context to the second-hand clothing network, is still under-explored.

METHODOLOGY

The research adopts a mixed method approach. Data is collected, in the first phase, through desk research to map the Swedish second-hand clothing value chains along their value creation stages and activities. A couple of interviews were also conducted with key actors in the network to gather information. Author has been a board member of a regional project on this topic and has discussed with experts in the field to gather supplementary data. In the second phase, twelve semi-structured interviews were conducted with five Swedish retailers and fashion brands, two second-hand retailers, two charities, and three small redesign brands. The interviews explored the key antecedents of the value creation activities they are engaged with. The interviews lasted between 60-90 minutes and were recorded, and later transcribed. Data analysis was done through thematic analysis. At first the interviews were deconstructed into value creation activities and their antecedents, followed by categorizing them into reverse value chain attributes and finally re-categorizing them into 3-DCE drivers.

RESULTS AND ANALYSIS

In this section we analyse the value generating operations identified in the existing second-hand clothing network in Sweden to explore their key antecedents along the deduced reverse value chain attributes (as summarized in Table 2).

Value generation in second-hand clothing chain

Collection

It was evident from the empirical data that the potential for reuse and other forms of value creation is facilitated by effective collection processes, enabling further value creation activities by diverting products disposed by the first user from the general waste stream. Fashion retailers revealed that collection is only financially viable in areas with high density of population as well as popular places for container placement. Further closeness to the retail stores and sorting centres is also strategic for location. However, due to the high fragmentation, centralization is not a viable alternative. I:Co highlighted its collaboration with Kappahl and H&M in arranging collection of used or unwanted clothes through computerized machines at retailer shops to be a key step in for appropriating value. These systems not only give the information about clothes it also counts the money that is charged for each piece of clothes. Most of the collected clothing is transported to other sorting locations accounting for a loss of value creation potential inside Sweden. Most of the fashion retailers involved with collection operate in collaboration with international sorters, like I:Co or Kicki, hence the second-hand clothing leaving the country. Further collection by commercial actors is to some extent perceived as competition to charity organisations. However, recently partnership between fashion brands and charities has emerged as a new phenomenon, as can be seen between Filippa K and Stadsmissionen. Further in order to increase the amount of collection for reuse and redesign purposes, consumer information and convenience need to be prioritised, as collection builds on donation partnerships and consumer involvement. This demands support in the collection process by the municipalities. The charity organisations also requested sharing of the economic burden of collection, on the condition that it does not hamper reuse and activities of existing legitimate actors.

Sort

Sorting provided organizations, like I:Co with merchandise for reuse that is sellable in various markets. Thus familiarity with different markets is identified as a critical success factor for sorting apart from the necessary skills and infrastructure for sorting. The logistics is arranged by I:Co from the retailer's consolidated facility to its own sorting facility in Germany. The monetization for I:Co is through purchase of second-hand clothing from the collaborating retailers and its subsequent sales outside the country of collection, leaving not much value realized within the local country's boundary. On the other hand, second-hand retailers (e.g. Myrorna, Emmaus) and second-hand luxury brands engage with very specialized selection and sorting of consignment providing more certainties and thus appeal to consumers. Sometimes the second-hand retailers exports the collected material (sorted or unsorted) to its customers which demands long-term relationships with these clients. In addition, sorting activities provide employment opportunities and promote the use of second-hand clothing as was indicated by the second-hand retailers. Fashion brands like Boomerang and Filippa K who resell their own brand of second-hand clothes are also engaged with higher value-added manual sorting to segregate the collected clothes into three categories, viz. (i) those sold at own store, (ii) those sold to charities, and (iii) those to be sent for recycling. This categorization depends upon the quality of the second-hand clothing; only the best quality is sold in own stores making the sorting activity extremely crucial and value-adding.

Refurbish
The purpose of repairing as observed in fashion brand, like Nudie Repair Shop, is to bring used products back to functionality through mending or replacement processes. The required level of disassembly or reassembly is usually low in repaired items. These activities offer value to the customers by extending the life and durability, either through repairing or altering it to a different size. Allied activities sometimes include cleaning to be more cost-effective (a common phenomenon in laundries). These services are sometimes add-on to the purchase of high-quality relatively expensive clothes (shifting the focus from product to product-service). The marketed concept is augmented through neck labels, embroidery, hang tags, marketing and visual merchandizing in the retail space. On the other hand, such services are also offered to original users in return of service charges. Nudie sometimes organizes training workshops, on basic mending and repairing activities as well. The environmental gain is dependent upon the increase in the usage time resulting from the repair and has been assumed to be significant in a prior study by Ekvall et al. (2014). However, the economic gains are still low primarily due to challenges from cheap high-street fashion and high labour costs resulting in ~10 years of payback time, however sometimes having considerable displacement effect.

Reuse by user
Empirical evidence suggested that normally the garments of the highest quality collected via take-back schemes are resold by fashion brands in their own stores, as was evident in case of the Swedish brands Boomerang and Filippa K. Key activities organized by these brands included picking & packing, laundering, receiving & storing, and finally restyling if necessary thus highlighting a vertically integrated structure. Nudie, for example, washes and repairs each pair and puts them back in the shop as second-hand articles which are then sold as "used own brand". In this context, the durability and longevity (hence the quality) of the collected clothes needs to be high. In addition, creative retail store formats are used as marketing tactics to showcase the products. For example, Boomerang Effect was communicated in-store visually through presentation of the vintage garments on the defined area. One challenge is however in terms of stock availability. This demands high level of sustainability communication to ensure continuous flow of old stock at sufficient volume. Nudie, for instance, ensures this through a story telling technique via its websites, shops and other advertising channels. Such sustainable corporate image enhances the brand image, e.g. Nudie is ranked as one of the most sustainable fashion brands by www.rankabrand.org. Reused clothes are also exchanged through second hand-retail, leasing-services or informal channels such as swapping events and consumer to consumer sales as was observed in a separate business model of collaborative consumption.

Redesign
Redesign aim at changing collected clothes through design characteristics that create new value for the consumer, turning collected and sorted textile material into new, usable products. Respondents perceived redesign activities could be done along three levels, with options for scalability and profitability. Some can by simple means be washed (refurbished) before they are resold, as was evident in Nudie and Boomerang. Key processes include disassembly, inspection, mending and reassembly to extend the service life of products. The intermediate stage of design aims at raising the value of the

garment. It can be cut to size, sew on labels, pockets, buttons, rivets, etc. It can also be about washing the garment so that it gets a special look etc. Nudie Jeans, on the other hand, is also involved in collaborations with designers and other creatives under the "Denim Maniacs" to give worn-out jeans a second life. Respondents valued time, skills and network with actors who can take an active role in the re-design process to be the critical success factors, both in design and production engineering. Further at the highest level is total redesign of the garment to create something new. For instance, Stormie Poodle is a small designer brand that manufactures children clothes out of either reused terry cloth or high quality hotel linen. The owner states, "it is an expensive process demanding a lot of time to be added, allowing the garments to be sold at high prices." Another redesign business conferred that ensuring the logistics of the incoming used products is the key to success, which they try to solve through story-telling about their brand. Micromanaging the design process, keeping the product constraints in mind, was also essential for such redesign activities.

Value generating stages	**Supporting empirical evidences**	**Key antecedents along reverse value chain attributes**
Collection of second-hand garments *(Some observed Cases: Kappahl, Filippa K)*	Enablers *-collection is only financially viable in areas with high density of population as well as closeness to the retail stores and sorting centres* *-strategic collection points* Challenges: *-Lack of centralized sorting* *-collection points is not evenly distributed* *-lack of consumer information* *-fragmented collection and competition from charities*	a. Supply chain planning: *Strategic collection network* b. Logistics architecture: *Well-developed automatic collection systems* e. Network collaboration: *Long-term collaboration with sorters* Information integration: *Consumer information to increase collection volume and quality*
Sort *(Some observed Cases: I:Collect - in collaboration with fashion retailers; Fashion Brands -Filippa K, Boomerang)*	Enablers *- familiarity with different markets* *- transportation from the retailer's consolidated facility to own sorting facility* *- very specialized selection and sorting of consignment* *- long-term relationships with these clients* Challenges *- manual sorting* *-informed quality-based categorization*	a. Supply chain planning: *Optimized collection and transportation network* b. Logistics architecture: *Strategic sorting and appropriation* e. Cooperation and sharing expertise: *with collectors* Information integration: *Market knowledge*
Refurbish: Mending, Re-labelling and washing *(Some observed Cases: Nudie Repair Shop)*	Enablers *- cost-effective processes, like washing etc.* *-innovative product-service concept* *-marketing concept* *-repairing to extend life and durability of garment* *- organize training workshops* Challenges *- cheap high-street fashion and high labour costs*	b. Logistics architecture: *Cost-effective repairing, etc.* c. Product architecture: *design for durability, extended usage, product-service system (PSS)* d. Product architecture: repair skills f. Collaboration with user: *repair education*
Reuse by user *(Some observed Cases: Boomerang, Filippa K, Nudie)*	Enablers *-vertically integrated structure* *-product durability and longevity* *-creative retail store formats* *-high level of sustainability communication* Challenges	b. Logistics architecture: *vertical process integration, creative retailing, sustainability communication* c. Product architecture: *design for durability* e. Information integration:

	-stock availability	*sustainability communication* f. Collaboration with user: *informal channels such as swapping events, consumer to consumer sales*
Redesign *(Some observed Cases: Boomerang, Nudie, Stormie Poodle)*	Enablers *-collaborations with designers and other creatives* *-redesign skills* *- logistics of the incoming second-hand products* *- Micromanaging the design* Challenges *-scalability and profitability* *-time*	a. Supply chain planning: *product & design merchandise planning* d. Product architecture: *redesign skills* e. Cooperation and sharing of expertise: *design collaborations* f. Collaboration with user: *co-design*

Table 2: Value generation in second-hand clothing: evidences and underpinning antecedents

DISCUSSION: EVIDENT PATTERNS IN ANTECEDENTS

Several key antecedents of value creation and appropriation are emergent through the data analysis following the interviews. These antecedents can be categorized into two levels, viz. intra-organizational and value chain.

At the intra-organizational level, one of the key enablers was strategic collection network for ensuring quality and volume of collection, as also highlighted by Ekström and Salomonsson (2014). In addition transportation of the collected clothes from individual collection points to intermediate warehouses and distribution centres and finally to the sorting facility (of the sorter) demands coordination of a well-networked transportation and distribution system as organized by the large sorting companies. Further merchandize planning both after the sorting and for redesigning purposes were crucial to appropriate the right value to the product. In addition, improvement in reverse logistics through automatized in-store collection, strategic sorting, cost-effective repairing/mending and creative retailing (like second-hand concept stores, shop-in-shops, etc.) were identified as key enablers of value creation. However, most of these operations were undertaken by individual value chain actors. The infrastructural enablers when complemented by the right market knowledge of the actors resulted in rendering critical success factors in value generation.

At the value chain level, long-term collaboration between collector and sorter emerged to be one of the key antecedents of successful value appropriation and grading, in line with findings of Blumberg (1999) and Debo et al. (2004). Such a commercial chain requires collection and sorting networks that provide ample and consistent flows of second-hand clothing in a cost efficient way, followed by operations to produce a variety of marketable products. Similarly, the fashion brands also collaborated with various designers for product redesign to achieve higher level of value creation. In addition, collaboration with end-user was also identified as a key antecedent for rendering innovative value chain models. Such collaborations could be observed through organization of various swapping events and renting services by fashion brands and other actors to enable collaborative usage. Further, some brands also incorporated users in the co-design process, as was observed in case of Nudie Jeans Repair toolkit. However some actors, predominantly the fashion brands were able to organize, coordinate, monitor, and execute complex reverse logistics by integrating through all value chain operations thus constituting distinctive capability or strategic resource, as also highlighted by Jayaraman and Luo (2007). Another key antecedent for higher value generation was identified along the product architecture to ensure durable design both during the product development and reuse phases, either by working with long living products with a high quality, design of products that make it easier to reuse, repurpose or recycle, or by finding out different ways to work with reuse mind set, etc. (Lifset and Lindhqvist 2008). Finally, it was observed that sustainability communication was also critical as an antecedent to value generation (in terms of both tangible profits and intangible brand value) across the entire reverse value chain which demanded the actors to communicate transparently their environmental friendly practices and solutions in terms of product, process and supply chain impacts. Such communication demands careful redesigning of product, process and supply chains to support sustainable practices in all frontiers.

CONCLUSION

The paper shows that various actors are engaged in the second-hand clothing value chain in Sweden, by adding/appropriating value in five ways, viz. collection, sorting, refurbishing, reselling of used clothes or redesigning, in varying degrees. In particular collection is still fragmented and less strategic, sorting is outsourced, and redesigning is still at the state of infancy. These stages have various enablers and challenges at the intra-organizational or value chain levels. At the intra-organizational level, key antecedents are strategic logistics infrastructure for collection, sorting, transportation and creative retailing. Further merchandise planning – both for reuse and redesign – is crucial for holding a strategic consignment, while design for durability also facilitates value creation through extended product usage. Along with these infrastructural enablers right market knowledge is essential as well. At the value chain level, key antecedents are: process integration, well-designed collection network, and collaborative partnership. Further, it emerged crucial to support communication of sustainability efforts as practiced in along the value chain. These antecedents of value creation in second-hand clothing network when mapped along 3-DCE also enabled to visualize the focus and driver of each reverse value chain attribute as shown in Figure 1. Design for durability, sustainable communication and creative redesigning with users were the key antecedents demanding 3-DCE attention.

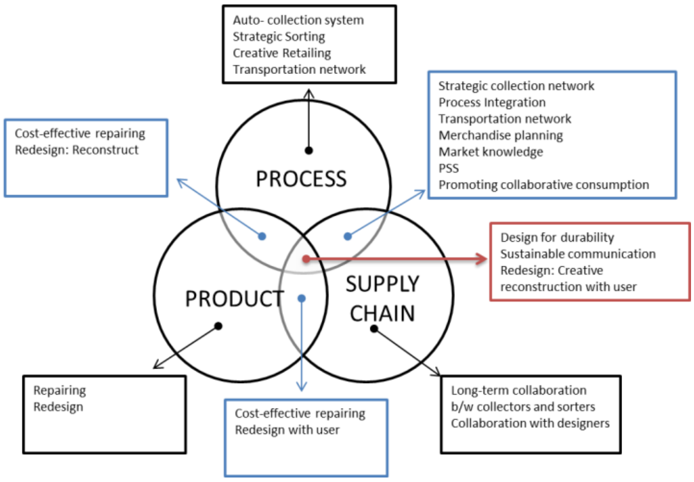

Figure 1: Antecedents of value creation along 3-DCE drivers

Limitations exist in terms of internal validity of the research. Author has delimited the discussion from mentioning other external value enablers, like legislation, product directive etc. In addition, explanation to the value creating activities and their antecedents apart from the 3-DCE linkages is not considered. Further, the paper does not address value creation in terms of its level, instead in terms of various stages. Future research is essential to develop quantitative measures of value creation along the identified activities for subsequent modelling. Further the effects of the identified antecedents needs to be investigated in connection to the measurable levels of value to explore their effects. Further the 3-DCE linkages needs to be monitored to propose solutions for higher value generation. The implications of the paper are vital for major actors in the second-hand clothing value chain to take efforts towards higher value creation by concentrating specifically on the various enablers. Further, the 3-DCE lens provides explicit understanding and categorization of the value creation activities, and 'where' and 'how' to invest.

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Section 8: Decision support techniques, technologies and processes

AN AGENT-BASED SIMULATION APPROACH FOR EVALUATING THE EFFECTS OF PICKER BLOCKING IN A RECTANGULAR WAREHOUSE

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ABSTRACT
This paper investigates the effect of "congestion" or "picker blocking" in manual picker-to-parts order picking systems. The effects are quantified using an agent-based simulation model, which determines the throughput times for order picking. The simulation model considers a standard rectangular warehouse and a set of different routing policies that guide the order picker through the storage area. Our results indicate that the largest gap routing policy leads to shortest mean throughput times when the same routing policy is assigned to all order pickers.

INTRODUCTION
Order picking is one of the most labor- und time-consuming processes in warehouses (Frazelle 2000; Tompkins et al. 2010). It is defined as the process of retrieving items from storage locations to fulfil customer orders (de Koster, Le-Duc & Roodbergen 2007). Hence, order picking is a critical process in supply chains with a direct influence on customer satisfaction, especially when damaged or wrong products are shipped to the customer (Gue, Meller & Skufca 2006; Parikh & Meller 2008). Additionally, order picking has an effect on the service level and performance of the supply chain (Chen, Wang & Xie 2013).

In warehouses order picking accounts for about 50% of the operating costs (Frazelle 2000; Tompkins et al. 2010). Travel time (with about 55% of the total time) is one of the most time-consuming processes in order picking operations (Tompkins et al. 2010). Hence, an important aim of warehouse managers is to reduce travel time (de Koster, Le-Duc & Roodbergen 2007). Several planning approaches can influence the time order pickers need for travelling through the warehouse. Among those are the planning of warehouse layouts, storage assignments, picker routes, and the batching of orders (de Koster, Le-Duc & Roodbergen 2007). The *warehouse layout* refers to the configuration of the warehouse and its number and size of aisles, cross aisles, etc. (cf. Meller & Gau 1996). *Storage assignment* rules define how products are assigned to storage locations (cf. Glock & Grosse 2012). *Routing policies* determine the way the order picker walks through the storage area (cf. Petersen & Aase 2004). *Order batching* finally combines or splits up customer orders (cf. Grosse et al. 2014).

Order pickers may block each other if more than a single order picker work in a warehouse zone and they pick in the same aisle or want to pick from the same pick-column. This phenomenon is commonly referred to as "picker blocking" or "congestion" (e.g. Parikh & Meller 2009), and it can result in longer throughput times due to additional idle or waiting times (Chen, Wang & Xie 2013; Parikh & Meller 2008; Mowrey & Parikh 2014). Because of the complex and stochastic nature of congestion, its influence on the performance of the order picking system is difficult to quantify (Heath, Ciarallo & Hill 2013). Due to the impact picker blocking can have on total throughput time, it has frequently been analysed in the literature. The literature commonly distinguishes between in-the-aisle blocking and pick-column blocking. *In-the-aisle blocking* occurs in order picking systems with narrow aisles where passing other pickers in an aisle is not possible. *Pick-column blocking* occurs if two or more order pickers want to collect articles from the same pick-column (Hong, Johnson & Peters 2013; Mowrey & Parikh 2014; Parikh & Meller 2009; 2010; Sainathuni et al. 2014).

To study the effect of picker blocking, several planning models have been proposed in the literature. In case of routing policies most studies focus on s-shape policy (e.g. Ruben & Jacobs 1999; Pan & Shih 2008; Parikh & Meller 2009; 2010a; 2010b; Hong, Johnson & Peters 2010; 2012a; 2012b; Pan, Shih & Wu 2012; Chen et al. 2013; Heath, Hill & Ciarallo 2013; Hong, Johnson & Peters 2013; Mowrey & Parikh 2014). Routing policies that have frequently been used in prior studies on manual order picking are the following (e.g. Caron, Marchet & Perego 1998; Petersen 1999; Petersen & Schmenner 1999; Petersen & Aase 2004; Roodbergen & de Koster 2001): s-shape, return, largest gap, midpoint, composite and combined.

While most studies on picker blocking focused only on the S-shape policy. We hypothesize that different routing policies can have different positive and negative influences on picker blocking in a storage area, depending on how they are combined and on how they interact with the storage assignment policy (e.g. Pan & Wu (2012) compared s-shape, return and an own policy and found differences for altered policies). This paper therefore aims on investigating the effect of picker blocking on a rectangular warehouse in a manual picker-to-parts order picking system. It considers six different routing policies, random storage assignment rule, and analysed the system's performance with the help of an agent-based simulation model.

The remainder of this paper is organized as follows: The next section introduces the simulation models and briefly describes our comprehensive simulation study. The following section then gives an overview of important results obtained in the simulation study. The paper is then concluded with a short discussion of results and future research opportunities.

SIMULATION STUDY

Method

Simulation is an appropriate method for studies which investigate human behaviour (Law 2013). In a simulation study, a computer is used to imitate real-world systems and to study their behaviour. Fundamental components of a simulation model are the assumptions (i.e. mathematical or logical relationships) about the real system under study. The purpose of the simulation model is to gain insights into the behaviour of the system (Law 2013). An important advantage of simulation is the possibility to deliberately change individual system conditions and to analyse their influence on the model's performance. In practice, such comprehensive analyses are often not possible, especially since individual system conditions can often not be varied in isolation (Heath, Ciarallo & Hill 2013).

Simulation has frequently been used in the past to study supply chains (for a review see Terzi & Cavalieri 2004). Also in the field of manual order picking, several simulation studies exist. These studies investigated the effect of different warehouse layouts (Berglund & Batta 2012; Roodbergen & Vis 2006) or order batching (de Koster, van der Poort & Wolters 1999) or compared the efficiency of different routing policies (Caron, Marchet & Perego 1998; de Koster & van der Poort 1998; Hall 1993; Roodbergen & de Koster 2001). In addition, the interaction between routing policies and the storage assignment rules used have been studied (Chen et al. 2010; Hwang et al. 2004; Petersen & Schmenner 1999; Petersen 1999; Petersen 2000; Petersen & Aase 2004). Especially in the field of picker blocking, simulation is a frequently-used approach (e.g. Chen et al. 2013; Heath, Ciarallo & Hill 2013; Pan & Wu 2012; Pan et al. 2012). Chen et al. (2013) developed a new routing method, which is based on Ant Colony Optimization. Heath et al. (2013) employed the agent-based simulation approach to investigate the impact of congestion on cost and performance. Pan and Wu (2012) used their simulation model to validate results of the approximation method for evaluating the throughput times in a multiple order pickers system. Pan, Shih and Wu (2012) created a new storage assignment policy for a multi-picker warehouse.

Borshchev and Filippov (2004) differentiated between three widely-used simulation approaches: system dynamics, discrete event and agent-based. Particularly, *agent-based simulation models* (ABS) seem to be well suited for investigating picker blocking, as the agents of the simulation model can imitate the behaviour of individuals (Heath, Hill & Ciarallo 2009). ABS consist mainly of three parts (Borshchev & Filippov 2004; Macal & North 2010): a set of *agents* (single entities, here: order picker), their *relationships* (interactions between agents, here: picker blocking), and an *environment* (here: the warehouse and the customer orders). For a review of agent-based modelling practices see Heath, Hill & Ciarallo (2009). Agents are modelled by a set of rules which define their behaviour, i.e. they can (inter-)act autonomously according to their implemented behaviour. Another feature of ABS is the possibility to interact with other agents and/or their environment. This helps to capture emergent phenomena in ABS. In the area of picker blocking, we found only few studies (Furmans, Huber & Wisser 2009; Heath, Ciarallo & Hill 2013) which use the relatively new approach of ABS.

Several software solutions support the development of ABS (Heath, Hill & Ciarallo 2009; Robinson & Ding 2010). We decided to use the software tool AnyLogic, as it is appropriate to simulate persons (active objects) (Borshchev & Filippov 2004) and offers a high level of flexibility due to a set of predefined libraries. Furthermore, models can be customized with additional classes and functions based on JAVA-Code (Borshchev & Filippov 2004; Macal & North 2010). The behaviour of each agent can be implemented with state charts which contain the behaviour of agents in states and transitions. State charts are comparable to UML (Unified Modelling Language) diagrams and offer a good trade-off between simplicity (predefined functionality) and complexity (extensions in JAVA).

Problem description and parameters

We study a frequently investigated warehouse layout with ten aisles and 1000 products (100 in each aisle) in this paper (cf. Grosse, Glock & Ballester-Ripoll 2014). Customer orders contain 20 picks per order and are assigned to a single order picker (agent). A list of 1000 orders are randomly generated and kept constant during all repetitions. Furthermore, the simulation model determines throughput times for each order and each agent with and without considering picker blocking. Agents traverse all aisles in both directions (according to their routing policy or blocking situation), and blocking exclusively occurs in aisles. For solving a blocking situation and to avoid deadlocks, the order pickers are able to leave the aisles on both sides. The order picker with the least distance to the next pick gets priority.

We further assume a standard order picking process (cf. Grosse et al. 2014), where the order pickers start at the depot and return to the depot after all 20 picks have been collected. The speed is constant at 0.75 meters per second, and the time to pick an item is 20 seconds (Gue, Meller & Skufca 2006; Pan, Shih & Wu 2012). The way of an order picker through the warehouse is defined by the routing policy used, where all agents use the same routing policy. The number of order pickers working in the storage area is varied from 2 to 15 agents. To reduce congestion in front of the first aisle, the next agent starts collecting items when the picker that started picking earlier arrives at the first aisle (i.e., after 18.5 seconds). The time count for a simulation run, which is required to calculate the mean throughput times, starts with the despatch of the first picker and is stopped once all agents arrive at the depot. This also triggers the next simulation run.

RESULTS

The simulation study quantifies the effects of picker blocking on throughput time for the six routing policies when the same policy is used by all order pickers (agents). Figure 1 illustrates the mean throughput times for simulation runs starting with 2 agents picking at a time up to 15 order pickers in the warehouse. The results indicate that the largest gap policy always led to the shortest mean throughput times. For this particular routing policy, the storage area is split and the order pickers retrieve items in the upper or the lower zone. This could lead to a reduced number of blocking situations and hence shorter throughput times. Also the midpoint policy divides the storage area into an upper and lower zone, but did not lead to shorter mean throughput times in comparison to the largest gap policy. The latter also led to lower throughput times without blocking (752 sec) in comparison to midpoint (769 sec). The return policy always led to the longest mean throughput times of all routing policies.

Furthermore, the simulation model determined shorter mean throughput times for the combined policy for up to 4 order pickers in comparison to the composite policy. For 5 to 7 order pickers, both policies led to almost the same mean throughput times. The results indicate that the composite policy is better suited for solutions where more than 8 order pickers are working in the warehouse

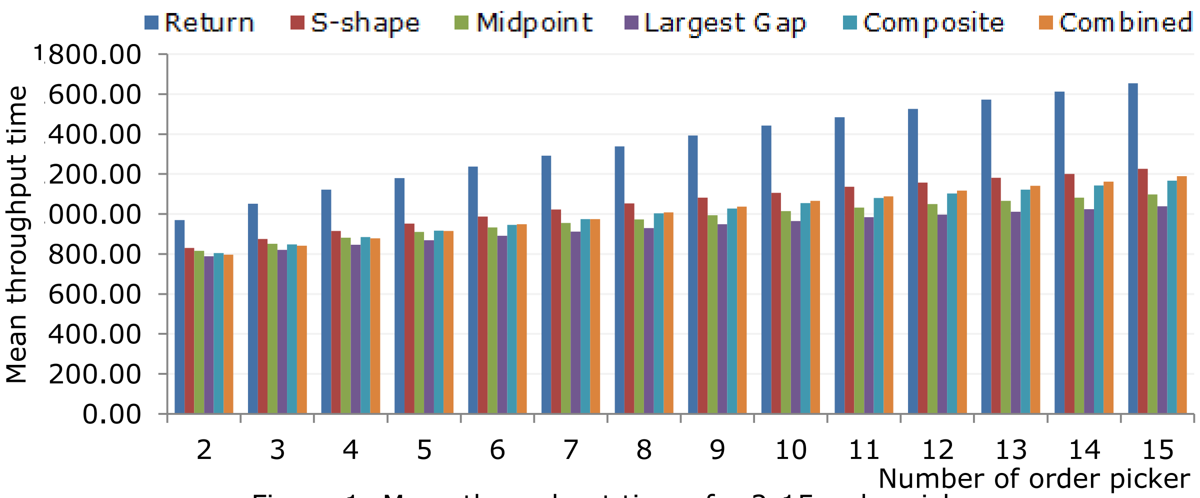

Figure 1: Mean throughput times for 2-15 order picker

Figure 2 shows the number of mean blockings per simulation run for 2 to 15 order pickers and different routing policies. The lowest number of mean blockings per simulation run is determined for the largest gap policy. The highest number of blockings was obtained for the return policy. While the number of order pickers increased by the factor seven when moving from 2 to 15 pickers, the number of blockings only tripled for the largest gap policy (starting with 52.75 mean blockings to 165.44 mean blockings per simulation run). Additionally, Figure 2 shows that a relatively high number of blockings occurred for the combined policy, which leads to longer mean throughput times in comparison to the largest gap, composite or midpoint policies. The return policy outperforms all other routing policies with respect to the mean number of blockings. This is due to the special characteristic of this routing policy, which specifies that all order pickers have to enter and leave the aisle only on one side. This dramatically increases the negative effects of picker blocking.

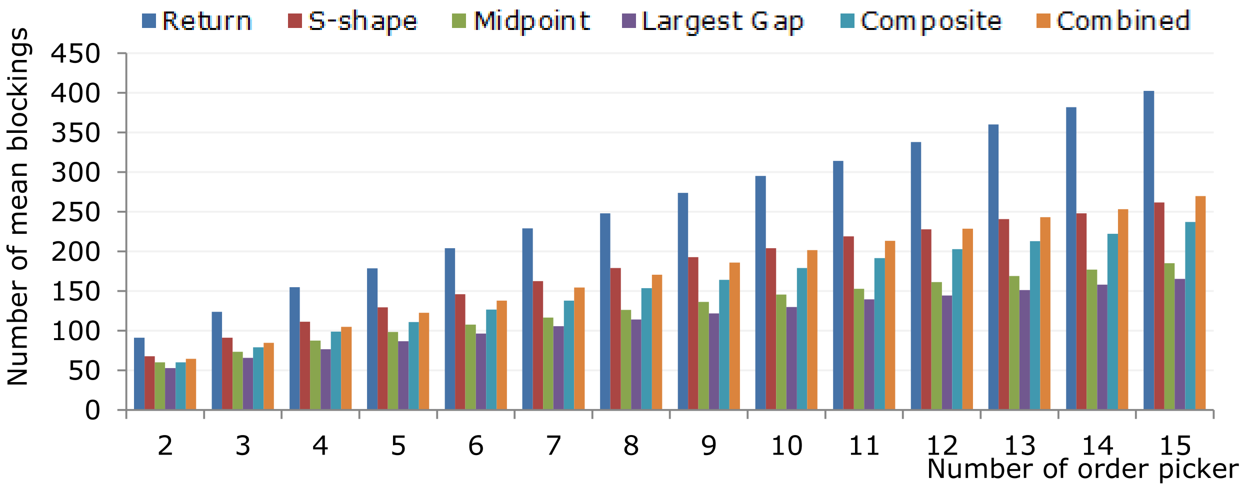

Figure 2: Number of mean blockings for each simulation run

The most common routing policy in practice is the S-shape policy (de Koster, Le-Duc & Roodbergen 2007). If picker blocking is not considered, this policy leads to longer mean throughput times as compared to more sophisticated routing policies such as combined, composite or largest gap. This gap increases if picker blocking is considered. With the exception of the return policy, the simulation model determined the longest throughput times and the highest number of mean blockings for the S-shape policy under each configuration.

DISCUSSION AND CONCLUSION

We investigated the effect of picker blocking on throughput times in a rectangular warehouse with a manual order picking system. Six routing policies and 2 to 15 order pickers were analysed to quantify the effects of picker blocking in an agent-based simulation model. The results of the paper indicate that the largest gap policy always leads to shortest mean throughput times when only one routing policy is assigned to all order pickers.

As an implication for practice, it is highly important to consider blocking during the planning process. Particularly, it was found that the combined policy minimizes the travel time without blocking in comparison to other investigated policies, but it leads to longer mean throughput times when picker blocking is considered. Therefore, warehouse manager should take picker blocking into account when planning order picking processes to obtain reduced travel times and distances. The paper also showed that more complex heuristics, such as largest gap, are recommended also in situations where picker blocking occurs. The longer throughput times determined with the S-shape policy without considering blocking increase dramatically if picker blocking is taking into account.

This study has several limitations. First, we employed only one storage assignment policy. Furthermore, only one routing policy at a time was assigned to all order pickers. This can be varied to investigate how combinations of different routing policies affect travel time. The effect for different storage assignment rules can be investigated and rectangular warehouse layouts with no cross aisles which can possibly reduce blocking. Additionally, sensitivity analysis can quantify the influence of other important factors (e.g. speed, acceleration/deceleration, …).

The results of this study have important implications for further research. Other storage assignment rules, like turnover-based strategies, can be implemented to study the effects of picker blocking. Those strategies contain busy areas with probably increased amount of blockings. Furthermore agent-based simulation approach allows studying several other influencing factors like individual routing policies for each agent or human behaviour when two or more picker encounter.

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MEASURING SUPPLY CHAIN ADAPTABILTY: A CASE STUDY ANALYSIS IN SOLAR PV INDUSTRY

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ABSTRACT

While the world is struggling with shortage of fossil fuels energy and seeking for alternatives to it over the past several years, experts and investors have already identified renewable energy as alternative energies for fossil fuels and nuclear power. Among different types of energies, solar energy is considered as one of the most environmental friendly source. Not to mention that investment in solar photovoltaic (PV) industry had become a boom especially after the 21st century. However, due to the volatile of demand and changing patterns in manufacturing and distribution between several countries, the industry started to collapse. For this reason, many of PV related companies eventually have gone bankruptcy. Several methods, such as efficiency, responsiveness and agility, which are used to measure competitive factors for a company, have already been widely applied. Nevertheless adaptability is still a new and largely unexplored area. As a result, our research aims to develop a mechanism to measure supply chain adaptability under radical environment by building up case studies and extracting potential elements for metrics of solar PV industry. Qualitative research is conducted as our methodology, which combined with company reports, industry statistics, literature review and six semi-structured interviews with solar energy related companies in Germany. In our case studies, six companies specialize in different aspects of solar PV supply chain and demonstrate different emphasis regarding the adaptability of supply chain. Based on our result, company could assess their individual contributions and evaluate what abilities they are insufficient for preventing the risks involved when encountering volatile changes in the market.

Keywords

Solar PV Industry; Interviews; Qualitative Research; Supply Chain Adaptability

INTRODUCTION

Solar energy is considered as one of the most environmental friendly sources of energy among several types of renewable energies available nowadays, because it is a natural energy source and does not emit CO2 (PVinsights, 2013). The solar energy panels are easy to be installed on buildings or private households. In addition to its environment friendly feature, improvements in technological, cost reductions in materials and government support have large influence on the demand and supply sides to enable solar photovoltaic power to catch consumers' attention in the past years. The industry experiences volatility of demand and supply, changing patterns in manufacturing and distribution in the US, Europe and Asian regions and strong governmental influence through feed-in tariffs and minimum import prices, which results in price fluctuations in this industry. The selling price of solar module has been increasingly volatile. For example, it experienced raises from 2001-2007 after a rapid plunge in 2000 but the price plumped down even more seriously from $3.5/W in 2007 to $0.98/W in 2012, i.e., a four times drop in price in only five years. As the price declined dramatically, demand ramped up and the markets became overheated. If companies cannot adapt and evolve carefully, inventory, production/installation capacity, labors, etc., will all be seriously affected by this volatility. Thus, some of the solar module industry in the US and Europe started to move their plants to countries with lower labor costs. Those that cannot adapt to this volatile change in price and demand may eventually go bankruptcy and lost their leadership in this industry.

To cope with the volatility of demand and supply, a supply chain can no longer just think of cost and responsiveness, but should consider agility and adaptability as well (Lee, 2004). Christopher and Peck (2004) also suggested that companies should take resilience into consideration, which contains flexibility and agility. There are several metrics such as efficiency, responsiveness and agility that can be used to measure the competitiveness of a company from a supply chain perspective; nonetheless, adaptability is still a new and largely unexplored area. As a result, this study aims to develop a mechanism to measure supply chain adaptability under radical environment by building up case studies and extracting potential elements for adaptability metrics of solar module industry. Ivanov and Sokolov(2010) proposed that supply chain adaptability is the ability of a supply chain to prevent, improve or develop other characteristics in order to achieve supply chain objectives in a changing market. It also has high correlation with supply chain complexity because supply chain may not be able to respond on time and to be controlled effectively in a company. Thus, supply chain complexity and adaptability are connected closely. They also developed a table with the concept of complex supply chain adaptation in five levels and they are implemented as a reference in our coding process. The 5 levels of complexity adaptation start from operative to tactical and then to strategic levels and are classified as

- Level 1: operative level; Level 2: operative-tactical level; Level 3: tactical level; Level 4: tactical-strategic level; Level 5: strategic level (Ivanov and Sokolov, 2010).

Table 1: The 5 Levels of complex adaptation concept (Source: Ivanov and Sokolov (2010))

	Adaptation level	**What is adapted?**	**How can it be adapted?**	**Management horizon**
1	Parametric adaptation	SC parameters	Capacities reconfiguration, rush orders, etc.	Operative
2	Structural functional adaptation	SC structures	Operations reallocation, supplier changing	Operative-tactical
3	Goal adaptation I	SC goals	Project goal adaptation, e.g. delivery delay	Tactical
4	Model adaptation	SC models	Introduction of new parameters, structures, restrictions and goals	Tactical-strategic
5	Goal adaptation II	SC strategies	Management goal adaptation	Strategic

To study the contingent strategies of a supply chain when confronting structural market fluctuations, we used case study to encompass the various aspects. The fluctuating market demand triggers the adaptive strategies in manufacturing and distribution in the global market and has led to a serious price variation in this industry. Moreover, its competitive characteristics in product technologies, such as PV cells production and crystalline thin film production are also notable factors for measuring the ability of a company when facing rapid changing market.

CASE STUDY AND INTERVIEWS

By assessing the six most frequently used qualitative approaches recommended by Creswell (2013), we decided to implement with case study because it can carry on an extensive investigation a company to obtain an in-depth data and learn more about their practical countermeasures by interviewing their decision makers. We applied semi-structured interviews to perform an in-depth discussion and to offer chances for the participants to explain in more details about their aspects.

We collected information from company reports, industrial statistics, literature reviews before having interviews with six companies in Germany. These companies have different core businesses in solar PV supply chain, Figure 1. Company A provides its customers consultation in project management, installation and efficient production facilities. Company B is one of the world's most important manufacturers of high-purity polysilicon, to be applied in semiconductor and solar industry. Company C has three core businesses, including agriculture, building materials and renewable energy segment, and it is one of the largest system suppliers in the European PV market. Company D is the only Chinese company in our case studies, which covers a large part of PV SC and specializes in R&D, manufacturing, sales and after-sales services for solar wafers, cells, modules and photovoltaic power systems. We interviewed their general manager of Imp& Exp division while they visited the electronica fair in November in Munich, Germany. Company E is a solar manufacturing equipment producer and provides production solutions in the fields of photovoltaics, semiconductors, and microelectronics. It is also the only case company sought for bankruptcy protection; Company F covers the whole value chain, from feedstock (silicon) to modules, and trades with solar panels to solar plant turn-key projects.

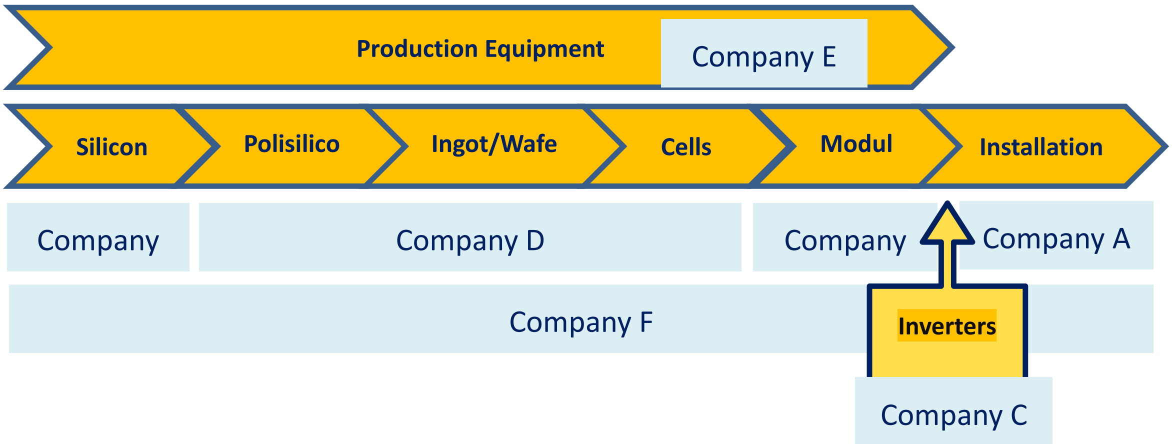

Figure 1: Value-adding positioning of interviewee companies

During the interviews, we explained to the interviewee a brief outline about our research first, and then began with a question that didn't get into the focal point directly. For example: which part of PV industry does your company mainly focus on, or what is the market share of your business, etc. The subsequent questions will depend on what the interviewees responded. Even though the interview results were diverse for companies, they covered in great detail of our research topic.

CODING PROCESS OF THE DATA

Based on the interviewing data, we developed a supply chain adaptation model with a comprehensive criterion list for long term adaptability of a company. We considered criteria from two sources - the first four criteria, coded as Code 1-4, were referenced from literatures of Lee (2004), Knoppen and Christiaanse (2007) and Ketchen and Hult (2007), while the second source of criteria was developed during the interviews for those that show to have profound effects on how to respond to the supply chain volatility and were coded as Code 5-21.

RESULTS

To make the entire criteria and the five adaptation levels more distinguishable, we further grouped these 21 codes into three dimensions and mapped them with the adaptation levels of Table 1 and obtained the result in Table 2.

Table 2 Adaptation criteria and three dimensions

Dimensions	**Criteria (code number)**	**Adaptation Levels**
Customer Related	5. Vertically integrate with down streams.	4
	9. Cooperate with second-tier downstream customers.	2
	12. Build long-term contracts.	2
	14. Concentrate on more than one customer.	2
	19. Focus on after-sale service.	2
	20. Cautiously authorize customer's credits.	1
Supplier Related	2. Have more than one SC to serve as a backup.	5
	3. Cooperate with third-party service providers to reduce assets investment	2
	5. Vertically integrate with upper stream suppliers.	4
	12. Build long-term contracts.	2
	17. Choose smaller companies.	2
	18. Make profits from smaller-sized companies	2
Company Related	1. Constantly screen markets to challenge the SC model and products.	1
	4. Cautiously hold inventory.	1
	6. Constantly manage costs and benefits.	3
	7. Change positioning within a supply chain.	4
	8. Consciously add up capacity.	1
	10. Standardize and modularize products.	3
	11. Be flexible in changing business model.	1
	13. Have flexibility in product designs.	1
	15. Cooperate with large insurance company.	4/5
	16. Share risks by setting up "Stock Protection" scheme.	1
	21. Reduce product variety.	3

For the six case companies in our research, after we have interviewed them, we collected all the notes and data during the interview and summarized them into a text form via the coding process. We summarized all the coding numbers from the 6 interviews and performed a mapping process with the 5 levels of complexity adaptation proposed by Ivanov and Sokolov (2010) as in Table 3.

Table 3 Case companies and the criteria extracted

Coding No.	**Criteria**	**A**	**B**	**C**	**D**	**E**	**F**	**Adaptation Levels**
1.	Constantly screen markets to challenge the SC model and products	●		●	●	●	●	1
2.	Have more than one SC to serve as a backup	●						5
3.	Cooperate with third-party service providers to reduce assets investment	●	●		●			2
4.	Cautiously hold inventory.		●	●	●		●	1
5.	Vertically integrate with upper stream suppliers.	●	●	●	●		●	4
⋮								
21.	Reduce product variety.						●	3

CONCLUSIONS

As can be seen from Table 3, for the case companies that show only lower levels of adaptation, because their adaptation levels are only in operations, it usually shows they have less ability to adapt to the environment from a strategic perspective and thus are easily influenced by the volatile market changes. However, companies should take several aspects into consideration when implementing our model. Because every case study of our research is located in a different position in solar PV industry, they are unable to represent the complete performance in this industry. Thus, we suggest that future research could develop a more comprehensive measurement in evaluating the adaptation levels of every criteria and figure out more good and bad examples from this industry to manifest their distinctions in facing market turbulences.

Supply chain adaptability is still a new and only slightly touched research area and without truly encountering volatile situations, many companies cannot foresee or envisage how to be adaptive in their SC position. Solar PV industry experienced an acute change in production volume and prices in recent years and has dramatically changed the SC ecology of the industry in a short time. Through case studies with interviews, we summarized additional 17 criteria which were not cited from current literature but from practical experiences of interviewees in this industry. Without further study, we do not claim the 21 criteria in Table 3 are a complete list for SC adaptation but are a starting point for future research.

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IMAGE ANALYSIS AS KEY TECHNOLOGY FOR LOGISTICS AUTOMATION SOLUTIONS

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ABSTRACT

The fast developments in automation technology especially in sensor systems and artificial intelligence enable the development of flexible and autonomous automation solutions. These systems can react to unknown situations and are able to learn their experiences in order to improve their future behavior. Thereby they are very suitable for optimising logistics processes, since these processes are usually characterized by a dynamic environment as well as unknown and not standardized objects. This paper describes new developments in analysing image data from modern sensors for improving logistics processes and shows the high potential focusing on automatic handling and material flow control systems.

INTRODUCTION

The rising availability of RGB-D (2D/3D) sensors provides various possibilities for optimizing logistic processes regarding efficiency and costs. This kind of sensors delivers 2D colour image information (RGB) and 3D distance information directly mapped to each other. Each image pixel has a corresponding distance value. This enables the investigation of textures simultaneously with geometric information. Thereby, automation systems can be developed which are able to analyse their working environment in process relevant real time, make decisions as well as predict future behaviour of recognised objects in the sensor data.

Automation in logistics is mainly performed by providing technical assistance systems which support human workers in performing their daily work or in processes where all relevant conditions such as environment and objects are constant and predefined. An example for the first type are camera-based technical assistance systems for forklift drivers. They support the driver by visualizing the environment in the case of pallet handling (Jung 2013) or detect human workers wearing marked clothing (Mosberger 2013). Process automation by robotic systems is in the second category of automation in logistics. For instance, palletizing robots usually know the packaging pattern, the size of the goods and the location where to perform the picking and handling process. Therefore, there exist high requirements for robotic kinematic and gripping technology. Here, image analysis has its benefits when the prior knowledge is reduced and the packaging pattern is variable but it is scanned before a transport process (Weichert 2013).

Another example for automation by robotic systems is order picking with mobile robots. The KIVA system was the first mobile robotic fleet which has revolutionized order picking in regard to goods-to-person systems (Guizzo 2008). The system consists of several mobile robots which are able to transport shelves to manual picking stations, where the single orders are combined. The system requires a labelled infrastructure for navigating the mobile robots and identifying the correct shelves. Image analysis is used for collision prevention of the mobile robots.

All these systems use prior knowledge to enable robust process automation. Nevertheless, new research trends such as semantic scene analysis, life-long learning and adaptability enable the development of flexible automation solutions which are suitable for logistics processes and can control the dynamic nature of logistics.

SENSOR TECHNOLOGY

Commonly used 3D sensing techniques already applied within logistics processes can be divided into Time-of-Flight (TOF), structured light and stereo vision. A description of the commonly used measurement technologies and their advantages and disadvantages in regard to logistics processes can be found in (Stoyanov 2013). A low cost sensor using the structured light measurement principle is the Microsoft Kinect or ASUS Xtion Pro sensor. The sensor delivers RGB-D sensor data. This can visualized in a set of points that replace the scanned surface. Each point contains in addition a colour value which corresponds to the colour of the scanned surface point. Figure 1 shows RGB-D sensor data from a packaging scenario for a palletizing solution.

Figure 1: RGB-D sensor data of a packaging scenario in a container

By analysing the distance information, the object location and geometric shapes can be detected. In combination, the texture provides information about edges, logos or package tape. Thereby, the packaging scenario can be analysed completely and a robotic system is able to unload the container.

AUTOMATIC HANDLING OF LOGISTICS GOODS

The automatic handling of logistics goods is a main application for robotic systems in logistics. Two main areas are the unloading of a container with unknown instances of predefined shape classes and depalletizing with unknown packaging patterns and good sizes.

The unloading of containers is mainly performed manually since automation systems need to fulfil high requirements regarding process time, accuracy and flexibility. Additionally, the return on investment of such a robotic system must be between 2-3 years. A system which has achieved the transformation from research project to a final product was the parcel robot (Echelmeyer 2008). This robot is able to unload a container filled with parcels in a predefined size range fully automatically. The robot uses a laser scanner in order to get a full 3D representation of the packaging scenario. The 3D image data is analysed in order to localize and detect single parcels in the packaging scenario which can be unloaded by the robotic system. After the successful market introduction of the parcel robot, research activities are started to make the system more flexible. Here, image analysis plays an important role since it provides the eyes of the robot and delivers all relevant information which the robot uses for its decision which objects to unload in the next process step.

In the first step, the intelligence of the robot was extended to more shape classes of possible objects in a container. In addition to parcels, the robot should recognize and localize cylindrical objects such as barrels and free-form deformable objects such as sack objects. A shape-based detection of different goods is predestined by analysing the 3D sensor data of RGB-D data. Here, the point cloud can be segmented in differently shaped parts. These shape parts are categorized to plane, cylindrical and ellipsoid by using the principal curvature (Thamer 2013). In the next step these shape parts are combined to complete logistics objects. Figure 2 shows the main idea of this approach.

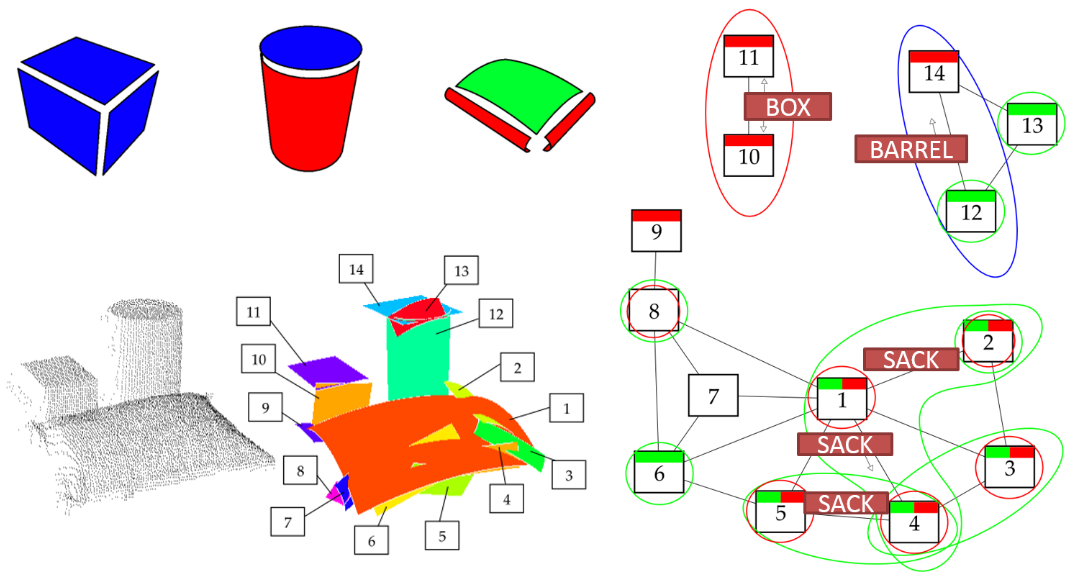

Figure 2: Surface parts and graph-based object reconstruction

Box objects can be reconstructed by 2 till 3 planar surface parts. A barrel is a combination of a planar and a cylindrical surface part. A sack object is a combination of an ellipsoid surface part and two cylindrical parts. 3D sensor data is segmented into surface parts which are classified to a shape part class. Afterwards, neighboured surface parts are connected in a graph and compared to a model graph. This approach is tailored to automated container unloading focusing on the three mentioned object classes.
A more general and flexible approach uses machine learning in order to learn the shape characteristics of all possible object shapes. The learning replaces the shape characteristics by using principal curvature by a shape training process. Machine learning offers the benefit to learn a model of a shape instead of providing a database with all possible instances of the shape. Additionally, the trained model can also be used to classify unknown instances of shape class. Thereby, the amount of objects to be recognized by the robotic system is much higher and the robot can also react and proceed working if he recognizes something unknown.
The parcel robot was further refined in the RobLog[1] project to a cognitive robotic system which can learn from its behaviour and can easily extend the range of objects to unload by an offline training stage. Within the RobLog project object recognition methods (Müller 2013) and gripping technology (Tincani 2012) specialised for a cognitive unloading robot were developed focusing on academic as well as industrial scenarios.

[1] http://roblog.eu

Modern RGB-D cameras offer the possibility to deliver colour information which can significantly improve the robustness and accuracy of object recognition methods. The accuracy of the approach of a shape-based recognition strongly depends on the separation of the cloud to single shape parts. Using the colour information in the segmentation step improves the accuracy of the final object recognition. This is shown at the example of depalletizing or unloading of boxes out of containers.
Boxes which are positioned in a structured order by using no prior knowledge are a real challenge for a vision system since singles boxes cannot be separated from each other using shape information. Here, 2D texture information can be used for improving the robustness of the vision system. Figure 3 shows an example of a structured packaging scenario for a depalletizing process.

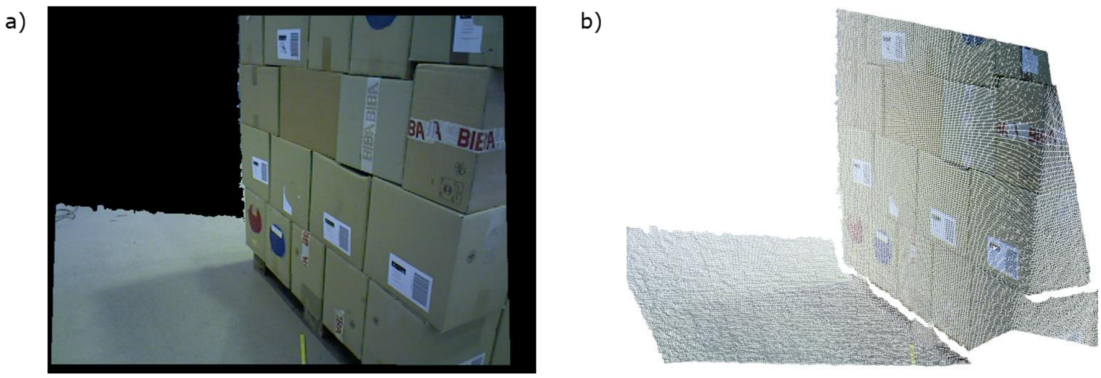

Figure 3: a) 2D colour information b) 3D point cloud with mapped colour (RGB-D)

Using a combination of 2D and 3D image analysis algorithms the scenario can be analysed and edges between single boxes can be detected. Nevertheless, edges which are caused by a packaging tape or stickers and barcodes are also characterized as edges. As figure 3 visualizes, this packaging tapes or stickers have an arbitrary places and cannot be described in advance and stored in an object database before starting the depalletizing process. Therefore, we use a knowledge based approach with machine learning to learn models of tapes and stickers in order to be able to handle unknown instances of these classes correctly. Figure 4 shows the results of classifying all edges in the scenario from figure 4 and the final detection of the valid edges.

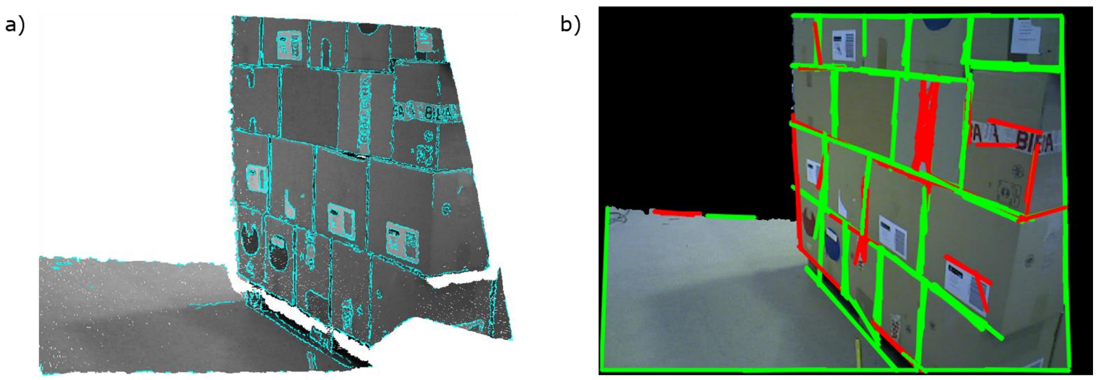

Figure 4: a) All edges marked with blue lines b) Valid edges (green) and non-valid edges (red)

The valid lines are used for the final segmentation. Afterwards the inner points of the valid lines represent the box clusters points which can be used for object localization and grasp planning. Figure 5a shows the separated objects by removing the valid lines from the RGB-D sensor data. Figure 5b presents the final clusters for object recognition. The single coloured clusters contains the detected objects. Since each cluster point is a xyz coordinate in the sensor coordinate system they can be easily used for computing the grasping points and the final trajectory for unloading or depalletizing.

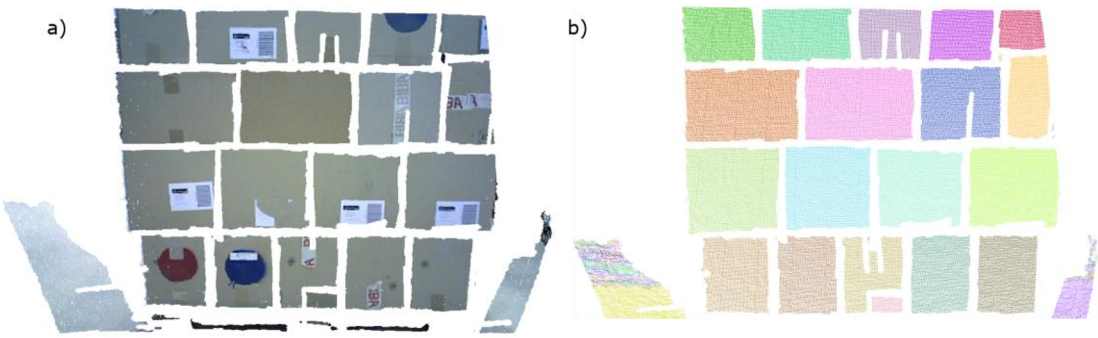

Figure 5: a) All edges marked with blue lines b) Valid edges (green) and non-valid edges (red)

MATERIAL FLOW CONTROL

Traditional material flow systems are controlled by light barriers and barcode reader systems. The trend to a more flexible and decentralized material flow and transportation systems needs a flexible and sometimes continuously tracking and position determining control system. Here, also camera based image analysis systems can play an important role, since they can recognize the transported goods in images and determine their exact position on the material flow system. The benefit of a camera based material flow control becomes visible when using highly flexible conveyor systems, which can perform almost all material flow tasks such as sorting, layer forming and singulation. An example for such a system is the Cellular Conveyor (Celluveyor) which was invented at the BIBA institute at the University of Bremen.
The Celluveyor is a modular conveying and positioning system based on a novel conveyor technology concept, which has a high flexibility with respect to the layout, the possible fields of application, the range of transported goods and adjustments to changes in throughput. The system consists of several small hexagonal conveyor modules. These modules consist of omnidirectional wheels which are driven by an electric motor. Figure 6 shows the concept of the Celluveyor system.

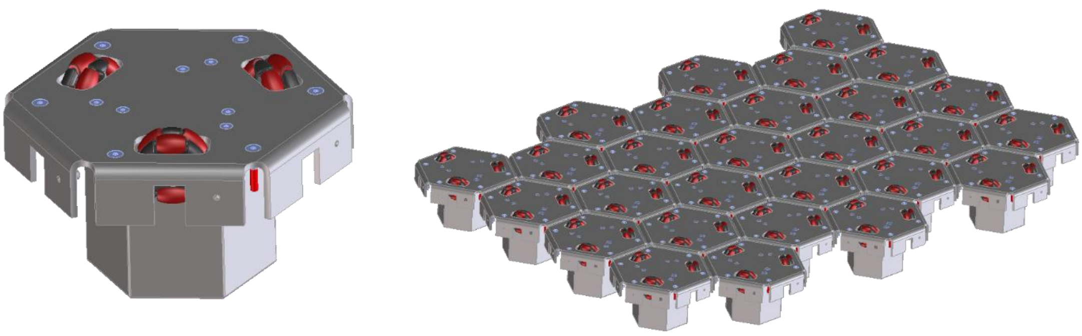

Figure 6: Celluveyor module and combination of modules to a complete cellular conveyor system

Due to the special arrangement of the wheels, as well as through a targeted control of the individual drives, the objects can be moved independently on any tracks. Without much effort, conveying surfaces with any dimensions and geometries can be set up which are universally applicable. Figure 7 visualizes the prototype of the Celluveyor fulfilling a sorting task. Through the cooperation of the individual modules objects can be moved freely and independently of each other and therefore the most complex tasks of material flow technology are realized with one system.

Figure 7: Celluveyor system

Since the transported objects can be moved and rotated in any possible direction all material flow processes can be performed with one single hardware setup only by changing the software system. Positioning tasks such as singulation or layer forming require an exact knowledge where the transported goods are located on the conveyor in order to perform corrections in the path planning and movement execution by a closed control loop system. A camera system recognizes all objects on the Celluveyor conveyor and determine their position in the camera coordinate frame. A transformation in the Celluveyor coordinate frame ensures the correct and exact position determination of the transported objects. If the deviation of the current and planned position exceeds a threshold a path correction step can be performed by the control system. This step must be performed at each recorded and analysed camera frame. In order to avoid a time intensive object recognition process at each camera frame, object tracking algorithms can be applied. These kind of algorithms recognize the object once in the first camera image. Then they compare the changes in the next frame and follow and track the position of the recognized objects without performing another object recognition process. This concept can be applied to any kind of material flow or transport system. Even the kind of transported object can be variable when a suitable feature-based object recognition method can be applied to detect and locate the objects in a robust way. Thereby, all positions of all objects can be determined continuously instead of having discrete scanning points within the material flow system.

SUMMARY AND OUTLOOK

New concepts and technologies in the field of automation science and artificial intelligence provide great potential for realizing flexible automation solutions for logistics processes. These processes are characterized by a highly dynamic environment which is a great challenge for traditional industrial robots. Image analysis has an important role in these developments since it provides the scene understanding and the intelligence for the automation systems.

This paper has presented image analysis applications in real logistics processes. Thereby two major application areas are identified. The first one addresses image analysis for handling of logistics objects by robotic systems. Example applications are automatic unloading of containers or depalletizing processes. Here, the parallel analysis of 2D and 3D image data shows great potential for automation solutions. The second area is the application of image analysis especially object tracking for highly flexible material flow control systems which was explained using the omnidirectional cellular conveyor system Celluveyor.

In future, machine learning techniques such as deep learning will play a more important role in order to create life-long learning automation systems which learn from the experiences such as success and failure and improve its system behaviour. These techniques automate the training and object description process with no manual interaction necessary. Logistics automation solutions can thereby improve their robustness and flexibility to unknown situations such as damaged or unknown goods.

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CUSING A VNS METHODOLOGY APPROACH TO SOLVING A MULTIPRODUCT EOQ-BASED INVENTORY PROBLEM WITH STORAGE SPACE CONSTRAINTS IN THE COMPANY LAFANTANA

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ABSTRACT

The objective of this paper is to model a static time-continuous multiproduct economic order quantity (EOQ) based inventory management problem with storage space constraints, as a combinatorial optimization problem in the corresponding dynamic discrete time system control process in company La Fantana in Serbia. La Fantana is a leader in the field of bottling and distribution of water and water coolers in Serbia and during the year 2013, company increased the product portfolio with coffe-based products. This paper analyses La Fantana company inventory system, with continuously changing state and constant average demand. Inventory control problem set in this paper is modelled and presented in spreadsheets for 21 artical, in accordance with the problems defined in company La Fantana. Spreadsheets are used for building of simulation model of a discrete controlled object and metaheuristics for solving the problem. The results obtained from discrete dynamic spreadsheet models are compared with actual inventory data obtained in La Fantana company for year 2014. The described inventory management problem with storage space constraints represents a widely applicable and popular problem in practice. This problem has been often addressed in many research papers. To solve this NP (Nondeterministic Polinomial) hard problem, we have developed Variable Neighborhood Search (VNS) algorithm based on the local search technique, and we have preliminary examined efficiency of heuristcs with a several numerical experiments. VNS algorithm was developed in order to facilitate definition of number of orders. As the result of the study, we were able to present here VNS algorithm that generates a feasible set of ordering scenarios. The contribution of this paper by should be prove that the dynamic simulation spreadsheet inventory model can be used as reliable and easy way for inventory control in company La Fantana. Model will be applied over the real data collected in the company in 2013 and will be compared with real-life obtained company's data for year 2014.

Keywords
Multiproduct EOQ inventory problem, Discrete time system control, VNS, NP-hard.

1. INTRODUCTION

The Economic order quantity (EOQ) model belongs to a class of classical inventory models with a known total deterministic product demand, where the order product quantity should be determined to minimize the total costs of the production, ordering and inventory holding. The model was originally developed by Harris [1], though Wilson [2] is credited for his early in-depth analysis of the model. It was a time without easily affordable computers and simple useful mathematical models were preferred (see Erlencotter [3] for the history of EOQ). As we can see in [4-10], even new books dealing with inventory control describe the classical EOQ model and its variants as a starting point for further understanding of inventory dynamics.

A discrete time system control is a more natural manner to describe inventory dynamics, as it is stated in [11]. A model of discrete system control could be both a simulation model of inventory dynamics and an optimization model which can give the optimal control according to a defined performance criterion.

There are numerous articles using the discrete time system control in a dynamic deterministic inventory problem. Most of them address lot-sizing problems, beginning

with Wagner [12] and Scarf [13]. In order to find an optimal inventory control for various variants of dynamic lot-sizing problems, dynamic programming algorithms are applied [14]. Numerous special heuristics and metaheuristic-based algorithms are used to solve such problems [15,16].
This paper presents a static time-continuous multiproduct EOQ-based inventory problem with storage space constraints. In order to solve it approximately the problem is modeled in Section 2. as a combinatorial optimization problem in a dynamic discrete time system control process for inventory management, by defining basic elements of a discrete controlled object, according to [17]. To solve this model we have developed a VNS algorithm based on the local search principle in Section 3. in order to solve the mathematical model described in Section 2. Section 4. contains a comparative review of numerical results obtained by VNS metaheuristics.

2. MATHEMATICAL MODELLING

We consider a time-continuous multiproduct EOQ-based inventory problem which has most of the characteristics of a well- known classical economic lot-size model.
A number of products *m* are given and for each product *i* , $i=1,\ldots,m$, the total deterministic demand D_i which should be satisfied within a finite time horizon *T* in the following way:

- the same amount Q_i of product *i* is ordered u_i times with the constant time t_i between two orderings;
- the whole ordered amount Q_i arrives on the stock simultaneously and immediately when desired, while it is withdrawn from the stock continuously by the constant rate equal to D_i/T . Shortages of the product on the stock are not permitted.

For each product *i* the only cost to be considered is the cost related to ordering – the setup cost S_i and the purchase cost of C_i per product unit , and the inventory holding cost of H_i per product unit in time unit. The total inventory holding cost in period t_i is calculated with respect to the average inventory level $Q_i/2$.
Ordered amounts of different products share the same storage with the total available space *G* which is known in advance, and consequently, for each product *i* the storage space P_i , occupied by its unit, is given. Therefore, inventory levels during the observed time period $[0,T]$ should satisfy the following *storage space constraints*: at any moment in this period the total space occupied by the stored amount of all products should not exceed the space limit *G.*
According to the classical EOQ model, the total cost *TC* for already described inventory system is equal to

$$TC=\sum_{i=1}^{m}(S_i+C_iQ_i+H_i\frac{Q_i}{2}t_i)u_i \tag{1}$$

Taking into account that $u_i=D_i/Q_i$ and $t_i=T/u_i=TQ_i/D_i$, the total cost *TC* can have the form

$$TC=\sum_{i=1}^{m}S_i\frac{D_i}{Q_i}+\sum_{i=1}^{m}C_iD_i+\sum_{i=1}^{m}H_i\frac{Q_i}{2}T \,. \tag{2}$$

Then, the following inventory problem is considered: find amounts Q_i , $i=1,\ldots,m$, which satisfy storage space constraints and minimize the total cost (2). In order to solve it approximately, the problem is modelled as a combinatorial optimization problem of the corresponding discrete time system control process in the following way.
Instead of continuous time period for ordering products, the whole time period $[0,T]$ is divided into *n* periods *t* with the same length T/n , where $t=1,\ldots,n$. (For example, if *T*

is a year then t could be a day). We assume that the ordering of any product can be realised only at the beginning of a period *t.* As during this period of length T/n the product is withdrawn from the stock continuously by the constant rate D_i/T, then the product demand which should be satisfied within the period is equal to D_i/n.

Instead of Q_i, $i=1,...,m$, we consider $u_i \in \{1,2,...,n\}$, $i=1,2,...,m$, as decision variables, while $Q_i = D_i/u_i$.

Now, for each product *i* a change of its inventory level during the whole time period can be formally represented as a discrete time system control process with the following elements:

X_t^i, $t=1,2,...,n$ – the total amount of product i remaining on the stock at the end of period t.

Y_t^i, $t=1,2,...,n$ – the amount of product i ordered at the beginning of period t.

If we consider X_t^i as the *state* of a process at period t then the *state equations* which describe the behaviour of the process can be defined as

$$X_0^i = 0 \qquad (3)$$

$$X_t^i = X_{t-1}^i + Y_t^i - D_i/n, \quad t=1,2,...,n. \qquad (4)$$

Obviously, ordering of amount $Q_i = D_i/u_i$ is realised at the beginning of a period t only in the case when the stored amount of a product i remaining at the end of the previous period $t-1$ is not enough to satisfy demand D_i/n within period t. Therefore, the value of Y_t^i depends on u_i and can be formally expressed as

$$Y_t^i = \begin{cases} D_i/u_i \ , & X_{t-1}^i < D_i/n \\ 0 \ , & otherwise \end{cases} \qquad t=1,2,...,n. \qquad (5)$$

Also, as $X_0^i = 0$ then, consequently, $X_n^i = 0$.

Let us mention that the process described by (3) - (5) does not represent a typical discrete time system control process, where at each period the current state is dependent on both the previous state and a chosen value of one or several control variables. Namely, using expressions (3), (4) and (5), for a fixed u_i amounts X_t^i and Y_t^i can be precisely calculated for each t, $t=1,2,...,n$. It means that Y_t^i is not a control variable, and that a real control variable in the process is u_i.

Storage space constraints are considered only at the beginning of periods t and consequently can be formally defined as

$$\sum_{i=1}^{m} (X_{t-1}^i + Y_t^i) P_i \le G \qquad t=1,2,...,n. \qquad (6)$$

Let us determine the total cost $J(u_1,u_2,...,u_m)$ for the inventory system described by (3)-(5). It is equal to the sum of the total costs for every product i at each period t, where the total inventory holding cost of product *i* in period t is calculated with respect to the average inventory level which is equal to $X_{t-1}^i + Y_t^i - \frac{D_i}{2n}$ and period length T/n. More formally,

$$J(u_1,u_2,...,u_m) = \sum_{i=1}^{m} J_i(u_i)$$

$$J_i(u_i) = \sum_{t=1}^{n} ((S_i + C_i \cdot Y_t^i) \cdot \delta_t^i + H_i \cdot (X_{t-1}^i + Y_t^i - \frac{D_i}{2n}) \cdot \frac{T}{n})$$

where $\delta_t^i = \begin{cases} 1, & Y_t^i > 0 \\ 0, & Y_t^i = 0 \end{cases}$.

A more simplified expression for total cost J is:

$$J(u_1,u_2,...,u_m) = \sum_{i=1}^{m} S_i u_i + \sum_{i=1}^{m} \frac{H_i T}{n} \sum_{t=0}^{n-1} X_t^i + \sum_{i=1}^{m} (C_i D_i + H_i D_i \frac{T}{2n}) \ , \tag{7}$$

where we include the fact that $\sum_{t=1}^{n} Y_t^i = D_i$.

Now the following combinatorial problem on the dynamic discrete time system control process (3)-(5) (named DTSC problem) can be formulated: for control variables $u_1,u_2,...,u_m$ of the process (3)-(5) find such values from $\{1,2,...,n\}$ which satisfy all storage space constraints (6) and minimize the total cost (7).

Formally speaking, it could happen that for control variables $u_1,u_2,...,u_m$ there are no feasible values from $\{1,2,...,n\}$, i.e. values which satisfy constraints (6). But, as $X_0^i = 0,\ i = 1,2,...,m,$ then the first ordering of each product should be realized at the beginning of period 1. Therefore, condition

$$\sum_{i=1}^{m} \frac{D_i P_i}{n} \le G \tag{8}$$

provides that at least values $u_1 = n,\ u_2 = n, ...,\ u_m = n$ are feasible. In further considerations we assume that condition (8) is satisfied.

3. VNS - BASED METAHEURISTIC ALGORITHM

The Variable Neighborhood Search (VNS) methodology [18,19] represents one of the most effective metaheuristic methodologies which has been successfully applied to a huge variety of both global and combinatorial problems [20,21]. The VNS approach uses a finite number of given neighborhood structures $N_k,\ k = 1,2,...,k_{\max}$, and the corresponding neighborhoods $N_k(x)$ of a solution x which contains all "neighbors" of x with respect to the neighborhood structure N_k. In each VNS iteration the neighborhood of the current solution can be systematically changed according to the given neighborhood structures in order to find a better solution than the current one. In this way the search process could avoid "traps" of local optima and it could be directed to some new regions of the search space. The basic version of the VNS methodology, applied to minimization of function $f(x)$ on a feasible set X , can be described with the following steps [19,22]:

Initialization step: define the set of neighborhood structures $N_k,\ k = 1,2,...,k_{\max}$;
find an initial solution $x_1 \in X$

Iteration step: for $n = 1,2,...$

- set $k = 1$;
- for $k \le k_{\max}$ repeat the following steps:
    - generate at random a solution x' from neighborhood $N_k(x_n)$ of the current solution x_n ;
    - apply some local search techniques with x' as the initial point; denote with x'' the obtained local minimum;
    - if $f(x'') < f(x_n)$, then $x_{n+1} = x''$ and pass to the next iteration step $n+1$;

- if $f(x") \geq f(x_n)$, then
  - for $k = k_{\max}$ set $k = 1$;
  - for $k < k_{\max}$ set $k = k+1$;

End: if a stopping criterion is satisfied the algorithm is stopped.

A stopping criterion can be the maximal number of iterations, the maximal CPU time, or the maximal number of iterations between two objective function improvements.
In this section we develop a VNS-based algorithm for solving DTSC problem approximately, as defined in Section 2. The main elements of the algorithm are defined in the following way:

The search space U: space *U* contains all *m*-triples $u = (u_1, u_2, ..., u_m)$ such that $u_i \in \{1, 2, ..., n\}, i = 1, 2, ..., m.$ It means that during a search process through space *U* the algorithm can generate not only feasible solutions u (where coordinates $u_1, u_2, ..., u_m$ satisfy storage space constraints (6)), but also unfeasible ones which do not fulfill these constraints.

Objective functions: the "quality" of a generated solution u is measured in two ways:

if *u* is feasible then its quality is measured by the corresponding value of total cost $J(u)$ defined by (7). Namely, a feasible solution u_1 is better than a feasible solution u_2 if $J(u_1) < J(u_2)$;

if *u* is unfeasible then its "unfeasibility gap" is measured by value $L(u)$, where

$$L(u) = \max_{t=1,2,...,n} \left(\sum_{i=1}^{m} (X_{t-1}^{i} + Y_t^i) P_i - G \right) \tag{9}$$

An unfeasible solution u_1 is better than unfeasible solution u_2 if $L(u_1) < L(u_2)$.

Neighborhood structures N_k, $k = 1, 2, ..., k_{\max}$: neighborhood $N_k(u^n)$ of the current solution $u^n = (u_1^n, u_2^n, ..., u_m^n)$ from space *U* is the set of all solutions $u = (u_1, u_2, ..., u_m)$ from *U* such that u^n and u differ only in one coordinate, e.g. the i-th one, and $|u_i^n - u_i| = k$. Theoretically speaking, in the case when there is no a coordinate *i* such that $u_i^n + k$ or $u_i^n - k$ belong to $\{1, 2, ..., n\}$, the neighborhood $N_k(u^n)$ is empty. But, in real-life problems n is much larger than $k_{\max}$ (usually $n = 365$ days) and therefore defined neighborhood structures provide non-empty neighborhoods.
In order to generate at random a solution $u' = (u'_1, u'_2, ..., u'_m)$ from neighborhood $N_k(u^n)$ we can first select randomly an $i \in \{1, 2, ..., n\}$ and then randomly chose whether $u'_i = u_i^n + k$ or $u'_i = u_i^n - k$, while the other coordinates of u' are the same as in u^n .

The local search technique: the local search technique starts from randomly generated solution $u' \in N_k(u^n)$ as the initial point and perform the following iteration step:
in the neighborhood $N_1(u)$ of the current point *u* find the best feasible point u_{best}^f (with respect to objective function (7)). If *u* is feasible and u_{best}^f is better than *u* , or *u* is unfeasible, accept u_{best}^f as the next point;
if u^n and *u* are unfeasible and there are no feasible points in $N_1(u)$, then find the best unfeasible point u_{best}^{uf} (with respect to objective function (9)). If it is better than *u*, accept u_{best}^{uf} as the next point.

The stopping criteria are:

- if the current point u is feasible, then stop when u_{best}^{f} is not better than u or there are no feasible points in $N_1(u)$;
- if the current point u is unfeasible and u^n is feasible, then stop when there are no feasible points in $N_1(u)$;
- if the current point u is unfeasible and u^n is unfeasible, then stop when there are no feasible points in $N_1(u)$ and u_{best}^{uf} is not better than u.

Move to the next solution: solution $u"$, obtained by the local search technique, is accepted as the next solution u^{n+1} only in the following cases:

- solutions u^n and $u"$ are both feasible and $u"$ is better than u^n, i.e. $J(u") < J(u^n)$;
- solution u^n is unfeasible and solution $u"$ is feasible;
- solutions u^n and $u"$ are both unfeasible and $u"$ is better than u^n, i.e. $L(u") < L(u^n)$.

In all other cases the search stays at solution u^n changing its neighborhood according to the next neighborhood structure N_{k+1}.

The initial solution: the initial solution $u^1 \in U$ can be generated at random. But, intending to find an initial solution which could be (even unfeasible) not so far from the optimal solution of DTSC problem, for each product *i* we consider independently the process (3)-(5) and the problem of minimizing the total cost for this product

$$J(u_i) = S_i u_i + \frac{H_i T}{n} \sum_{t=0}^{n-1} X_t^i + C_i D_i + H_i D_i \frac{T}{2n}$$

referring to storage space constraints $(X_{t-1}^{i} + Y_t^i) P_i \le G$, $t = 1,2,...,n$. We find the optimal solution u_i^* of this problem using a total enumeration procedure. Now, the VNS algorithm starts from $u_1 = \left(u_1^*, u_2^*, ..., u_m^*\right)$ as an initial solution.

The stopping criterion: the maximal number of iterations between two improvements of objective function (7).

4. NUMERICAL RESULTS

La Fantana is a leading company in Serbia in the field of water bottling and distribution via water cooler devices in the corporative segment. La Fantana goal is to become the leader in the household sector too, and to be the first choice when it comes to delivery of fresh, high quality water using water cooler devices. Their slogan „It comes to you"describes in the best way the nature of La Fantana service. Their business is based on the principle of subscription packages adapted to the needs of families and companies. Today, company has more than 10.000 clients with 25.000 water cooler devices installed with private and legal entities. La Fantana Company produces and distributes yearly over 16.000.000 litres of natural noncarbonated mineral water. Diversity of company offer is reflected in subscription packages adapted to various requests of our clients, as well as in the functionality of water cooler devices, enabling to enjoy cold, hot, carbonated or water heated to room temperature. La Fantana carries out water production and bottling in its own modern factory located in Mitrovo Polje, near Aleksandrovac Župski in Serbia. La Fantana has 7 logistics distribution centres (LDC), positioned in all different parts of country. From these LDCs company La Fantana is supplying customers with small truck fleet about 30 vehicles. All deliveries are done in 24h, and company has 99,6% rate of success deliveries in 24h. Full truck loads (FTL) are supplying LDC, from the plant and less than full trucks loads (LTL) shipments are supplying customers. At the begining of year 2013, company enlarged product portofilio

with additonal 11 cofee-based products, which in total present 21 product in seling portfolio.
The implementation of VNS algorithm, described in Section 3. was realized in *Visual Basic for Application*, and it uses intermediate results obtained from the model developed in *Excel spreadsheets*. All experiments were performed on *Windows* 7 Ultimate operating system on a *Pentium* (R) Dual-Core CPU T4200 processor with 4.00 GB of RAM and 2.00 GHz. In order to investigate the behavior of the VNS metaheuristics, VNS was preliminarily tested on a problem with m=21 products, where the inventory management process is considered during period T=1 year which is divided into n=365 days. The total available storage space is equal to G= 1400 m^2. Ranges of other input data for all products are given in Table 1. The optimal solution to this problem is not known in advance.

	D_i [unit]	P_i [m^2/unit]	S_i [$/order]	C_i[$/unit]	H_i[$/unit/day]
ranges	[1000; 10000]	[0.10; 2.00]	[1;15]	[0; 100]	[3; 7]

Table 1: Ranges of input data

We performed four groups of numerical experiments with $k_{\max} = 5, 10, 15, 20$. For each of these values the VNS algorithm was applied 10 times generating an initial solution by the deterministic procedure, described in Section 3. The stopping criterion for the VNS algorithm is more than 1000 iterations between two improvements of objective function (7). The corresponding best values of the objective function (7) as well as the average execution CPU time for both solving techniques are presented in Table 2.

k	**Solving technique**	**Best value of the objective function**	**Used storage space**	**Average time [sec]**
5	VNS algorithm	13323,31	1399,961	0:00:04
10		13200,76	1399,928	0:00:03
15		13176,03	1399,994	0:00:03
20		13786,86	1399,916	0:00:05

Table 2: Numerical results

6. CONCLUSION

In this paper a static time-continuous multiproduct EOQ-based inventory problem with limited storage space is modelled as a combinatorial optimization problem in the corresponding dynamic discrete time system control process for company La Fantana. To solve this problem we have developed VNS metaheuristics. Preliminary numerical results show that the algorithm could be efficiently applied to problems of smaller and higher dimensions.
Further research could be directed toward more systematic research into the algorithm efficiency in real-life problems with larger dimensions, i.e. a model with increased number of units and constraints. Also, some other special heuristics or hybrid heuristic approaches for solving the described model could be developed.

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A STUDY OF THE COST-MATRIX MODEL AND 3D PRINTING TECHNOLOGY WITH FOCUS ON PROCESSING AND LOGISTIC ACTIVITY: APPLICATION FOR A WIREFRAME MANUFACTURING COMPANY

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INTRODUCTION

In recent times, the Japanese economy has recovered from a business depression. It calls an "ABEnomics" effect. On the other hand, consumers consciousness is not satisfy. It has a trend to be severe to a low price of a product and service. As a result, companies need to consider to set the low price heedless of the cost.

On the other hand, 3D printing technology is advent in these days (Campbell et. al., 2011. Anderson, 2012). 3D printer technology allows the 3D replication of a solid object, and can virtually shape any item from a digital graphics file. The print product is made from a powder or resin. The range of applications for this manufacturing technology is extensive, including the automobile industry, consumer electronics parts, medical organs, and architectural models (Leukers, et. al., 2005. Silva, et. al., 2008. Parthasarathy, et. al., 2011).

In consideration of these backgrounds, this paper tries to focus on an analysis comparison of the process in the real wire frame company between the usual manufacturing process and the case of introducing the 3D printing technology. The integrated definition of function modelling (IDEF0) method introduces for clearing the process. The cost-matrix method is also using to calculate the cost through the IDEF0. Through these analyses, the cost structure has to clear in the processing flow. Future prospects also are able to discuss if the real manufacturing company introduces the 3D printing technology.

USING THE IDEF0 AND THE COST CALCULATING MODELHEADING

Using the IDEF0

To clarify the process activities involved with human resources, products, and equipment, this study introduces the concept of the IDEF0 for the manufacturing process model (Figure 1).

The IDEF0 method is useful for distinguishing the activities through a drawing base. They have many researches attention to the cost management with the IDEF0 method (Qian and Ben-Arieh, 2008. Bargelis and Stasišk, 2008. Ishii et. al., 2012). The box is activity such as "the manufacturing process" or "delivery." Arrows is the flow of the material, the design file, the product and so on. These are the entering the left side of the box are inputs ($I^n{}_{i(n)}$), and the right side are outputs ($Y^n{}_{y(n)}$). Inputs are transformed outputs through the activity. Outputs are created the data or objects produced by the activity. Arrows entering the box on the top are controls. Controls (C) specify the conditions required for the activity to produce correct outputs. Arrows connected to the bottom side of the box represent mechanisms ($M^n{}_{m(n)}$). Upward pointing arrows identify the support the execution of the activity. Activities are linking through the inputs and outputs of the arrows and a generic term of these four arrows is called an "ICOM." Activity also makes clear a hierarchical feature as well as a nested structure of the new activities. The nested structure explains the detail of the activity.

After clearing the activities through the IDEF0 method, each activity's cost calculates by using the cost-matrix method. This method is composed from labor cost and time, total raw materials cost, and total equipment costs. In this approach, each activity's cost is clarified through calculations.

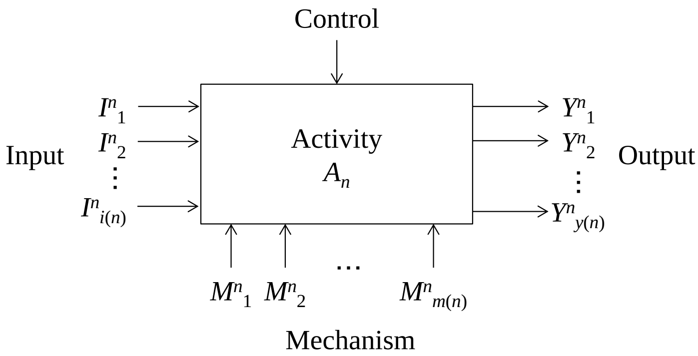

Figure 1: Activity of IDEF0

The cost-matrix model

The cost-matrix method (Kumagai S, 1998. Karunakaran et. al., 2010) is formed as follows:

$$\begin{aligned} C^n &= \left[c\left(Y_1^n\right) c\left(Y_2^n\right) \cdots c\left(Y_{y(n)}^n\right) \right] \\ &= \left[Q^n \middle| R^n \right] \left[SQ^n \middle| SR^n \right] \left[\begin{array}{c|c} E^{i(n)} - L^n & 0 \\ \hline 0 & E^{m(n)} - K^n \end{array} \right] \left[\begin{array}{c|c} U^n & 0 \\ \hline 0 & S^n \end{array} \right] \left[\begin{array}{c} I^n \\ \hline M^n \end{array} \right] \end{aligned} \tag{1}$$

where

n: the activity number;

C^n: the unit matrix of the cost;

$c(Y^n_{y(n)})$: the cost of the output $Y^n_{y(n)}$.

This matrix calculates the cost of the products or the semi-manufactured products $Y^n_{y(n)}$ in activity An.

Detail of each member is shown former paper (Nakamura, 2014). This paper explain only new additional item, which is SQ_n and SR_n.

SQ_n is the rate of the material matrix depending on the requested size.

$$SQ^n = \begin{bmatrix} sq_1^n & 0 & \cdots & 0 \\ 0 & sq_2^n & \cdots & \vdots \\ \vdots & \vdots & \ddots & 0 \\ 0 & 0 & \cdots & sq_{y(n)}^n \end{bmatrix} \tag{2}$$

sq^n_{ij} is the rate at which materials or semi-manufactured products j are used to make semi-manufactured products or products i depending on the requested magnitude of activity An. Final product changes are made according to customer requests, which create variations in the amount of materials, semi-manufactured products, and human resource consumption.

SR^n is the rate of operating time matrix depending on the requested size.

$$SR^n = \begin{bmatrix} sr_1^n & 0 & \cdots & 0 \\ 0 & sr_2^n & \cdots & \vdots \\ \vdots & \vdots & \ddots & 0 \\ 0 & 0 & \cdots & sr_{m(n)}^n \end{bmatrix} \quad (3)$$

sr^n_{ij} is the rate at which operating time of the necessary material or semi-manufactured products j for making semi-manufactured products or products i depending on the requested magnitude of activity *An*. Same as SQ_n, it transforms the customer's requests, which crate variations in the amount of the materials, semi-manufactured products, and human resource consumptions.

The logistic calculating model

This study needs to discuss about the logistic consideration. Thus, equation set to calculate time from supplying the material to delivering the final product.
LT^n is the lead time between input to output in activity *An*.

$$LT^n = [R^n][S^n][I^n] + [Q^n][\lambda^n][I^n] \quad (4)$$

The first member of the equation (4) is the sum of operating time and second one is the moving time of the material or semi-product input and the semi-product or product output.

$$\lambda^n = \begin{bmatrix} \lambda_1^n & 0 & \cdots & \cdots & 0 \\ 0 & \lambda_2^n & & & \vdots \\ \vdots & & \ddots & & \vdots \\ \vdots & & & \ddots & 0 \\ 0 & \cdots & \cdots & 0 & \lambda_{i(n)}^n \end{bmatrix} \quad (5)$$

λ^n is the delivery time before starting the activity *An*.

APPLICATION FOR COMPANY AHEADING

About Company A and the IDEF0

Applied manufacturing company, called "Company A," engages in processes to make wires from plastic. This wire product is utilized for a paper making company, uses an impure substance during filtering, and transfers the pulp as an endless conveyor.
Figure 2 illustrates the IDEF0 of Company A's manufacturing process. They have four important activities as follows: A1 represents base fabric manufacturing, A2 represents the stock process for the base fabric manufacturing, A3 represents the finishing product and A4 represents the delivery process.

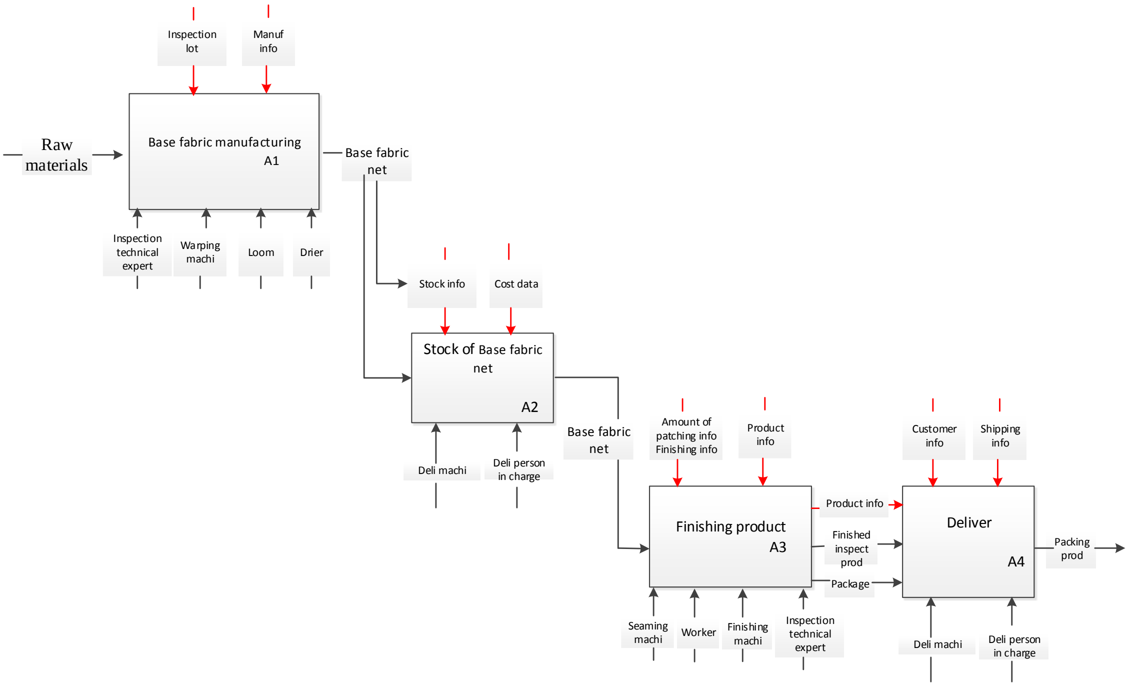

Figure 2: Usual manufacturing process

Figure 3 is nested structure of A3 activities. At activity A3, measurement is cutting the wire for the customer order size. Activity A32 is a seaming wire. It is a connecting the wire by human hand. This activity is a problem for Company A. The reason is that the order size from the customer is very long and large. It takes much time to seam the wire, because of by human hand. Activity A33 is the production inspection, about the strength, longs, a density, etc.

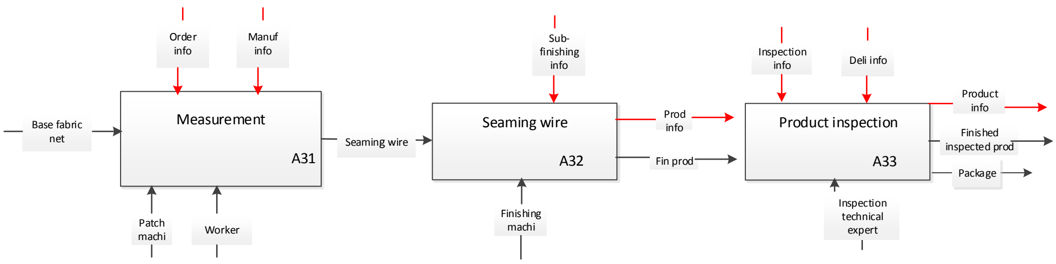

Figure 3: Nested structure of A3 activity

Next, 3D printing technology is applied to Company A, as shown in Figure 4. In this case, they have three activities: B1 represents making the design, B2 represents 3D printer's molding and B3 represents delivered.

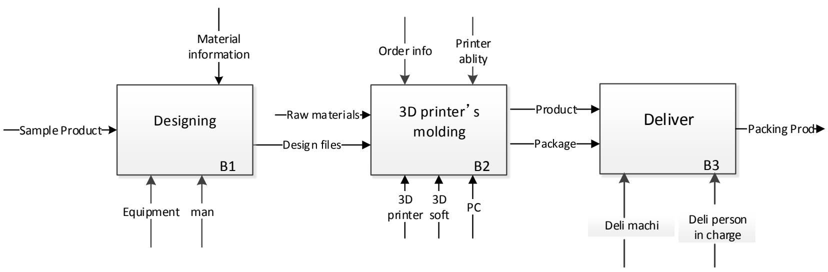

Figure 4: 3D process

In activity B1, they have three methods to make the design: 3DCAD, 3DCG, and 3D scanner. These methods create a STL file. The STL file is the documents of the three-dimensional representation created by the PC. STL file consists of 3D data for applying to the 3D printer. This file also is able to check quality check through the PC: shape, strengthens, density, etc.

CALCULATE AND STUDY THE COST OF THE USUAL MANAFACTURING AND 3D PRINTING PRCOESS

Calculating the cost of the usual manufacturing and 3D printing technology

In this chapter, each activity's cost is calculated through the cost-matrix method. Table 1 is the activity A1's unit cost calculation into the final product assumed the size: width 50 mm, depth 100 mm and height 20 mm. Depending on the setting data, the processing time is able to calculate both the usual manufacturing process and 3D one from the cost-matrix method. The left column represents the "Activity." "ICOM" and "Content" is from the IDEF0. "Total price" is the material cost of the input and output of the "Contents." Calculation of the total price is sum of "Quantity after the loss" multiple "Unit price per quantities." The total cost of the processing price calculates from the mechanism. The total cost of the processing time is calculated with the processing time multiple "Unit price per processing." A12's warping process, for example, input 500 g wire changes to the 2,000 mm^2 warping net through the activity. From this output, the material cost is that 500 g after the loss multiple 500 yen from Table1 is 250,000 yen. This is the material cost of the wire in this case. And the unit cost of 250,000 yen divided by the 2,000 mm^2 warping net is 125yen. This 125 yen goes to A13's input unit cost per quantities. For making out the warping net, a warping machine needs to operate 0.5 hours. 200,000 yen cost from the machine and preparing the wire to the machine takes

Table 1: Activity A1's unit cost calculation

Activity		Arrow	Content	Quantity	Quantity after the loss	Unit price per quantities	Total price	Processing time	Unit price per processing	Processing price
A1:Base fabric manufacturing	A11:Material inspection	Output	Inspected wire	100 g	100 g	500 ¥/g	50,000 ¥			
		Mechanism	Examiners					0.50 h	20000 ¥/h	10,000 ¥
		Control	Inspection info	100 g						
		Input	Raw material	100 g		500 ¥/g	50,000 ¥			
		Total					50,000 ¥			10,000 ¥
		Unit cost with loss					500.00 ¥			100.00 ¥
	A12:Warping	Output	Warping net	2,000 mm2	2000 mm2					
		Mechanism	Warping wire					0.50 h	100000 ¥/h	50000 ¥
			Warping machine							
		Control	Manufacturing info							
		Input	Inspected wire	500 g	g	500 ¥/g	250000 ¥		100 ¥/h	50000 ¥
		Total					250000 ¥			100000 ¥
		Unit cost with loss					125 ¥			50.00 ¥
	A13:Weaving wire	Output	Weaving wires	1500 mm2	1470 mm2					
		Mechanism	Loom					0.75 h	100000 ¥/h	75000 ¥
		Control	Manufacturing info							
		Input	Warping net	1500 mm2	1500 mm2	125 ¥/mm2	187500 ¥		50 ¥/h	75000 ¥
		Total					187500 ¥			150000 ¥
		Unit cost with loss					127.55 ¥			102.04 ¥
	A14:Heat set	Output	Base fabric net	500 mm2	500 mm2					
		Mechanism	Drier					0.5 h	50000 ¥/h	25000 ¥
		Control	Manufacturing info							
		Input	Weaving wires	500 mm2	500 mm2	127.55 ¥/mm2	63775.51 ¥		102.04 ¥/h	51020 ¥
		Total					63775.51 ¥			76020 ¥
		Unit cost with loss					127.55 ¥			152.04 ¥

Table 2: Total material processing cost

Cost item	Material cost	Processing costs	Total
Material cost	134.26		134.26
Wire	10.00		
Package			
Processing costs			
Inspection cost		26.85	26.85
Warping cost		26.85	26.85
Weaving cost		53.71	53.71
Loom cost		52.63	52.63
Delivery equipment cost		105.26	105.26
Delivery person in charge		105.26	105.26
Seaming cost (machine)		438.60	438.60
Seaming cost (human)		3.29	3.29
Measurement cost		20.00	20.00
Finished prod inspection cost		300.00	300.00
Subtotal	144.26	1,132.45	1,276.71
Total	144.26	1,132.45	1,276.71

Cost item	Material cost	Processing costs	Total
Material cost			
Resin	500		500
Package	100		100
Processing costs			
Design soft cost		57.49	57.49
Design equipment cost		14.37	14.37
Designer's cost		1655.80	1655.80
Molding cost		8.62	8.62
Delivery equipment cost		26.04	26.04
Delivery human cost		10	10
Subtotal	600	1772.33	2372.33
Total	600	1772.33	2,372.33

100 yen. Finally, total cost of the processing is 100,000 yen in activity A12. 50 yen is unit cost per once activity. Same as the other activities and 3D process one, the cost-matrix method is able to calculate the total cost of the processing.
Table 2 is the total material cost and processing cost in the case of width 50 mm, depth 100 mm and height 20 mm. The material cost is calculated using the cost-matrix method. Subtotal of the material cost is 144.26 yen in the usual process. Subtotal of the processing costs is 1,132.45 yen. The total cost of the usual process manufacturing is 1,276.71 yen. Same as 3D process, total costs are 2,372.33 yen. As a result, it is lower the usual manufacturing cost than the 3D processing one. Decision-making will conduct to the usual process for making width 100mm, depth 200mm and height 50mm's wire. In the detail cost analysis, seaming cost by the human is 6,358yen. In the seaming wire process of the usual manufacturing process, it takes a long time-consuming with the volume of the final product. As a result, it takes more man-hours and the equipment process hours to the seaming wire in Figure 3. Finally, it takes many production cost in this activity. However, it must be changed depended on the size of the final product.

Calculating the lead time and sensitivity analysis
Lead time calculating from the equations (4) and (5) is 11.67 hours taken usual process and 7.18 hours taken 3D process. From the time aspect, 3D process is more little time than usual process.
Therefore, sensitivity analysis is conducted in case of the size of the final product. In this time, lead time compares between usual process and 3D. Table 3 is the alternative plan and outputs of the lead time. Figure 5 is a transition of a volume and lead time of the activity. The volume is the multiplication of the width, depth and height. From this output, every volume of the lead time is more much lead time than 3D process. Moreover, more volume of the final product, more time takes to finish and deliver the product. Through this comparison, it is possible to discuss the view points of the lead time between usual process and 3D one.

Table 3:The alternative plan and outputs of the lead time

W	D	H	Volume	U-Time	3D-Time
50	100	20	100,000	11.67	7.18
100	200	50	1,000,000	13.29	7.63
100	400	100	4,000,000	17.25	8.39
200	500	100	10,000,000	24.44	8.94
200	600	150	18,000,000	32.13	9.46
200	700	200	28,000,000	41.48	9.95
300	800	200	48,000,000	61.50	10.57
300	900	200	54,000,000	67.81	10.92
300	1000	200	60,000,000	74.13	11.25

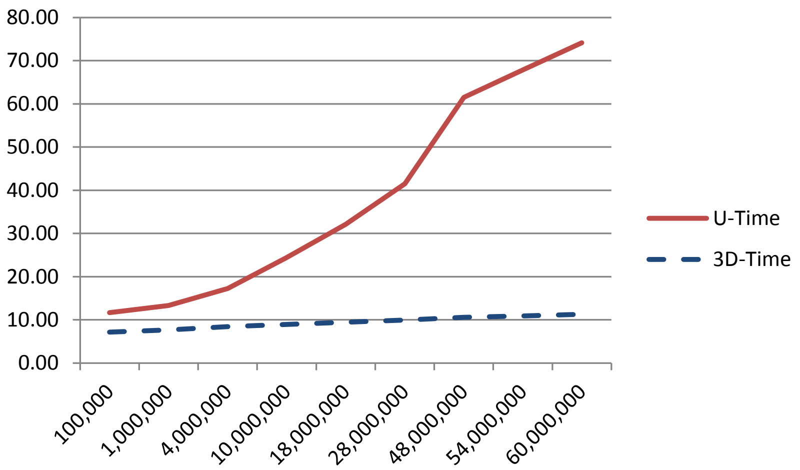

Figure 5: Transition of the sensitive analysis

CONCLUSION

This paper tries to focus on the analysis comparison of the process in the real wire frame company between the usual manufacturing process and the case of introducing the 3D printing technology. For that purpose, IDEF0 method introduces for clearing the process. From the visualize process, it clears the difference between them and clarifies the problems in each model. The cost-matrix method is also using to calculate the cost and its lead time through the IDEF0. Through these analyses, the cost structure has to clear in the processing flow. Lead time also finds the increasing rates of those.
The problems and future prospects pick up if the 3D printing technology introduces in the manufacturing company. Table 4 is the future issues: the design information, cost and profit items, quality check, and the stock.

Table 3: Future issues about introducing the 3D printing technology

<table>
<tr><th colspan="2">Considering issues</th><th>Usual process</th><th>3D process</th></tr>
<tr><td rowspan="3">Design information</td><td>About time</td><td colspan="2">Time expenditure is same</td></tr>
<tr><td>Merit</td><td>Vague design is not problem. Easy to change.</td><td>Decides the working time and finishing quality. Need to set strictly design.</td></tr>
<tr><td>Demerit</td><td>Not understand how much time takes.</td><td>Need to revise and modify the design before the printing.</td></tr>
<tr><td rowspan="2">Cost and profit items</td><td>Merit</td><td rowspan="2">History and many method have.</td><td>Able to discuss about the cost consideration.</td></tr>
<tr><td>Demerit</td><td>Need to argue the consideration of the profit or a distribution of the value-added.</td></tr>
<tr><td colspan="2">Quality check</td><td colspan="2">Comparison with final product of the real product and 3D one. Check items is like the strength, durability, shape and so on.</td></tr>
<tr><td colspan="2">Stock</td><td>Many Stock and its point.</td><td>The 3D printer process need the material stock.</td></tr>
</table>

About the design information, time expenditure is same among the usual process and 3D. However, 3D design needs very strictly degree of perfection. The reason is that the design information decides the working time and finishing quality. There is no chance to change the design after the printing starts. About the cost and profits, this study has to clarify the cost structure by using the IDEF0 and cost-matrix method. The profit, however, has not discussed yet in this paper. Quality check is also future issues to compare between them. About the stock, even introducing the 3D printing technology needs to stock the material. Therefore, it needs to consider the stock point and its cost. In these manners, this study finds many considerable things about the situation introducing the 3D printing technology.
A lot of future studies, however finds. Those are 1) application to other companies, 2) numerical real example, and so on.

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KNOWLEDGE DISSEMINATION IN VALUE NETWORKS: CASE STUDY INSIGHTS FROM 3D PRINTING

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ABSTRACT
Governments around the world increasingly recognize that leading-edge research, continuous improvement, and innovation are all needed if industry is to become more competitive. In seeking to define the ideal structural design that can most effectively disseminate innovation knowledge into a value network, the purpose of this study is to begin to appreciate some of the different approaches that currently exist. Findings from qualitative field research conducted in the USA illustrates how an imposed artificial 'hub and spoke' arrangement utilizes a newly created institute as part of a 'Spider in the Web' approach to knowledge dissemination relating to 3D-printing. In contrast, in the UK a 3D-printing value network has developed organically over some 12 years of operation in what might best be described as a 'Dandelion' approach.

INTRODUCTION
The BRICS (Brazil, Russia, India, China, and South Africa) economies are marshalling substantial resources in the wake of the recent global financial crisis which weakened the manufacturing sectors of many countries (CAN, 2013; Cassiolato and Lastres, 2009). In responding to this, many governments and trading blocs around the world (e.g., Australian Government, 2013; EU, 2013) are urging their industries to become more innovative and are also becoming increasingly aware that ongoing leading-edge research, continuous improvement, and innovation are needed (e.g. Coon, 2014).

A prime example of contemporary innovation in manufacturing is 3D-printing (known in industry as Additive Manufacturing), in which the production of three-dimensional physical objects is achieved via layer-by-layer formation of matter from a digital blueprint (Gebler et al., 2014). The ever-growing suite of 3D-printing technologies has been described as novel, innovative, disruptive, and even a "third industrial revolution" (e.g., Prince, 2014). It is predicted that the value of 3D-printing in a global marketplace will grow from around $2.3billion (in 2013) to as much as $21.3 billion by 2020 (Deloitte, 2014). For example, Singapore has budgeted US$500 million over five years to invest in skills development around 3D-printing technology (3ders, 2013). Similarly, South Korea intends to educate 10 million creative designers by 2020 and to have 50% of its schools equipped with the technology by 2017 (3Dprint, 2014); and China intends to install a 3D-printer in every elementary school by 2017 (3Dprint, 2015). Australia, Germany, the USA, and the UK have also initiated significant programs (Atlantic Council, 2011). This massive dissemination of 3D-printing knowledge promises to be challenging in light of the complexity and interdisciplinary nature of a technology towards which communications, economics, operations, political science, sociology, anthropology, technological studies, and information sciences all provide necessary insights (Ratto and Ree, 2012).

The purpose of the present study is to understand how innovation and new knowledge is currently being disseminated, specifically within 3D-printing value networks. The paper is organized into three sections; a literature review is followed by a brief methodology section; which in turn is followed by a discussion and further work section.

LITERATURE REVIEW

Knowledge Dissemination

Encouragement by government of manufacturing innovation and leading-edge research is increasingly recognized to be a priority in developed countries, to help counteract their often diminishing manufacturing bases (e.g. Coon, 2014). And around the world, governments aim to bolster their innovation capability through increased commercialisation of research (Cutler, 2008). For instance, the United States government recently established a US$1 billion fund to establish a manufacturing innovation network (Livescience, 2012). In Australia, AU$500 million was recently set aside for the establishment of industry-led innovation clusters (Australian Government, 2013). Similarly, in New Zealand the government's Building Innovation report (NZ Government, 2012) forms a key part of the Business Growth Agenda and makes clear that innovation and best practice adoption are set to become focal points for development and support.

In practice, acquiring more effective innovative business practices and processes is fraught with difficulties (Heygate, 1996). Since the early 1990s, many organizations needing rapid and radical redesign of their core processes have turned to Business Process Reengineering (Zhang and Cao, 2002). However, even with the support of top management and specialist consultants (Spear and Bowen, 1999), such initiatives often fail to achieve expected benefits (Hughes, 2011). To illustrate this point, a study of 257 organizations reported failure rates for new product development of 38-55 percent (Edgett, 2010). This is very concerning in light of a planned large-scale rollout of 3D-printing technologies by many governments.

Knowledge dissemination itself is also beset with difficulties (Shapiro et al., 2007). For example the problem of 'knowledge transfer', or 'lost in translation', implies that although research-derived knowledge might be relevant to practice, practitioners hardly ever use it because it is not produced in a form that can be easily applied (Tranfield et al., 2003); and, largely because academics rarely engage in transferring the knowledge they produce (Beer, 2001). However this view is based on an oversimplified view of knowledge reproduction, defined by van De Ven and Johnson (2006, p. 805) as a "trickle down view of the knowledge supply chain". In this view, knowledge can be easily transferred in a linear fashion from academics, to students, consultants and practitioners (van de Ven and Johnson, 2006).

The problem of 'knowledge production', or 'lost before translation' implies that "scientific results are untranslatable for practice" (Kieser and Liener, 2009, p. 517); because science and practice are two separate systems that operate according to separate logic and rules. It is claimed that the purpose of science is the pursuit of truth and critical purity; which therefore excludes research findings from being relevant for practice (Beer, 2001). However, as Rousseau and Hodgkinson (2009) point out, there is no empirical support for Kieser and Liener's definition of science and their definition does not take into account that social phenomena are compounds of formal regulations, codes of conduct, mutual co-ordination and structures of co-operation (Kay, 2004). As a result, management research, education and practice are dynamic and adaptive rather than closed, separate systems (Rousseau and Hodgkinson, 2009). In fact, Kieser and Liener (2009) do not deny the possibility of a useful exchange between theory and practice by means of "facilitators who are able to apply scientific knowledge in flexible ways to problem situations in practice" (p. 528). Thus, the 'knowledge transfer' and 'knowledge production' approaches both present difficulties.

Rasche and Behnam (2009) argue that research relevance cannot be achieved by means of a direct application of scientific knowledge into practice, since scientific knowledge must be modified and adapted by the system of practice itself (Rasche and Behnam, 2009). Practitioners can make sense of theory by modifying, extending and reconstructing scientific knowledge within their organizations to legitimize their courses of action (Rasche and Behnam, 2009). This approach leans more toward the concept of design science as developed by Simon (1967). Design science is based on the question, "Will it work better?" (Jelinek et al., 2008, p. 317) and it aims to identify methodologies that can design artefacts which lead to more effective practice (Starkey et al., 2009). A summary of the three approaches is shown in Fig. 1.

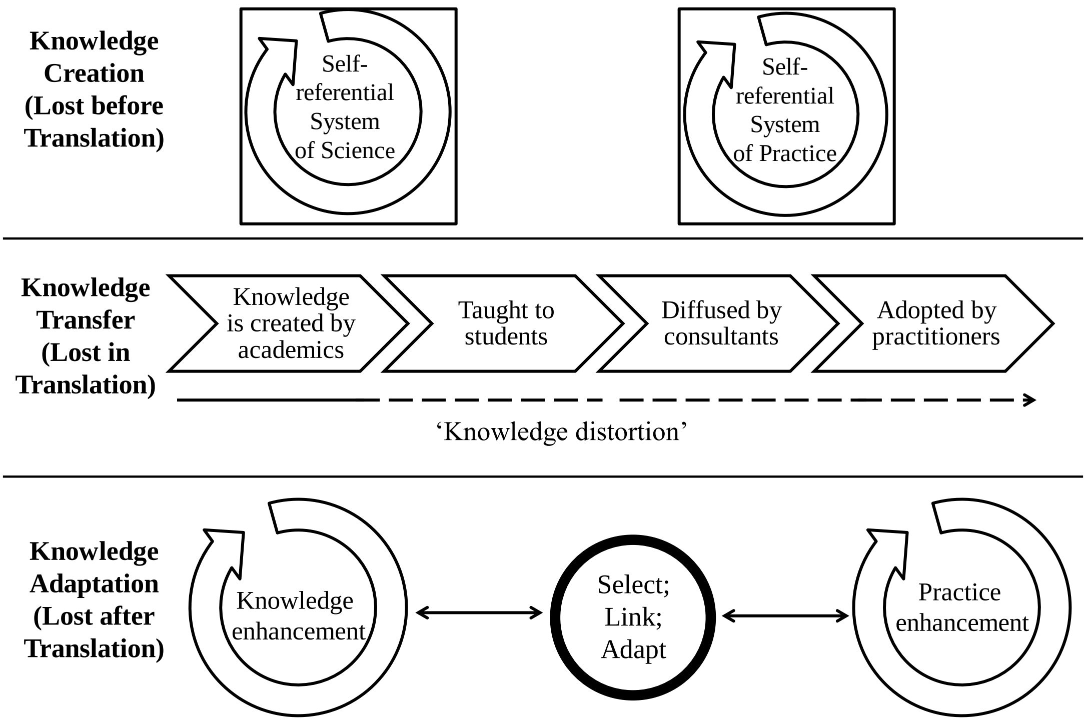

Fig. 1. A summary of the three epistemological approaches Adapted from: (Rasche and Behnam, 2009; van de Ven and Johnson, 2006).

Value Networks

Innovations should not be seen as a product of one actor but rather the result of interplays between several actors (Hakansson, 1987), and it has long been suggested that innovation and business networks belong together (e.g., Ojasalo, 2003). The term value networks represents an attempt to make the concept wider and more strategic; by harnessing the resource potential of the network as a whole in a more effective manner (Lamming et al., 2000; Romano, 2003). Thus in value network (the term is a offshoot from the classic supply chain management literature) consists of nodes and links that manifest as interactions between the various actors. Value networks have been studied intensively over the past 50 years (e.g. Aiken and Hage, 1968; Lamming et al., 2000; Romano, 2003). Recurring themes are the role of power and the social imperative of embeddedness (Gulati, 1999), and innovation (Ojasalo, 2008). In identifying four distinct classifications of value networks, Lamming et al (2000) focused on product type (as being functional or innovative) and product complexity (as being high or low complexity). They highlighted that engaging in information sharing and resource sharing is particularly problematic when dealing with innovative products and services that involve sensitive information and knowledge. This has the potential to create a critical barrier to the dissemination of 3D-printing knowledge at a time when governments are advocating widespread adoption by industry.

METHODOLOGY

In order to investigate how innovative 3D-printing knowledge is really being diffused into local value networks, value network designs were investigated via two field research case studies. The study focused on narrow networks, which Harland (1996) points out is critical for collaborative innovation. The first case concerned the 'America Makes' national program in the USA, and the second case involved the regional approach taken by Lancaster University's Lancaster Product Development Unit (LPDU) in the UK.

Site visits within the USA involved several organizations affiliated with the National Additive Manufacturing Innovation Institute (NAMII), with its headquarters in Youngstown Ohio. Within the United Kingdom site visits were made to the LPDU, which is located in the North West of England. Both centres form an integral part of their local value networks. A total of seven interviews were conducted with senior members of the respective centres of excellence and accompanying value networks. For consistency, the same protocols were used in both countries with all of the interviewees. Interviews were transcribed and a thematic analysis was conducted to identify the core recurring themes (Eisenhardt, 1989).

FINDINGS

Site visits to the 'America Makes' program and to the LPDU program took place in 2014. Both centres are located in former manufacturing strongholds and both aim to advance technology innovation at a much faster pace than is possible by any single company; by integrating and sharing available resources.

Case Study #1: The 'America Makes' Program

The 'America Makes' program (rebranded from the National Additive Manufacturing Innovation Institute - NAMII) was the first of a series of institutes in the USA rolled out under the National Network for Manufacturing Innovation (NNMI) initiative. 'America Makes' focuses on commercialising manufacturing technologies through public-private partnerships and is aimed at improving the competitiveness of manufacturing and encouraging investment in the United States (Livescience, 2012).

'America Makes' was described by various interviewees as being a trial of the whole US$1billion NNMI program, to see if such initiatives driven by the federal government actually enhance knowledge adaptation. In 2014 its value network consisted of 40 companies, 9 universities, 5 community colleges, and 11 not-for-profit organisations. The first institute attracted some US$70 million for its initial set up and hence may be characterized as an artificial network structure having a design approach termed 'Spider in the Web', Fig. 2. While this arrangement enables tighter control and easier funding mechanisms, the centre's organization at times did not align with the objectives of the individual entity stakeholders; this could be seen as slowing down an innovation process. Furthermore, a lack of understanding about how individual members function has both hindered integration and delayed project start dates.

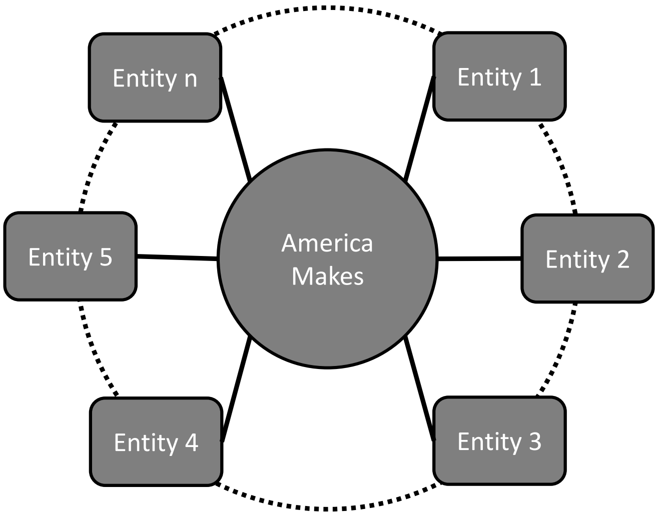

Fig. 2. Spider in the web approach – government push (artificial design)

Initial setup of the value network took a great deal of time despite the participants agreeing to be involved. A major inhibitor was working out contractual details, especially around Intellectual Property (IP), with some universities waiting over a year to officially join. At times the individual functions came into conflict with the goals/regulations of creating the 'America Makes' framework. For instance, foreign workers were not allowed to work on projects which came into conflict with university norms and practices.

Another difficulty was caused by the emphasis that was placed on sourcing technology from the USA (indeed the program has the objective of increasing domestic manufacturing competitiveness); despite the fact that depending on the technology certain countries in Europe and Asia already had longer-established and/or more cost-effective products on the market. Despite this, 7 projects had already been funded (covering 6-12 month timeframes); including at least one university, an equipment company, and a materials supplier. Interviewees indicated that the overall success of many projects is still being questioned. Core ingredients for enhanced knowledge dissemination in value networks like openness and trust will require time to establish. It was apparent however that the interviewees agreed that the program was helping to build national support for general US-based advanced manufacturing and that this could drive innovation beyond just the 3D printing sector.

Case Study #2: The Lancaster Product Development Unit
The Lancaster Product Development Unit is the outreach team of Lancaster University's Engineering Department. It was initially funded by the European Union with the aim of delivering effective knowledge exchanges that increase the uptake of design and advanced manufacturing technologies among local SMEs. The LPDU employs a diverse range of additive manufacturing equipment, and utilizes different processes and materials in order to create parts and assemblies. Its value network has developed organically over some 13 years and most referrals are by word of mouth. The network structure may be characterized as being loose and can be best described as a "Dandelion" approach (organically grown over time), Fig. 3.

The LPDU is a major knowledge source for the participating members and it is perceived to be a respected, trusted, and critical node (knowledge supplier) within the network. However, availability of critical investment capital remains a challenge. The network structure is market-driven (involves business-based projects) and heavily relies on collaboration. One interviewee stressed that trust is an important factor in motivating regional businesses to seek assistance from universities to adopt additive-manufacturing technologies, either in-house or via shared arrangements and facilities.

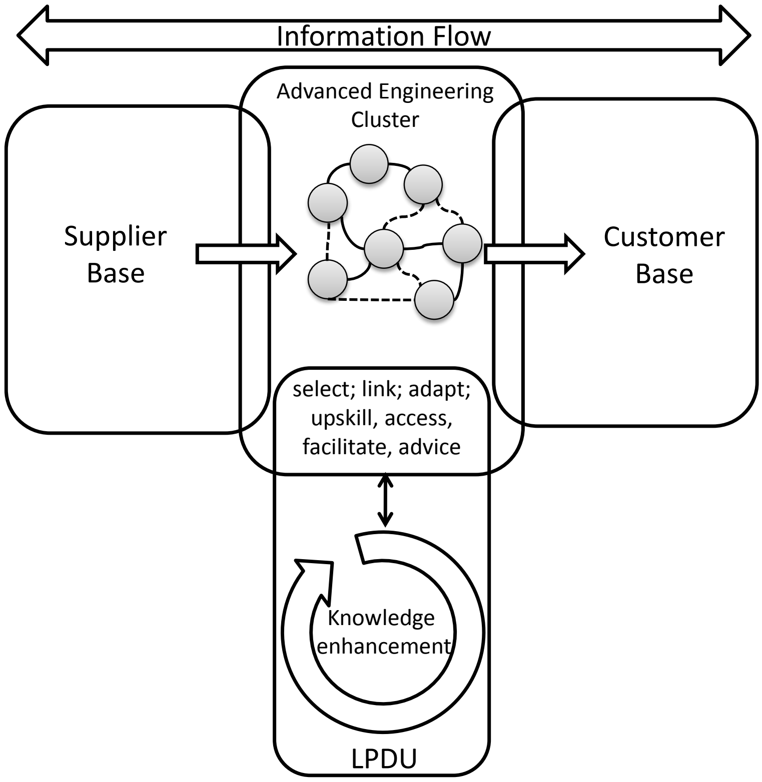

Fig. 3. Dandelion approach – company pull (organic growth)

LPDU offers two distinct pathways for knowledge to be disseminated; knowledge transfer (courses, workshops, events and conferences); and, knowledge adaptation (joint process/ product development, student placement, direct assistance). Interviewees pointed out how a long history of regional manufacturing is a key driver for businesses choosing to employ local staff and other resources, rather than engaging in outsourcing. In short, business ethics is perceived to be more important than strictly maintaining the bottom line. Such an ethical standpoint also drives knowledge dissemination within the cluster, since members share their knowledge freely and openly with the trusted network members.

DISCUSSION AND CONCLUSION

In seeking to define the ideal structural design that can most effectively disseminate innovation knowledge into a value network, the purpose of this study was to begin to understand the degree of success of different approaches to disseminating innovation knowledge. Findings from qualitative field research with two case organizations that fundamentally differ in their design reveals how their actions are aimed at enhancing knowledge dissemination in local value networks.

The 'America Makes' initiative is a major push by the USA government to onshore its manufacturing. However, its artificially imposed network structure currently struggles to gain momentum due to a lack of trust and collaborative initiative. In contrast, the LPDU has grown organically as an organization over the past 13 years into a respected, trusted, and critical node within the local value network. The LPDU initiative is a ‘pull’ (market demand orientated) initiative, which at times reduces the impact of innovation when it is not demanded by the market.

In essence, both organizations exhibit a design sciences approach to knowledge adaptation, in which practitioners make sense of theory by modifying, extending and reconstructing scientific knowledge within their organizations to legitimize their courses of action. The study has also confirmed that both trust and collaboration within a network are fundamentally important, which supports the argument by Lambert et al (2000). However neither of the case approaches is entirely compelling and it is likely that their true potential will only be revealed over time. Thus, the question remains: *What is the ideal design to enhance the dissemination of innovation knowledge into a local value network?*

Innovation value networks need to become the catalyst for innovation and major investment. It is clear from this study that future initiatives to accelerate the diffusion of innovation knowledge will need to be carefully crafted in order both to take advantage of any existing well-functioning value network and establish a more effective knowledge hub.

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A NOVEL INTEGRATED DECISION SUPPORT PLATFORM FOR THE DESIGN AND MANAGEMENT OF A JOB-SHOP MANUFACTURING SYSTEM OF FOOD PERISHABLE PRODUCTS

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Abstract

The food processing industry is growing with retailing and catering supply chains. Efficiency, safety, quality, service level and sustainability are key objectives in both food production and distribution systems. In particular, with the raising complexity of food products to meet consumers requirements and food habits, the food production system are progressively shifting from processing line to processing job-shops. Job-shop is the most complex manufacturing system configuration, affected by multiple items (i.e., food, toppings, dressings, ingredients), resources and machines, and complex working cycles. The generic working cycle is the result of multiple concurrent and not concurrent tasks (i.e., processing operations), carried out by different human and/or automatic resources in multiple working stations.

These systems present several storage and buffering areas and many assembly tasks, which are critical for perishable products sensible to environmental and physical stresses. Logistic efficiency, cost reduction, food quality and food safety are key goals in managing the food production system.

Aim of this paper is the development and application of an innovative interactive simulation-based platform for the design of a job-shop system in a manufacturing facility of perishable food products. This is the result of the integration of multiple models and supporting decision methods in capacity-constraints multiple resource environments. Several key performance indicators (KPI) can be evaluated, including logistics and operations metrics, product shelf-life erosion, energy consumptions, etc. A case study from catering industry demonstrates the effectiveness of the proposed simulation based modelling.

Keywords: food industry, job-shop, visual interactive simulation, decision support system, perishable products, shelf-life, visual interactive simulation.

1. Introduction and literature review

The food and drink industry is the largest manufacturing sector in the EU (14.6% in 2014) with a turnover of about euro 1.048 billion and 4.2 million people (Fooddrinkeurope 2015). This is the leading employer in the EU manufacturing sector (15.5% in 2011). The number of companies is about 286,000 (Fooddrinkeurope 2012) and the largest part of them is made of small and medium size enterprises (SMEs).

The food industry presents several processing and production methods. However, during the last years, the need of high level of flexibility, due to the increase of demand variability and the development of different lifestyles, led to shift from flow production to batch end/or job production systems (Curt et al. 2007).

The design and control of job-shop food production system involves long and mid-terms strategic decisions (1) (e.g., the plant layout, the determination of the number of machines or working stations), mid- and short-terms tactical decisions (2) (e.g., the planning of ingredients purchasing, the production planning, and operational decisions (3) (e.g. the capacity constrained scheduling of tasks, priority, working cycle precedence, safety limitations). The aim of the supply chain planner and controller is to fulfil the food demand according with minimal target service levels, minimizing the production and logistic costs, the environmental impacts, controlling the residual shelf life and the quality and safety of products.

This study presents an original conceptual framework for the integrated design, management and control of a job-shop production system in food industry. The framework is based on the development and application of different modelling and solving approaches and techniques. In particular, an original simulation-based supporting decision tool is developed and illustrated. This Decision Support System (DSS) supports decision makers, from the food and system engineers to the gastronomes passing from logistic and material handling providers, in the long-terms strategic design as well as in the short-terms planning and control of a food manufacturing system.

The proposed methodology is based on an original interactive, systematic and multi-scenario simulation approach for the determination of the best mix of machines, human resources and tools (1), the allocation of products and tasks to the resources, storage areas and buffers (2), the plant layout of the resources and equipment (3), the identification and control of the most critical Hazard Analysis and Critical Control Points (HACCP) (4), planning and scheduling food products according to the generic facility and resource given finite capacity constraints (5). This is a novel experience in food industry.

Discrete Event Simulation (DES) is one of the most effective techniques to represent the dynamics of a system through an event-by-event basis. These events comprise specific changes in the state of the system at specific time points in a selected planning period of time. This technique measures the performance of the system during this period of time and supports the decision making process. Extensive range of complex manufacturing system issues can be described through DES.

The adopted original DES engine emphasizes the time-based dynamics affecting the system performance.

A case study from an Italian food catering company is illustrated in order to demonstrate the effectiveness of the proposed approach, models and tool (i.e. the DSS). Catering is a sector that has recently grown a lot and has been growing strongly, especially in developing countries (Zhang et al. 2014).

This paper focuses on the so-called corporate catering, which provide services for companies, schools, banquets and restaurants, providing pre-cooking food products with a wide variety of items. This type of production and the sequence of tasks to carried out vary product by product in accordance with the recipe, resulting in an high complexity of both production/logistic system and Food Safety Management System (FSMS) (ISO 22000:2005).

These issues have been usually addressed separately in the literature that presents several techniques and tools to approach them (e.g. Jacxsens et al. 2011, Mahdavi et al. 2010, Pérez-Rodríguez 2014, Valero et al. 2012). The proposed approach is the effective key to the integration of such experiences and competences.

The remainder of this study is organized as follows. Section 2 presents the proposed original top-down supporting decisions methodology to design and control a job-shop manufacturing system of perishable food products, and the main techniques adopted by the proposed DSS. Section 3 presents a case study and a multi scenario analysis conducted on different system settings and hypotheses. Finally, Section 4 discusses conclusions and further research.

2. Decision support platform architecture

This section illustrates the architecture of the proposed original and top-down supporting decision platform for the design and management of a job-shop production system in food industry. This is the result of a novel and integrated approach to the production planning and scheduling in such a complex production system.

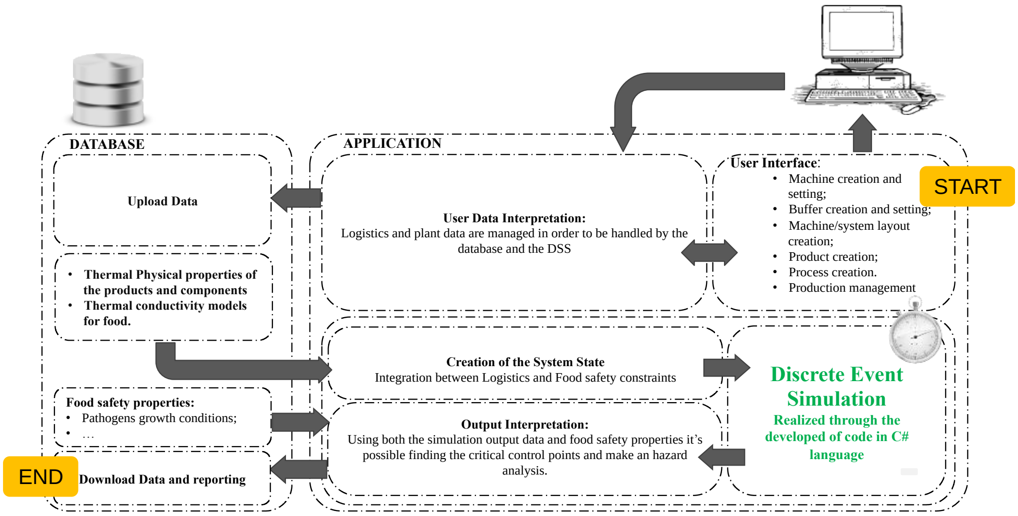

Figure 1. Decision support system – DSS architecture

The proposed DSS embeds some graphic user interfaces (GUIs) which aid the decision maker in the design and set-up all the entities which configure the generic food processing system. The required data and settings dealing with the type and number of machines (i.e., cooking stations), the product recipes, the operators, the layout zones, are properly stored and managed by a database that has been designed for the simulation of a food job shop system, involving the dynamics of the food processing system and the environmental conditions of the logistics operations within the plant.

The production system configuration and the product/process settings are the so-called "system state", i.e. the model that hosts the simulation run in a what-if multi scenarios environment. The aim of the simulation is to find the best production and logistic solution to supply products demand on time, minimizing production and logistic costs, reducing the environmental impacts, and in accordance with safety and quality standards and requirements.

The platform architecture is based on some classes that can be adopted to simulate the behaviour of the items operating and/or moving within the system (e.g. machines, tools and equipment). These items configure the production system. The class library was developed in C# language. Output of the simulation run is a complex report ranking the existing criticalities affecting the system, e.g. bottleneck, critical waiting times, unbalanced assignment of tasks and processing operations to the available set of resources and equipment, etc. Input and output data are stored inside the database in order to conduct multiple simulation runs and comparative analyses.

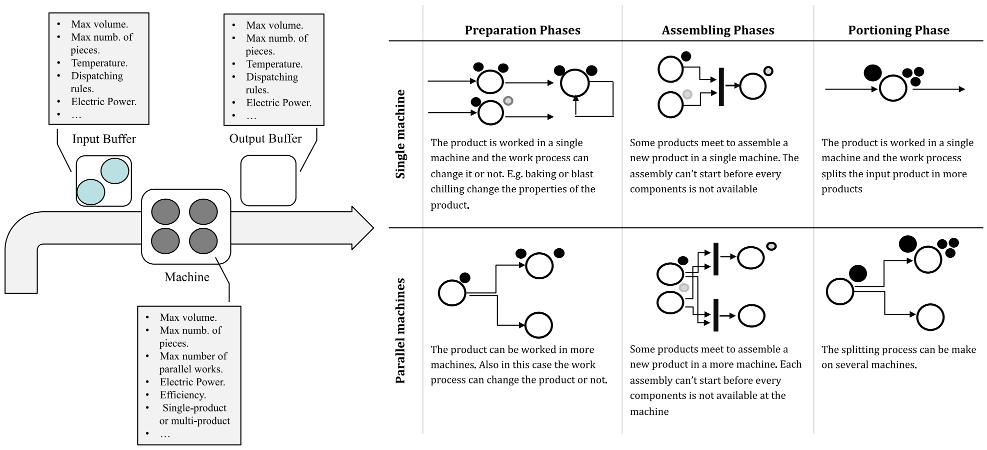

Figure 2. Basic configuration of a single resource.

Figure 2 presents the basic configuration of a generic resource, named machine, and involving an input and output buffer. The output buffer hosts the generic WIP product waiting to be processed by a fully saturated machine (or a pool of multiple machines). Several settings and dispatching rules support decision maker to virtually simulate the process according with realistic constraints and operating conditions. Figure 2 presents also the available configurations of machines equipped with input and output buffer in the so-called preparation phases, assembly phases and portioning phases. An in-depth description is not the object of this paper. The user sets multiple parameters for both buffers and machines, e.g. the maximum admissible instantaneous volume of product processed or stored according with existing capacity constraints. Alternative dispatching rules are available to manage the flows of products and the assignment of production tasks to the resources.

3. Case study

Aim of this section is the illustration of a real Italian case study of a food processing system made of 42 machines (see green items in Figure 4), 10 manual (i.e. involving human resources) departments (see blue items in Figure 4), 21 operators, 9 storage areas for raw materials (see orange items in Figures 4 and 5), components (semi-finished products), final food products and an automated material handling system mainly based on conveyors (see yellow lines in Figure 5). This production system produces food catering products for companies, schools and other working places not equipped with local kitchens.

Figure 3 reports the layout of the system with the specification of the most important processing and storage areas. The number of final products selected for the design and simulation is 12, i.e. 12 production processes or recipes (i.e., made of working cycles and bills of ingredients). They involve 37 ingredients properly processed and assembled. Figure 4 presents a so-called “draft layout” as a possible configuration of the system. Figures from 4 to 7 presents some views of the system configuration as proposed by the supporting decision tool as the result of the selection of the entities (e.g., machines, tools, material handling devices, human resources) and the determination of their plant layout. Figure 4 reports the macro flow of materials moving within the system. In Figure 5 continuous lines correspond to conveyors; dashed lines correspond to flows of materials executed via forklift and/or manual-on-board, i.e. picker-to-parts, trucks. Different colours correspond to different typologies of flows (e.g. products and/or packages).

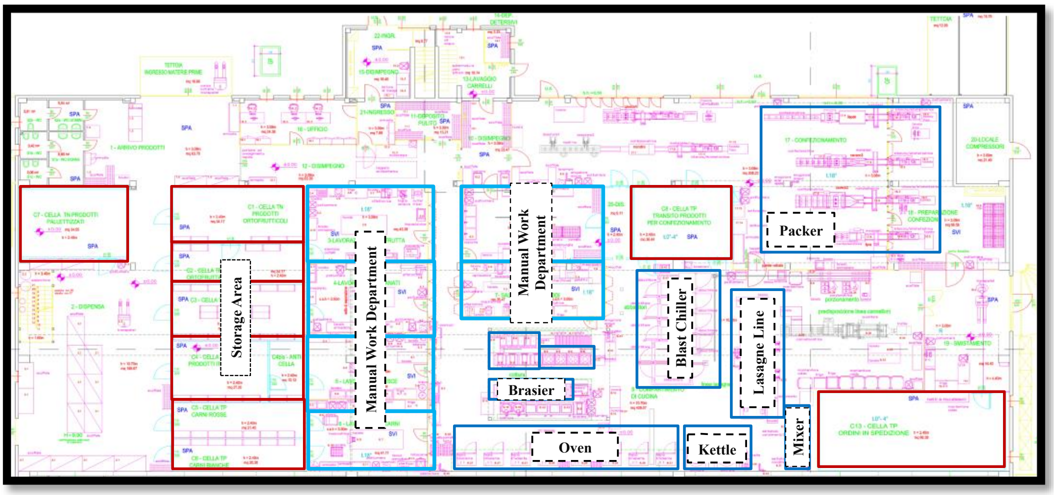

Figure 3. Case study. Draft layout of the production system

The generic machine is equipped with an input and output buffer. The capacity of the input buffer is assumed to be infinite. As a consequence parts and products flowing within the system do not wait before moving from a machine to another according with the working cycle. Another assumption is that all raw materials are available at a starting time point t_0 corresponding to the beginning of the generic daily production and the beginning of the simulation run. The generic run finishes when all products, which are planned daily, are completed. The proposed analysis counts and compares some different operating scenarios corresponding to different available equipment and machines in the packing department (see the machines id. 290, 291, 292 and 293 in Figure 6).

The adopting dispatching rule for the selection of items to be processed is the FIFO (i.e. first-in-first-out), but the proposed tool can adopted alternative rules (e.g., LIFO, FEFO), one for each available machine. Another additional hypothesis is that multiple processing tasks can be executed on a single machine. The generic task can be executed in a set of alternative machines, e.g. 291 and 292. This is a sort of pre-assignment of tasks and related items to a finite number of alternative machines. This pre-assignment is an input setting of the model. During a simulation run, the machine selected for the assignment of a task is a dispatching rule. In particular, the rule adopted in this analysis is "the selection of the machine more available", i.e. the machine "less saturated" or waiting the longest time from the last (i.e. previous) execution.

Machine 293 (see the location in Figure 6) is the only packing machine able to process items supplied by the Line A (see Figure 5).

We illustrate what happens for different settings of the packing department where the generic processing time is usually very short and parallel tasks can be executed simultaneously. For the proper management of the food job-shop, a lean and balanced production is necessary to maximize the system throughput and increase plant saturation, as well and to reduce the waiting time and delays, which is very critical for perishable food products.

All these assumptions have been assumed to exemplify the proposed what-if simulation based approach. By this case study we try to demonstrate the complexity of the decision process and the effectiveness of the proposed DSS, especially in a food manufacturing system where perishability is a very critical issue to be controlled.

Four scenarios have been selected for a comparative analysis. They differ for the following assumptions/hypotheses:

- different pre-assignment of items to the packagers;
- number of tasks simultaneously executed on a single machine;
- different operating velocity of the generic machine;
- different scheduling rules for processing tasks on single and parallel machines.

In particular, Table 1 reports the assignment of items to packagers in agreement with the working cycles and for the selected scenarios (x corresponds to scenarios 1, 2, 4; § to scenario 3). It reports also the number of items which can be processed simultaneously by a packer in the selected scenarios. Machine 290 is assumed to have a double speed in Scenario 4.

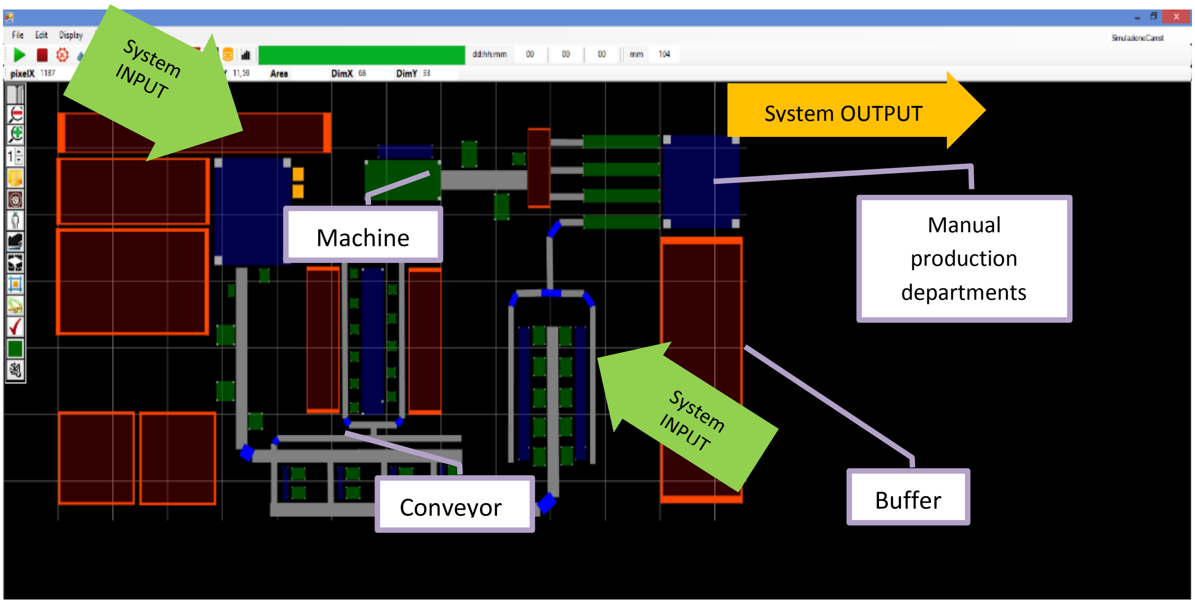

Figure 4. Case study. Job-shop system layout and macro flows of products and components

Figure 8 presents the trend of the instantaneous volumes (in m^3) to be processed and waiting at the input buffer for the selected packing machines. In particular, machine 293 processes all products, named "items" in Table 1, in correspondence of the final working task. Moreover, the setting of this machine is constant passing from a scenario to another (see the previous assumption). In 205 minutes all processing tasks assigned to the machine are completed (see Figure 8 sx). Given Scenario 1, Figure 8 (dx) presents the trend for Machine 290 whose completion time is significantly higher than the benchmark time for machine 293. On the contrary, in Scenario 2 the time the input buffer returns empty for the machine 291 is about 70 (trend in red colour in Figure 9), because given machine 291 the Scenario 2 outperforms the others (see Table 1).

	Packager			
	290	291	292	293
Item1	× §	× §		
Item2		× §		
Item3				× §
Item4				× §
Item5	× §	× §		
Item6	×		§	
Item7	×		§	
Item8		× §		
Item9	× §			
Item10				× §
Item11	× §		× §	
Item12			× §	

number of items processed simultaneously				
	290	291	292	293
Scenario 1	2	2	2	2
Scenario 2	3	4	2	2
Scenario 3	2	2	2	2
Scenario 4	2*	3	2	2

Table 1. Case study. Pre-assignment of items to packing machines and number of items processed simultaneously. *x* refers to scenarios 1,2 and 4. § to scenario 3. * = machine with a double speed.

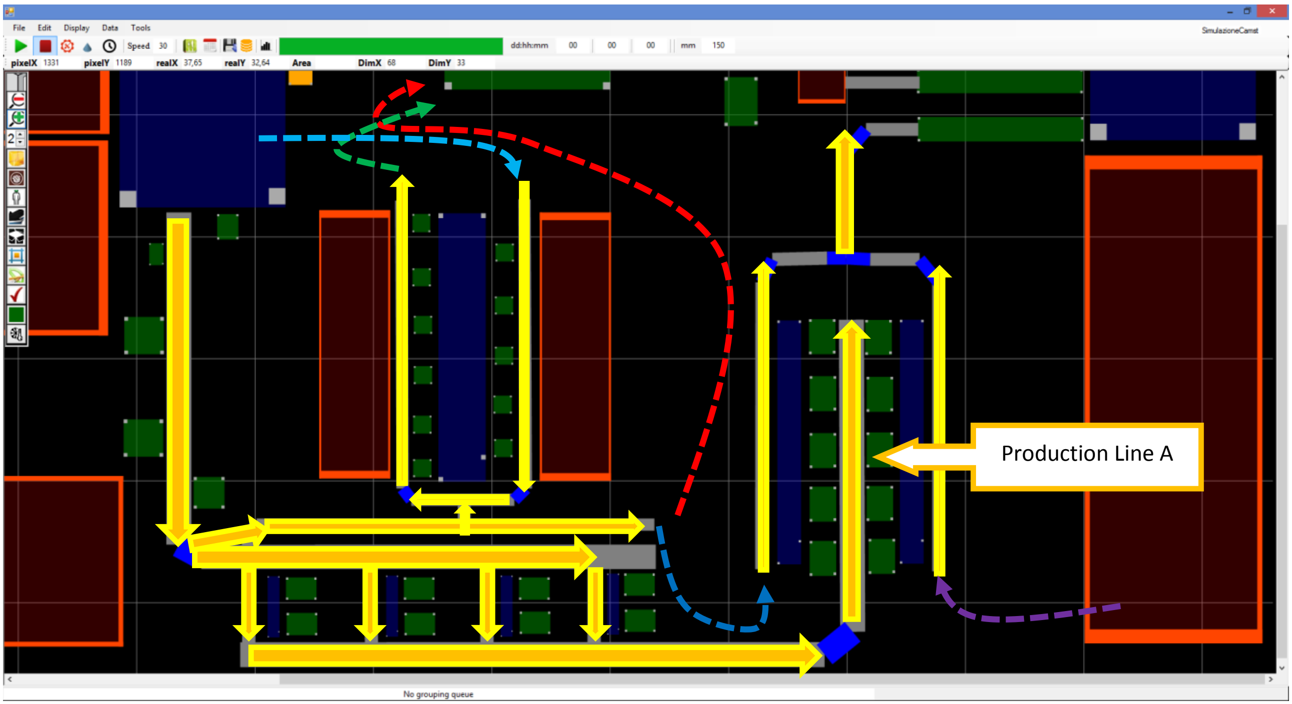

Figure 5. Flows of materials. Continuous lines corresponds to conveyors, dashed lines corresponds to forklift trucks.

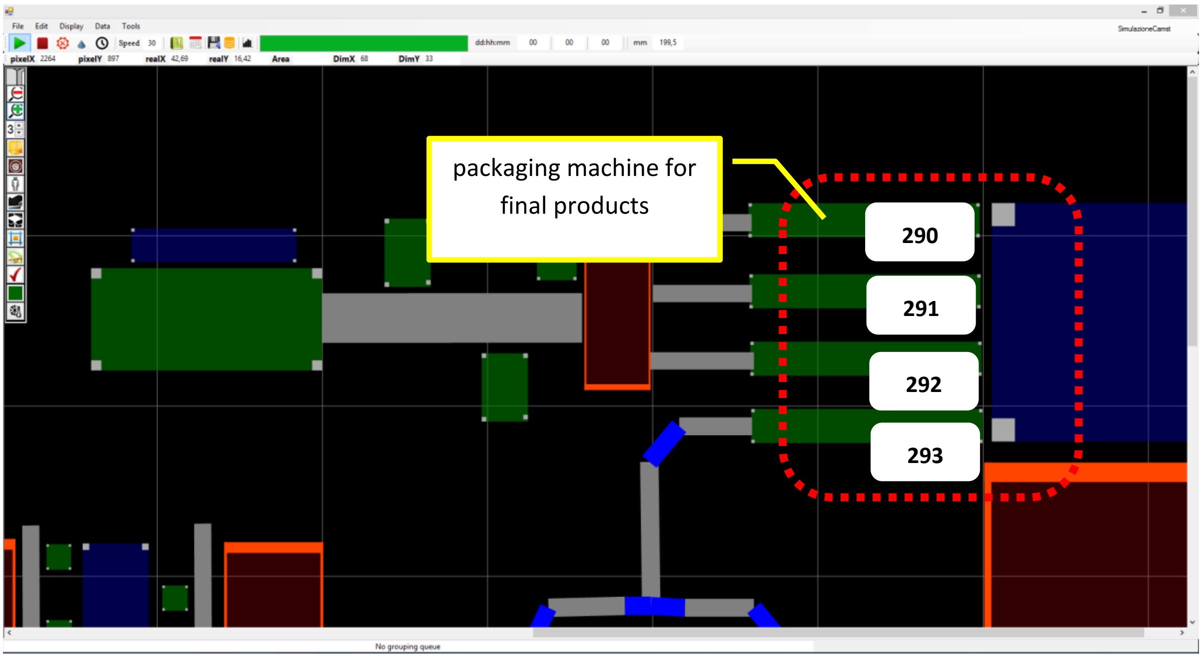

Figure 6. Packaging department and involving machines.

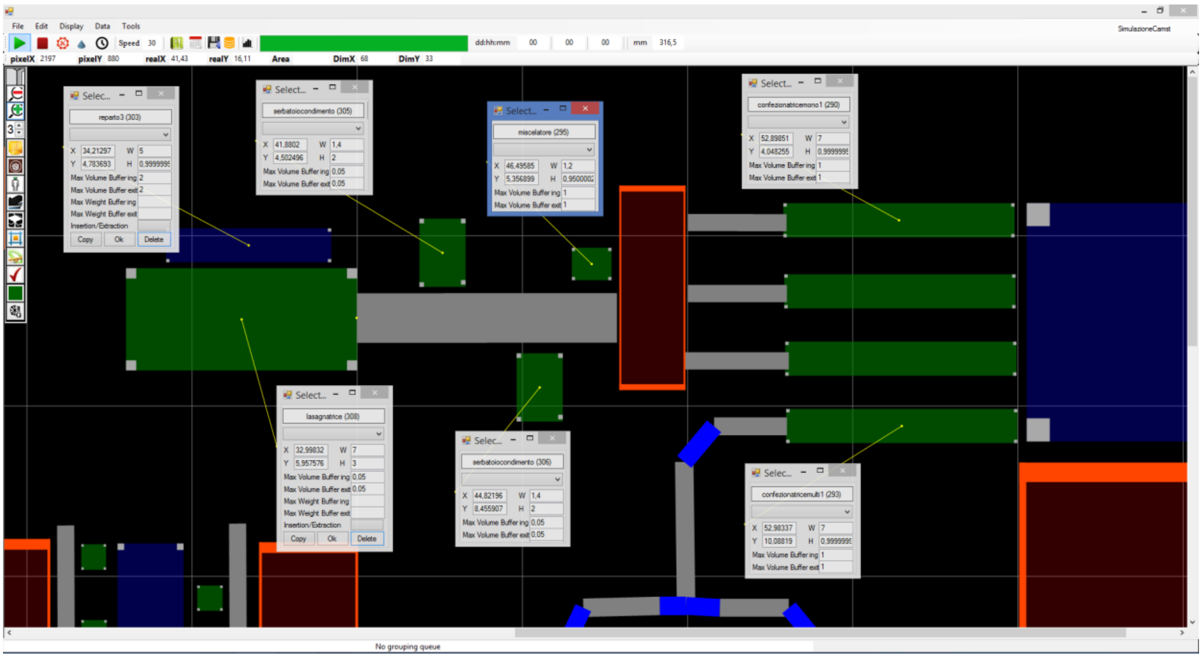

Figure 7. Case study. Exemplifying object-oriented setting.

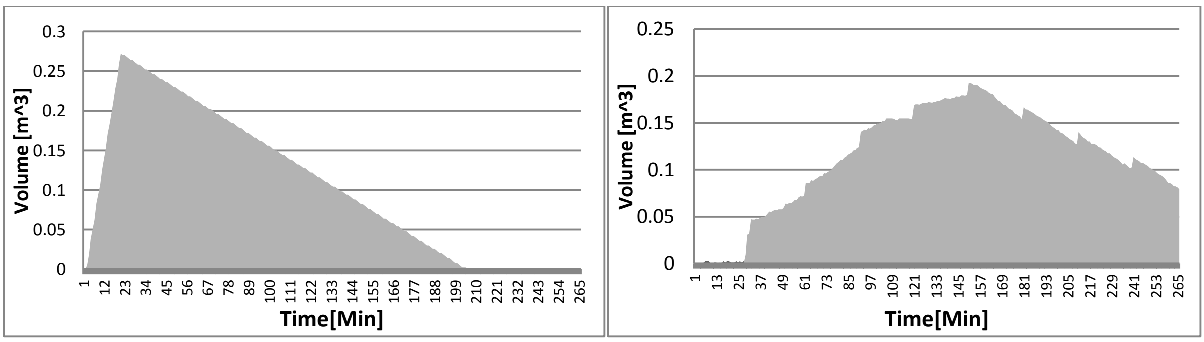

Figure 8. Trend of instantaneous volume waiting in the input buffer of the machine 293 (sx) and machine 290 (dx). Scenario 1.

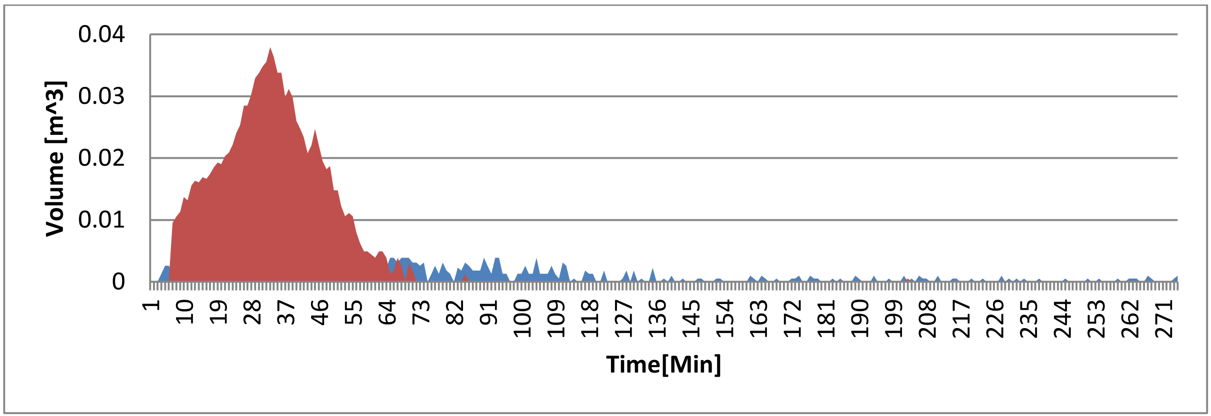

Figure 9. Trend of instantaneous volume waiting in the input buffer of the machine 293 (in red) and the trend of the processed volume. Machine 291, Scenario 2.

4. Results, conclusions and further research

Figure 10 (sx) exemplifies what happens in terms of product temperature in alternative temperature-controlled buffers working with different target values (e.g. 15°C, 25°C and 45°C) and for different waiting times. The proposed tool supports the identification of the best trade-off between energy cost/consumption and waiting times, which are significantly correlated with operational and logistic decisions, according with the maximum admissible time under and over safety critical threshold temperatures. The colors in figure exemplifies what happens in terms of bacterial growth (low or high). Similarly, Figure 10 (dx) exemplifies the temperature profiles of different ingredients assembled in a single food portion before and during the assembly and packaging task (see the dashed line in figure). Figure 11 presents the turnaround time for each scenario combined with the involved machines in order to quantify which is the most balanced system configuration and setting. Finally, Table 2 compares the 4 scenarios in terms of energy consumption as a result of the task assignment to the available resources.

These results clearly demonstrates that logistics and operational decisions play a very important role to assess safety and quality issues (1) and the proposed simulation based approach is effective to support decision making (2) within a food processing system. Further research is expected on the development of optimization models and methods to support this process thanks to its application to new case studies.

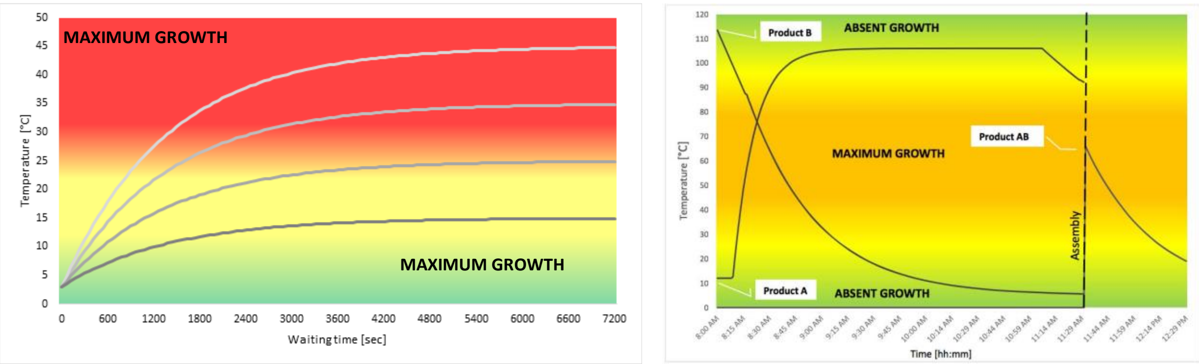

Figure 10. Temperature profile for different waiting times and environmental conditions (sx) and temperature profiles of parts assembled in a single product (dx).

Figure 11. Turnaround time to balance the system.

Machine	Scenario 1	Scenario 2	Scenario 3	Scenario 4
290	10	13	10	16
291	11,5	15	11,5	13
292	9,3	9,3	9,3	9,3
293	12,7	12,7	12,7	12,7
total [kWh]	43,5	50	43,5	51

Table 2. Energy consumption for each scenario.

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LINKING SUPPLY CHAIN RISK MANAGEMENT AND STRATEGIC TECHNOLOGY PARTNERING – TOWARDS A CONCEPTUAL FRAMEWORK FOR IMPROVED ORGANISATIONAL PERFORMANCE

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INTRODUCTION

In the light of the dynamism and intricacy of the current business environment, supply chain risks (SCRs) now represent a notable threat to firms (Golgeci and Ponomarov, 2013). Fuelled by several well-documented events, such as natural disasters (e.g. Tsunami 2004, Hurricane Katrina 2005, Taiwan earthquakes 1999, 2009, 2010), diseases (e.g. foot- and mouth disease 2001 in the UK, SARS-pandemic 2003/2004, avian influenza 2005, swine influenza 2009), and terrorist attacks (e.g. New York 2001, Madrid 2004, Jakarta 2009), the Iceland volcano eruption in 2010, the nuclear disaster in Fukushima, 2011, or Hurricane Sandy in 2012, interest in supply chain risk issues has steadily grown. Consequences of SCRs can be many and varied; fall in demand, reduction in product quality, reduced service levels, delivery delays, high recovering costs, a negative corporate image, reputation loss, damage to equipment and property, as well as in security and health, or financial losses (Blackhurst et al., 2005; Tummala and Schönherr, 2001; Tang and Tomlin, 2008; Trkman and McCormack, 2009). As our world becomes more and more disordered and turbulent, the management of risks will play a greater role in both global supply chain (SC) network design and daily operating decision-making. Thus, a better understanding of what accounts for an adequate risk management approach are required (Fawcett et al., 2011). Hence, it is essential for firms to develop specific organisational capabilities to countermeasure these adversities. For the purpose of this paper, and and in accordance with Dosi and Teece (1998, p. 284) we define capabilities as "the reflection of a company's ability to "organize, manage, coordinate, or govern sets of activities". Along these lines, firm capabilities may be oriented to various competitive objectives such as profitable new market entry, agile and lean supply chain management (SCM), effective new product development, excellence in manufacturing technology, etc. Interfirm partnerships may be useful in accomplishing these focused goals through asset exchanges and interorganisational synergies (Dyer & Hatch, 2006; Dyer & Singh, 1998). Vertical and horizontal networking is being used by organisations to manage risks and pursue knowledge transfer through a joint creation of technology and new knowledge (Teece, 2000; Kogut and Zander, 1997; Powell et al., 1996). More precisely, we advocate that the capabilities needed for STP serve as enablers for effective SCRM. This paper focuses on the fusion of the two research streams SCRM and STP as an innovative solution to an ever changing world in the industry environment. In the strategic management literature, STPs are frequently postulated as a critical enabler of organisational innovativeness because STP is strongly interrelated to creating value (Cho and Pucik, 2005), reacting to market uncertainty (Stevens and Dimitriadis, 2004), and overcoming demand fluctuations (Fisher, 1997). Considering the significance of both SCRM and STP as competitive features in turbulent and dynamic market conditions, it is to some degree astounding that the linkage between these two essential factors has not been sufficiently focused on so far (Bierly, Gallagher, and Spender 2014). Thus, this research aims at bridging this gap. The investigation will be carried out to understand the conditions under which the STP helps reduce and mitigate supply chain risks. The authors devote on the following research question: How can the integration of STP and SCRM be effectively used to manage successfully supply chain risks? Stated, the purpose of this analysis is to examine the nexus of linkages between SCRM and STP. In the following section, we will briefly discuss the background of our research and provide the theoretical foundation for our propositions. The social capital theory (SCT), serving as a theoretical basis will encourage the dialogue between SCRM and STP and informs the establishment of the future proposed conceptual framework.

Theoretical perspective	SCRM	STP	Author(s) in this issue
Social capital theory	Risks and cost can be reduced through the long term supply chain effectiveness that has been established through mutually beneficial relationships, shared values and trust. The social capital is used to strengthen supplier relationships, knowledge transfer promotion and the regional production networks.	According to the social capital theory, the external network of an organisation, is a strong contributor towards its performance. Quality and price competitive products are created for the customers and for this purpose the organisation transacts with suppliers as well as other partners to attain external resources.	Krause et al., 2007; Hunt and Davis, 2012; Pennings and Lee, 1999; Allee, 2003; Vasileiou and Morris, 2006; Vasileiou and Morris, 2006; Johnson et al., 2013; Larson, 1992; Hagedoorn et al., 2006; Carey, et al., 2011; Inkpen & Tsang, 2005; Yli-Renko, 2001; Borgatti and Foster, 2002; Koka and Prescott, 2002;

			Lawson et al., 2008; Villena et al., 2011; Mukherjee et al., 2013; Siu and Bao, 2008; Lechner et al., 2010; Parra-Requena et al., 2010

Table 1: Linkage between SCRM and STP through the social capital theory.

Theoretical foundation - The social capital theory

The external network of an organisation, according to the SCT, is a strong contributor towards it performance (Leenders and Gabbay, 1999). Quality and price competitive products are created for the customers and for this purpose the organization transact with suppliers as well as other partners to attain external resources (Burt, 1992; Pennings and Lee, 1999; Pennings et al., 1998; Uzzi, 1996). The external networks allow them to mobilise the extramural resources, to attract customer and to attain entrepreneurial opportunities. This is mainly because the social relations help mediate the economic transactions and legitimacy of the organization is conferred (Granovetter, 1985; Chang, 2003). Higher levels of coordination and cooperation can be gained through supply chains with rich relational resources, and this may increase the value creation process across the entire SC (Hunt and Davis, 2012; Uzzi, 1996). Similar to differences in STPs, supply chains vary in critical competencies such as the learning ability (e.g., McFarland, Bloodgood and Payan 2008), the innovation ability (e.g., Ahuja 2000) or then the ability to respond in a quick and speedy manner towards the changed conditions of the market (Merschmann and Thonemann 2011). Risks and cost can be reduced through the long term supply chain effectiveness that has been established through mutually beneficial relationships, shared values and trust (Allee, 2003; Vasileiou and Morris, 2006); in other words social capital in the supply chain context, can be defined as the information, trust and norms of reciprocity inhering within SC networks (Woolcock, 1998). Individuals and organisations within social networks have been focus of research and the social capital is used to strengthen supplier relationship (Uzzi, 1996), knowledge transfer promotion (Inkpen and Tsang, 2005) and the regional production networks (Romo and Schwartz, 1995).

Integrating SCRM and STP: The social capital theory

Nahapiet and Ghoshal (1998) have developed an approach to cluster attributes of social capital in three distinct categories which has been widely adopted in the fields of SCM, operations, and strategic management (e.g. Hagedoorn et al., 2006; Carey, et al., 2011; Inkpen & Tsang, 2005; Borgatti and Foster, 2002; Koka and Prescott, 2002; Krause et al., 2007; Lawson et al., 2008; Villena et al., 2011; Mukherjee et al., 2013; Siu and Bao, 2008). They describe attributes of social capital, clustering them into the three dimensions of structural, cognitive and relational social capital (Nahapiet and Ghoshal, 1998). In the following we will derive our propositions based on those three dimensions of social capital since they constitute the foundation of our future conceptual framework.

Structural dimension of social capital

The structural dimension is a variant of social capital studies in a structuralist and topological manner. At the actor level, the central position of the actor in the network and the associated benefits (e.g.Brass and Burkhardt, 1993; Powell et al., 1996) or having an ego-centered network with a certain structure (e.g., Coleman, 1990; Coleman, 1990; Burt, 1992) are the main focus of these studies. Structural capital is often discussed in terms of the wider network of different actors with which a firm holds ties (Autry and Griffis, 2008; Koka and Prescott, 2002). To maximise gain, the actor, in this case, is an active agent who exploits his position and is known to be rational. There is a desirable abstract pattern of ties that may be represented in the form of a sparse ego-network or then the location along the shortest path of the unconnected actors (Borgatti and Foster, 2002). The local network topology is the principal function of the actor that provides benefits and ties are subliminally perceived of as forming leverageable structures (Athanassiou and Nigh, 1999; Markovsky et al., 1993). At MIT, Bavelas (1950) conducted a research where the relationship between group performance and centralisation was examined (see the review by Shaw, 1971) (Borgatti and Foster, 2002). Better performance was observed when frequent and diverse communication was present due to strong ties amongst firms, established through high structural capital levels (Krause et al., 2007; Lawson et al., 2008). The business related information exchange was stronger with the increase in the social interaction between the organisation and its exchange partner (Larson 1992). In the similar vein, the sharing of information for optimised capacity management can be informed by social capital theory, based on which information is passed back and forth between the supplier and buyer to develop a well-informed capacity plan (Yli-Renko, 2001). In line with this reflection, it is well recognised that structural capital between companies leads to better communication quality and in turn to enhanced performance (Krause et al., 2007; Capaldo, 2007; Lawson et al., 2008). Nooraie and Parast (2015), demonstrate that increased visibility in SCs offers tremendous cost savings when SC disturbances occur. The outcomes show that increased visibility is alluring because it builds efficiency in a SC and reduces both risks and costs. Moreover, it is possible to streamline costs at bottom levels as far as possible when visibility is incorporated in the financial statement (Nooraie and Parast, 2015). Without visibility of upstream and downstream flows, managers are uncertain about the demand forecasts and order cycle time, etc. According to Bowersox et al. (2003) and Chen et al. (2013) information sharing is the starting point of supply chain collaboration. The importance of top management support for this process is an advice to managers to better respond to risks by developing and implementing an efficient SC contingency planning process with appropriate mitigation measures within their organisations (Skipper and Hanna, 2009). Moreover, through structural capital, an essential benefit gained by actors is the access to information (Coleman, 1990, Koka and Prescott, 2002). The speed of information transfer is influenced by the configuration and network ties that also concern the resource alternatives and opportunities at place amongst the respective supply chain members (Johnson and Elliott, 2011). This leads us to our first proposition:

P1: Combining SCRM and STP leads to higher organisational performance and reduced supply chain risks of firms through enhanced information-sharing, communication, and visibility.

Cognitive dimension of social capital

The resources that have the ability to provide shared systems of interpretations, representations and meanings between network parties are referred to as the social capital cognitive dimension (Nahapiet and Ghoshal, 1998). The joint understanding of fundamental assumptions and concepts, as well as shared language, are the foundation of cognitive capital (Bolino et al., 2002). Hence, it provides free communication, resource exchange through common interests, objectives and a joint understanding (Parra-Requena et al., 2010; Tsai and Ghoshal, 1998). Between two actors, there are high levels of cognitive capital according to previous research, while the definition and clarity may vary according to the task, network type and outcomes (Lechner et al., 2010; Villena et al., 2011). The partners form a strategic alliance based on the cultural compromise as there are usually distinct cultures involved. However, communication is enhanced through shared codes based on mutual rules, goals, values and common language (Spender's, 1989; Inkpen and Tsang, 2005). Hence, a collaborative effort between buyers and their strategic suppliers is maintained through mutual understanding development, when sharing values and objectives, the interactions are based on continued networks with self-reinforcing process where the parties are found to establish a shared understanding (Weick, 1995). The collaboration capability may also be enhanced through language and shared codes and it further facilitates the collective understanding emergence within the domain of the inter-organisation sphere (Krause et al., 2007). Collaboration generates new knowledge through joint product design, collaborative research, or collective process innovation, which enhances the capability of the supply chain to respond promptly to environmental changes (Christopher and Holweg, 2012; Chen et al., 2013). According to Rajesh et al. (2015) when the operations of two firms are well-coordinated, the capability of suppliers and their performance are improved, the continuity of supply is ensured and supply-side risks are reduced. Finally, Chen et al. (2013) in their study examine supply chain collaboration (SCC) as a risk mitigation strategy. Their evaluation reveals that each type of collaboration reduces its respective SCR. At this point, the members of the supply chain share their understandings and explain how improvements may take place and how tasks may be efficiently completed. Thus we formulate our second proposition as follows:

P2: Combining SCRM and STP leads to higher the organisational performance and reduced supply chain risks of firms through higher levels of collaboration.

Relational dimension of social capital

A supply chain may be seen as a value chain of social networks (Gulati et al., 2000). Recurrent bonds with known companies generate a pattern of interactions in which central companies can access data about the quality and performance of existing and potential partners (Zaheer et al., 2010). The social capital theory, in general, applies to the analysis of inter-organisational relationships as firms endeavour to share data, synchronize their plans and create products conjointly (Galaskiewicz, 2011). In light of the SCT, we conclude SCRM is an ongoing process that implicates long-term commitment and dedication of all supply chain members involved (Narasimhan and Barbieri, 2010; Giunipero and Eltantawy, 2004; Manuj and Mentzer, 2008) and requires mutual trust (Bode et al., 2011; Lavastre et al., 2012; Faisal et al., 2006; Tang, 2006b). The social quality of the relationships such as mutual identifications, obligations, relational norms, friendship and trust are part of the relational attributes of the social capital structure (e.g. Cousins et al., 2006; Petersen et al., 2008). Mutual interdependence (Nahapiet and Ghoshal, 1998), partners' similarity (Rivera, 2010) and geographic proximity (Chetty and Michailova, 2011; Felzensztein et al., 2010) are the factors behind the development of relational capital between two so-called actors. Relational capital is essential as it enhances communication systems amongst actors, cooperation, performance and reduces the costs of monitoring (Carey et al., 2011, Liu et al., 2010; and Lawson et al., 2008).

Collaboration is facilitated by mutual trust as most parties collaborate only after they have gained confidence towards the other party (Zacharia et al., 2009). Hence, when managing flexibility within the supply chain network, trust building is extremely essential. If it is not present, the information sharing amongst suppliers may be a reluctant process and the resources which help with flexibility may not come into operation (Faisal et al., 2006; Lavastre et al., 2012). Capabilities towards higher flexibility and greater efficiency through complementary capabilities mentioned by Vilkamo and Keil (2003) are sharing of risks, common objectives of partners, explicit contributions from partners. The operating assets status is also affected by trust in terms of building confidence and exchanging valuable information (Pettit et al., 2010). This helps reduce the issues of unnecessary interventions, overreactions and ineffective decisions as part of a risky situation (Christopher and Lee, 2004). Commitment must also be reinforced by members to share valuable information with other SC members as part of visibility (Johnson et al., 2012). When a risky situation occurs, the trust shows how a SC partner allows its fate into the hands of the other party to take action and make decisions (Inkpen and Tsang, 2005). The network actors are willing to share knowledge, and it is trust that plays a crucial role in that process. Competitive confusion may exist if there is a lack of trust and a network organization is not an ally (Powell et al., 1996). Duysters et al. (1999) have developed a framework that emphasizes the need for building business communities with partners, improving partner selection, and the sharing of risks. The dependence on external knowledge and skills is strongly connected to two elements: the nature of the relationship and the extent of commitment (Siu and Bao, 2008). As a result, we offer the third proposition:

P3: Combining SCRM and STP leads to higher the organisational performance and reduced supply chain risks of firms through mutual trust and commitment.

A summary of the research propositions is provided in Table 2.

	SUMMARY OF RESEARCH PROPOSITIONS
P1	Combining SCRM and STP leads to higher the organisational performance and reduced supply chain risks of firms through enhanced information-sharing, communication, and visibility.
P2	Combining SCRM and STP leads to higher the organisational performance and reduced supply chain risks of firms through higher levels of collaboration.
P3	Combining SCRM and STP leads to higher the organisational performance and reduced supply chain risks of firms through mutual trust and commitment.

Table 2: Summary of research propositions.

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MODELING INTENTION TO USE 3PL SERVICES: AN APPLICATION OF THE THEORY OF PLANNED BEHAVIOR

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ABSTRACT

Purpose of this paper

This paper develops a model to identify the factors that influence the business customers' intention to use third-party logistics (3PL) services using the theory of planned behavior (TPB).

Design/methodology/approach

A quantitative approach to data analysis is adopted by applying the structural equation modeling method. Data is collected using a survey questionnaire, which are administered to 243 organisations – a response rate of 24.3 percent.

Findings

The results show that the TPB model has a good fit to the data. Attitude, subjective norms and perceived behavioral control are the key drivers underpinning the intention to use 3PL services. Respondents are more likely to use 3PL due to their perceived social pressure. Positive attitude tends to favour the use of 3PL; however the respondent's perception about their ability to control such as skill, resources and opportunities, to act and make a decision directly impact on intention. Multi-group invariance test shows no significant difference in intention between 3PL users and non-users, indicating similar responses to attitude, subjective norms and perceived behavioral control.

Research implications

This research provides an evidence base for organisations to help formulating strategies to improve decision-making process of 3PL outsourcing. It is suggested that organisations who value the benefits of 3PL outsourcing should create an inclusive and collaborative working environment to: promote positive attitude; implement strategies to minimise the impact of perceived social pressure; and empower managers in improving decision-making. This behavioral change within an organisation would potentially increase the use of 3PL services, which in turn enhance productivity and improve economic efficiency.

Value of paper

The application of TPB in 3PL context is a new area of research because there had been no previous research attempts to estimate the impacts of attitude, subjective norms and perceived behavioral control altogether on the intention to use 3PL.

INTRODUCTION

Research in 3PL has attracted considerable attention in recent years. The growing trend of outsourcing logistics functions across industries attests the significance of 3PL services. The

3PL enabled organisations are capable to achieve a better trade-off between efficient and agile supply chain (Langley & Capgemini 2010). While the use of 3PL can yield positive outcomes for organisations, the process of achieving those benefits is not without difficulties (House & Stank 2001). Impediments are likely to be encountered by organizations in different phases of 3PL decision-making process and often lead to the termination of 3PL contract (Ackerman 1996; Foster 1999). Therefore, various models and decision frameworks of 3PL development and implementation have been suggested in the literature in an attempt to improve the 3PL decision-making process (Bagchi & Virum 1998; Bottani & Rizzi 2006). For example, Sink, Langley and Gibson (1996) provided a conceptual model of 3PL decision-making which consists of five stages: identify the need to outsource logistics; develop feasible alternatives; evaluate and select supplier; implement service; and ongoing service assessment. Andersson and Norrman (2002) modelled and compared the purchasing process for advanced versus basic logistics services.

Studies in the area of 3PL decision-making have also relied on conceptual research to provide decision-making models and frameworks for the selection process of 3PL service providers. For example, Meade and Sarkis (2002) offered a decision-making model based on the analytical network process (ANP) to assist the management in the selection of 3PL providers for the reverse logistics process. Moreover, de Boer, Gaytan and Arroyo (2006) presented a prescriptive model for guiding outsourcing decision processes that incorporates some basic principles of behavioral decision-making theory, in particular the satisficing concept. However, that study only explained discrepancies between existing outsourcing decision models and outsourcing processes in practice. Therefore, it appears that the research related to 3PL decision making process mostly concentrated on finding the solutions to the problems that experienced by the organisations while selecting 3PL providers and designing 3PL contracts. Moreover, research on 3PL decision making concentrated mostly on the aspects of post decision making process (when the company already decided to outsource). However, the pre-purchase behavior (whether to make or buy) and the factors that have impacts on the decision "to use"/not to use" 3PL remains overlooked. In addition, the literature on 3PL (specially the forward logistics) is mainly focused on the operational issues, however little progress has been made in the area of linking logistics-decision making process and psychological or behavioral realities.

The role of human behavior in 3PL decision making process has not attracted much attention. According to the Council of Supply Chain Management Professionals (CSCMP 2008), behavioral research in supply chain management is of equal importance because the process of decision-making involves multiple decision makers (e.g. suppliers, customers and service providers) from different firms. Tokar (2010) also reiterated that unless behavioral realities are built into models of logistics activities and are incorporated into theory, the accuracy and usefulness of the decision making judgment would be limited. Therefore, the integration of behavioral research in logistics and supply chain management is required to ensure that human factors, such as human perception, attitude, behavior, value judgment, decision-making are taken into account when making management decisions (Camerer & Lowenstein 2003; Dunn, Seaker & Waller 1994). Integration of behavioral theory with third-party logistics add value to the discipline of supply chain management by generating broader theoretical insights, better prediction, and more effective policy outcomes.

This paper therefore argues for conducting a study that focus on the applicability of the theory of planned behavior (TPB) in explaining intention to use 3PL and behavior for two reasons. First, there is a lack of research that integrates behavioral models with 3PL decision making process. Second, no empirical study has been conducted to understand why 3PL user behave the way they do. This research chooses Bangladesh as its context because Bangladesh has export-oriented industrial base, geostrategic location advantage, lower-labor costs, skilled workforce and convivial government policies for foreign direct investment. These imply that it has a competitive advantage to compete globally and to become an alternative destination for outsourcing (Akter, 2012; BDFM, 2010; EPB, 2010). Despite these lucrative opportunities, little has been done to understand the factors that characterized the decision making process of business customers' use of 3PL services in Bangladesh. This paper thus aims to understand the factors that determine the likelihood of business customers' use of 3PL services in Bangladesh. More specifically, the paper aims to answer the followings questions.

- Do *attitude*, *subjective norms* and perceived *behavioral control* predict the intention of business customers to use 3PL service?
- Does the intention to use 3PL services translated into the actual 3PL use?
- Does the *intention* to use 3PL vary between users and non-users of 3PL?

In the following section, we first present the conceptual framework- the theory of planned behavior (TPB) that supports the research hypotheses. This follows the methodology section, where we describe the procedures to identify the belief items, to develop measures and to collect and analyze the data. Finally, study findings, and research implications are discussed in the results and conclusion sections.

THEORY OF PLANNED BEHAVIOR

The Theory of Reasoned Action (TRA)(Fishbein and Ajzen, 1975) and the Theory of Planned Behavior (TPB) (Ajzen,1985) has been the most influential and well-supported social psychological theory for predicting human behavior. The TPB is an extension of the TRA and is designed to predict and explain human behavior in a specific context (Figure 1).

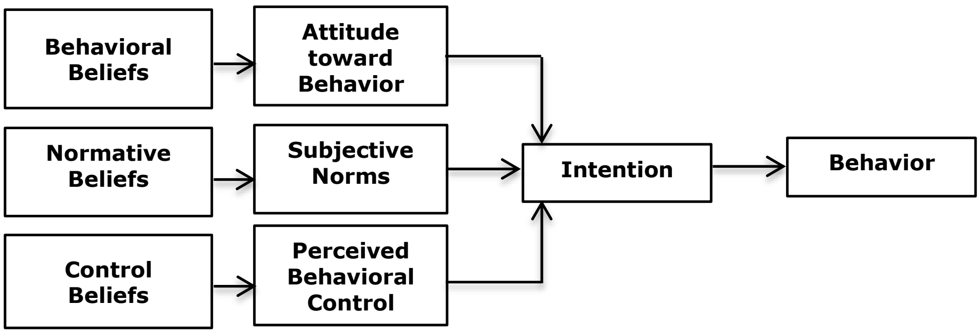

Figure 1: The Theory of Planned Behavior

Attitude and behavioral belief

Attitude toward behavior refers to the degree of personal evaluations of any activities in which a person has favorable or unfavorable appraisal to perform the behavior. According to Ajzen (1985), an individual is more likely to undertake a certain behavior if he/she has a positive attitude toward that behavior and behavioral beliefs are considered as antecedents to attitudes. TPB assumes that having a positive attitude towards a behavior is based upon believing that the behavior will likely to lead to positively evaluated outcomes, or will unlikely to lead to negatively evaluated outcomes. For example, if a logistic manager believes that, outsourcing of some activities will bring cost savings, he/she would form a positive attitude toward outsourcing activities.

Subjective norms and normative belief

Subjective norms originated from normative beliefs and it reflects one's perceived social pressure to perform or not to perform certain behavior (Ajzen, 1991).Normative beliefs are based upon two components which are multiplicatively combined. These are: perceptions of whether specific significant others believe that one should perform the behavior or not (normative beliefs) and desire to comply with the wishes of specific significant others (motivation to comply). In this research context, for example, when significant others think that using 3PL services to fulfill the supply requirements is a proper behavior, one's perceived social pressure to use 3PL services would increase his/her motivation to comply.

Perceived Behavioral Control and control belief

Perceived behavioral control (PBC) refers to the magnitude of one's perceived control over a particular behavior. It is the easiness or difficulties that a person perceives while performing a particular behavior. The source of perceived behavioral control is control belief (Ajzen, 1991) which consist of two components; the frequency of occurrence of factors those are likely to facilitate or inhibit the behavior (control beliefs) and a perception of the extent to which factors may facilitate or inhibit performance of the behavior (power). In the current research context PBC stands as for example, the intention to use 3PL services is likely to be positive when one perceives that he/she has the resources/opportunities of performing the behavior and assessing those resources/opportunities as important to get the desire outcome.

RESEARCH METHODOLOGY

A quantitative approach has adopted to understand the business customers' intention to use 3PL services in Bangladesh. This section outlines survey questionnaire & measures, the survey participants, the data analysis process and constructs validity.

Survey questionnaire and constructs

The questionnaire was divided in two broad sections. The first part of the questionnaire was focused on the characteristics of the respondent organization and the second part was focused on the intention to use 3PL. This study used both direct and indirect measures of TPB due to its aspiration to predict intention to use 3PL along with identifying the salient beliefs that contribute to attitudes, subjective norms and perceived behavioral control. The measurement items for salient beliefs and referents were developed from a review of literature and from a subsequent elicitation study. The results of a pilot test that had 25 logistics academics and professionals, each revealed adequate level of reliability and face validity of the belief instruments. To measure direct constructs of intention to use 3PL, this study adopted existing measures (Ajzen and Fishbein, 1980, Millen et al., 1997).

Survey participants and data collection

The key personnel of supply chain/logistics operations of the organizations, registered in the federation of Bangladesh Chambers of Commerce and Industry (FBCCI) were selected as the respondents of this survey. During the last quarter of 2012 and first quarter of 2013, the survey was administered and received 243 usable responses, which represents a response rate of 24.3 percent.

Data analysis

Structural equation modeling (SEM) was used to analyze the data. In the data analysis, first correlation was measured between direct constructs and indirect constructs of intention to use 3PL. Then, confirmatory factor analysis (CFA) was done to estimate both the measurement model and the structural model. Finally, a multi-group invariance test was run to know whether the components of the measurement model and/or the structural model are equivalent across user and non-user of 3PL.

Construct validity

Construct validity is the extent to which a set of measured items actually reflects the theoretical latent construct. It includes the examination of convergent, discriminant and nomological validity (Hair et al. 2007). The examination of the convergent validity revealed that all items of the constructs (except one item related to perceived behavioral control) supported the adequacy of factor loadings. All constructs had average variance extracted (AVE) values higher than 0.5 except behavioral beliefs, control beliefs and PBC. The AVE values for those three constructs (behavioral beliefs, control beliefs and PBC) were fall short only by .028 from its recommended value 0.5. This suggested that most of the constructs had adequate convergence and the items taken from a sample represented the actual true score that exists in the population (Thompson & Daniel 1996).

Moreover, composite reliability of study constructs, indicated that the internal consistency of multiple indicators for each construct, ranged from 0.640 to 0.794, exceeded the recommended threshold suggested by Bagozzi and Yi (1988). In addition, the AVE values for each construct were greater than the squared correlation between constructs (Table 1), indicating that discriminant validity was achieved. Nomological validity is tested by examining whether the correlations among the constructs in a measurement theory make sense (Hair et al. 2007). Correlation between each possible pairs of constructs supported the prediction that these constructs are positively correlated to one another (Table 1).

RESULTS AND FINDINGS

The results of this study are presented as per the research questions in three sections. The first section presents the results related to correlations between direct and indirect constructs of TPB. The second represents the results related to the intention to use 3PL and the third show the multi-group invariance test results.

Table 1: Measures Correlations (squared), Average Variance Extracted (AVE), Composite Reliability and Cronbach's Alpha Values (**p < 0.01)

Measures	Behavioral Beliefs	Normative Beliefs	Control Beliefs	Attitude	Subjective norms	PBC	Intention
Behavioral Beliefs	1						
Normative Beliefs	.388**(.150)	1					
Control Beliefs	.363** (.132)	.065 (.004	1				
Attitude	.237**(.056)	.607**(.368)	.057(.003)	1			
Subjective norms	.359** (.129)	.678** (.459)	.123(.015)	.627** (.393)	1		
PBC	.197** (.039)	.478**(.228)	.067(.004)	.548**(.300)	.614**(.377)	1	
Intention	.291** (.084)	.638** (.407)	.075(.005)	.650**(.422)	.665**(.442)	.524**(.274)	1
Cronbach's Alpha	***.824***	***.856***	***.662***	***.886***	***.833***	***.815***	***.902***
AVE	***.473***	***.512***	***.484***	***.522***	***.591***	***.472***	***.815***
Composite Reliability	***.646***	***.704***	***.640***	***.681***	***.700***	***.651***	***.794***

Correlations between direct and indirect measures

The results related to correlation analysis revealed that two pairs of correlations (between [attitude and behavioral beliefs] and between [subjective norms and normative beliefs] were found to be significant at 0.01 level. However, the correlation between perceived behavioral control and control beliefs was not statistically significant. This implies that attitudes and subjective norms are related to the set of salient behavioral and normative beliefs (Table 1); however, that did not reveal the exact nature of these relations with certainty (Ajzen, 1991).

Modeling the intention to use 3PL

This section present the results of modeling intention to use 3PL as per the relationships drawn in the theory of planned behavior in two sections: the first section presents the results related to the measurement model; the second represents the structural model fit and hypothesis testing.

Measurement model

The measurement model define the relationships between the latent variables and the observed variables and focuses solely on how, and the extent to which, the observed variables are linked to their underlying latent factors (Forward, 2010).The multi-factor confirmatory analysis revealed that all item loadings are statistically significant at p<0.01. Based on an overidentified model the results demonstrated a reasonable fit to the data ($\chi2$=404.918, df=164, p<0.001, RMSEA=.078, CFI=.920, normed$\chi2$=2.469). However, an analysis of the modification indices and standardized residuals indicated the possibility of a better model fit. The hypothesized model was modified by examining the standardized residuals and the modification indices (MIs). Consequently, it included two sets of covariance among the error terms of e8-e9 and e15-e16. These two sets showed the highest value of the modification index which implied that the need for re-specification. Moreover, the standardized residual matrix also exhibited high values for item rAT4, rAT6 and IU2. Thus, for a better model fit these three items were deleted from the hypothesized model. Overall, the final modified model fits the data well: $\chi2$(96, n=243)=187.433, normed$\chi2$=1.952, GFI=0.913, CFI=0.959, NFI=0.920, RMSEA=0.063. However, good fit alone is insufficient to support a proposed structural theory. The hypothesized relationships are also expected to be statistically significant and in the predicted direction (Taylor and Todd, 1995).

Structural model
In contrast to the measurement model, the structural model allows for the specification of regression structure among the latent variables. The overall fit statistics from testing the structural model revealed that the data-to-model fit is not even approaching to a reasonable level ($\chi2$=589.439, df=18, p<.001, $\chi2$/df =32.747; CFI=0.608; RMSEA=0.362). However, an examination of the regression weights revealed that the path from control beliefs to PBC and the path from intention to use 3PL services to reported 3PL behavior are not significant. The covariances of control belief with behavioral belief and normative belief are also non-significant. Therefore, to construct parsimonious model, the model was re-estimated by excluding those non- significant paths and covariances.

The re-specified model revealed a model fit which was still below the minimum range except CFI. A closer look at the modification indices suggested a regression path from subjective norms to attitude in which par change statistics was 0.306. In addition, the MIs value is large enough to consider added path to the structural model. Therefore, a path from subjective norms to attitude was added and later estimated the model. It is worth to mention that prior research made numerous attempts to refine the relations between attitudinal and normative components of the model (Chang, 1998, Oliver and Bearden, 1985, Ryu and Jang, 2006, Taylor and Todd, 1995, Vallerand et al., 1992).The Goodness-of-fit statistics related to the revised structural model revealed a statistically significant improvement in chi square ($\chi2_{(4)}$=59.974; $\Delta\chi2_{(1)}$=191.413, normed $\chi2$(14.994 versus 50.277) CFI(0.951 versus 0.782) and RMSEA (0.240 versus 0.451) values. This revised model has better explanatory power for intention to use 3PL services. The final modified model is presented in Figure 2.

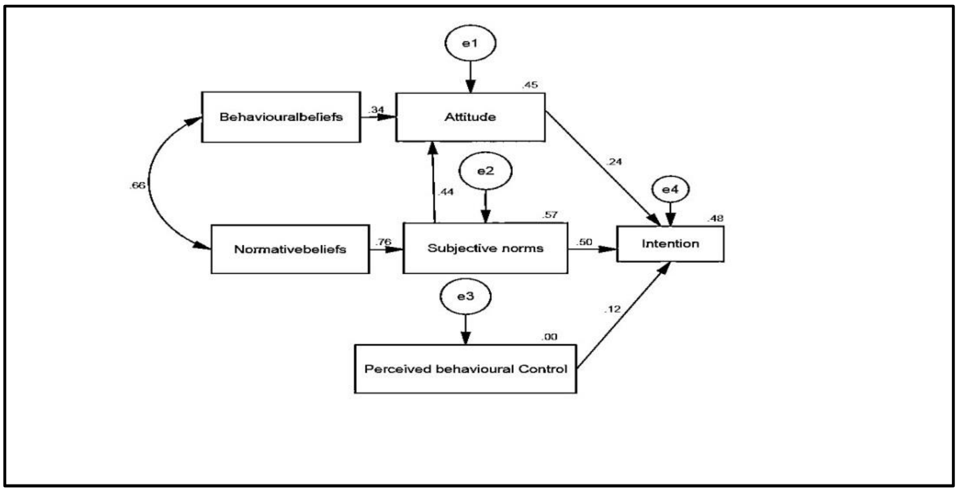

Figure 2: Intention to use 3PL Model

More specifically, subjective norm positively affected 3PL usage intention through attitude (p<0.05). This suggests that attitude mediates the relationship between subjective norm and intention to use 3PL. Consistent with previous studies (Chang, 1998, Ryu and Jang, 2006), the added path between subjective norm and attitude in the model modification process was positive (β=.436; t=7.947, p<0.01), indicating the interdependence of attitudinal and normative structures (Table 2). Overall, the final model fits the data reasonably well: χ2 (df=96, n=243)=187.433, GFI=0.913, CFI=0.959, NFI=0.920, RMSEA=0.063.

Table 2: Structural Equation Modeling Results (final model, n =243)

Structural Relationships	t-Value	Coefficient (Standardized)	Hypotheses
BB $\longrightarrow$ AT	6.221	.341**	Supported
NB $\longrightarrow$ SN	17.921	.755**	Supported
CB $\longrightarrow$ PBC	1.339	.086	Not Supported
AT $\longrightarrow$ Intention	4.172	.244**	Supported
SN $\longrightarrow$ Intention	8.606	.504**	Supported
PBC $\longrightarrow$ Intention	2.477	.115**	Not Supported
SN $\longrightarrow$ AT	7.947	.436**	Added Path
Intention $\longrightarrow$ 3PL use	.220	.008	Not Supported

Note. BB = Behavioral Beliefs, NB = Normative Beliefs, CB = Control Beliefs, AT = Attitude; SN = Subjective Norm; PBC= Perceived Behavioral Control; Intention = Intention to use 3PL. **p< 0.0

Differences in the intention to use 3PL between users and non-users

In order to test the invariance of measurement instruments, respondents were divided the into user and non-user groups based on their 3PL use related revealed behavior. 153 respondents are classified as 3PL user and the rest (90 respondents) as non-user of 3PL services based on the frequency table. First, measurement invariance was tested to determine whether the measurement models across groups are invariant. A non-restricted model was assessed (Model 1 in table 3) and compared to the full-metric invariance model (Model 2A in Table 3). Computation of the invariance test takes into account the differences of the χ2 and CFI values between configural model and equally constrained model, which yielded: $\Delta\chi2_{(14)}$=000 and ΔCFI=.003. As shown in Table 3, two models were not statistically different ($\Delta\chi2_{(14)}$ =000, p=>0.01). However, it can be different for a specific construct. Therefore, the next test was for the invariance of all factor loadings comprising each subscale (i.e., all loadings related to the one particular factor) separately. Nonetheless, the result related to specific constructs (2B, 2C, 2D and 2E) yielded Δχ2 value which were statistically not significant and below the range of ΔCFI cut-off value.

Table 3: Multi-group Invariance test results

Model Description	Comparative	χ2	df	Δχ2	Δdf	Statistical Significance	CFI	ΔCFI
1. Configural Model; no equality constrained	------------	374.865	192				.959	
2. Measurement Model								
2A. (Model A) All factor loadings constrained equal.	2A versus 1	374.865	206	000	14	Not Significant	.962	.003
2B. (Model B) Factor loadings for only intention	2B versus 1	374.865	193	000	1	NS	.959	.000
2C. (Model C) Factor Loadings for	2C versus 1	374.865	196	000	4	NS	.960	.001
2D. (Model D) Factor Loadings for intention, SN and PBC constrained equal.	2D versus 1	374.865	202	000	10	NS	.961	.002
2E. (Model E) Factor Loadings for intention, SN, PBC and attitude constrained equal.	2E versus 1	374.865	206	000	14	NS	.962	.003

Note:SN = Subjective Norm; PBC = Perceived Behavioral Control.

DISCUSSION AND CONCLUSION

This study tested the applicability of the Theory of Planned Behavior in explaining business customers' intention to use 3PL services. The key research findings of this study are:

- Attitudes, subjective norm and perceived behavioral control explained 44 per cent of the variance of intention to use 3PL, thus TPB was fairly robust to explain the intention to use 3PL service among business customers in Bangladesh.
- Intention is not reflected in the revealed behavior.
- Respondents' perceived subjective norm was the strongest driver of intention to use 3PL.
- Behavioral and normative beliefs were reflected as the foundation for predicting attitude and subjective norms respectively.
- Attitude mediates the relationship between subjective norm and intention to use 3PL.
- Group (user and non-user of 3PL) differences do not have a statically significant influence on the three sets of structural relationships- attitude to intention; subjective norms to intention and perceived behavioral control to intention.

By establishing these claims this study offers useful insights in regards to comprehending the determinants of business customers' intentions to use 3PL services thereby has important theoretical and managerial implications. For the first time the theory of planned behavior is applied to explain the intention to use 3PL services. The TPB provided a robust framework to explain the underlying factors that impact on the intention to use 3PL service among business customers in Bangladesh. TPB also explained more variance in the intention to use 3PL services when the interdependence of attitudinal and normative structure was taken into account.

This was the first vigorous research that elicited the business customers' beliefs (e.g. behavioral, normative and control) in 3PL context and its contribution to the intention to use 3PL. To represent or reflect those belief structures, few general motivational factors (that drives 3PL use) such as low cost, faster delivery and focus on core business were used. Hence, it is arguable that those factors (e.g. low cost, faster delivery and focus on core business) are applicable to understand the general motives to use 3PL services regardless to the contextual differences. However, it cannot be argued that those motivational factors will contribute equivalently to form business customers' belief systems in every context (e.g India and Australia). Therefore, Ajzen and Fishbein (1980) were correctly suggested that new sets of beliefs and salient referents should be elicited for each new context and population.

The findings of this research therefore provide an evidence base for organisations to help formulating strategies to improve decision-making process of 3PL outsourcing in three ways. *Firstly,* using the findings related to attitude toward 3PL, a collaborative strategy such as two way communications between 3PL providers and 3PL clients can be adopted to create positive attitude in the working environment. This would aid the decoupling of the negative salient attitudes (e.g. 3PL use lead to the lack of control over business operations and/or leakage of competitive information) from the overall attitude toward 3PL services. By engaging in two-way communication with the 3PL clients, and fielding suggestions and complaints as well as conveying important information, 3PL providers can fosters positive attitudes. *Secondly,* the findings show that the normative pressure played a predominant role in forming the intention to use 3PL. It suggests that there might be a possibility of mechanisms that undermine the capacity and capability of supply chain managers in decisions to outsource business functions to 3PL. Managers reported lower levels of confidence and autonomy, which show that the decision to use 3PL is less affected by their perceived control. Thus, empowering employees can prompt managers to make decisions, take action, and strengthen their confidence and belief in their capacity to make evidence based prudential decisions. This belief leads to self-motivation and a sense of independence that is translated into improved 3PL decision making and in turn minimize the perceived social pressure in 3PL decision making. *Finally*, since the intention to use 3PL did not differ between user and non-user, 3PL service providers and the non-profit associations, such as Bangladesh Supply Chain Society (BSCS), can work together to conduct workshops and training to demonstrate the benefits (e.g. low transportation costs, focus on core business, shorter lead time) and constraints (e.g.) of 3PL outsourcing to non-users.

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Section 9: Service supply chains

BUSINESS RISK MANAGEMENT WITH ASYMMETRIC INFORMATION FOR SERVICES SUPPLY CHAIN

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Abstract

This study investigates risk mitigation strategies for tourism industry in service supply chain under which service providers engage in trade with high-risk service customers or tour operators, which may hide payment intention from their creditor. In addressing this issue, traditional revenue maximization thinking in operations management is disregarded. Given the intervention of information asymmetry and the trade-off between defaulting risk and financial income, this study employs mechanism design theory to devise a menu of contracts for choices of trade credit and price discount to acquire private payment intention from the risky travel operators. With possessing the truth of customers, effective mitigation strategies are then suggested in this study. We confirm that tour operators always select the contract that reveals payment intention by offering commensurate financial compensation for information rent. Based on our analysis, our findings indicate that hotels should adopt risk transfer strategy and risk acceptance strategy for high-profit high-risk operators and high-profit low-risk operators, respectively. Conversely, risk avoidance is suggested for low-profit operators, regardless of risk. Most existing studies in service supply chain focus on utilizing statistical models for default risk assessment or prediction. On the contrary, risk management mechanisms other than risk prediction, such as the use of contractual approaches to distinguish and select between low-risk and high-risk buyers, are rarely discussed in service supply chain literature. Being uncertain of the willingness of agents to pay, a hotel should design a contract in such a way that encourages partners to cooperate and increases willingness to pay. The hotel should also provide information rent to agency customers with good or poor credit to encourage sincere cooperation and discourage incurring bad debt. Under cooperative efforts, hotels should also consider the effect of bad debt and the probability of its occurrence. Rejecting cooperation is recommended for poor profit. We conclude that high-reward and low-risk cooperation drives hotels to adopt the risk transfer strategy. A high-reward and high-risk cooperation prompts hotels to employ the risk adoption strategy, which focuses on how to accept risks and effectively weaken their effects before and after they occur. The risk avoidance strategy is employed under two conditions: low-reward and low-risk, and low-reward and high-risk conditions, which revolve around methods used to avoid certain special risks.

Keywords—Contract design; Asymmetric information; Tourism distribution channel; Hospitality service provider; Trade credit; Defaulting risk.

I. INTRODUCTION

For most business practice, a company usually has to follow business convention to offer trade credit and bears risk of financial transaction. A prudent buyer may carefully screen customers with long credit histories and good reputations, but some buyers may inevitable accept aggressive customers with irresistible offers for the consideration of profits. Although a basic credit check can discover bad history of credit, trading risk continues to exist and inflict various damages to businesses. Screening customers may not be the best strategy if the businesses eagerly need new sales opportunities. An effective risk management tool is therefore required.

The tourism industry encompasses accommodation, transport, catering, recreation, and visitor services, making it one of the world's highest priority industries and employers. The World Tourism Organization (2001??) forecasts that the number of international arrivals worldwide will increase (from 565 million in 1995) to almost 1.6 billion by 2020 and that revenues from international tourism will reach US$2 trillion. Out of this figure, travel packages will account for 69% of total sales. Among different travel agencies, tour operators usually play the integrated role of tour and travel providers to create a holiday package, usually pre-reserving lodging services for this purpose. Most service providers (e.g., hotels, amusements, and cruises) have only limited ability to promote themselves. Massive reselling via intermediary tour operators has only recently become popular (Buhalis, 2000).

Despite the important role that the tour operators are playing, they usually do not live with the normal tourism business but they earn substantial profits from risky financial investments. On contrary, the investment return on other business can be as high as 25% to 30%. In the special business practice of the tourism industry, a huge amount of cash from consumers is swiftly accumulated on the agency side for future payment and this accumulation can easily increase to billions of dollars for a medium size operator. This practice of delayed payment is equivalent to granting trade credits to operator customers. Offering generous business term may bring higher profits because operators are less inclined to ask for a lower price in the bargaining process. However, losses may incur and the hospitality suppliers suffer severely when any operator fails to pay debts or goes bankrupt. Payment defaults account for a major source of loss for the cash flow of small-scale suppliers.

In this study, we help hospitality providers to trade with high-profit high-risk tour operators. Given the intervention of information asymmetry, this study employs mechanism design theory to devise a menu of contracts to acquire private information from the risky travel operators. With the discovery of payment intention in the mind of each operator and the trade-offs between defaulting risk and financial income, we thus suggest effective risk mitigation strategies for the minority hospitality providers in the tourism industry.

We confirm that the tour operator always selects the contract that reveals payment intention by offering commensurate financial compensation for information rent. Based on our analysis, our findings indicate that hotels should adopt risk transfer strategy and risk acceptance strategy for high-profit high-risk operators and high-profit low-risk operators, respectively. Conversely, risk avoidance is suggested for low-profit operators, regardless of risk.

II. **MODEL**

In our stylized model, a principal supplier sells hospitality products to agent operators that collect money from end consumers in advance and pay the supplier at travel time. To attract more business, service providers sometimes offer price discounts or provide trade credit to customer agencies. These agencies may fail to pay the debts at the end of the holiday season if credit is offered.

Each operator agency privately holds a type of default risk θ. Reliable tour operators prefer sales discount while unreliable ones like delay payment. The prior distribution F of θ is known to the public. Hereafter, we refer to operators with high and low payoff abilities as high type (H) and low type (L), respectively. For simplicity, the proportion of high type agents is assumed to be $\alpha \in (0,1)$.

For each type of agent, there is a willingness-to-pay amount z_i associated with type *i*. Let z_L be close to zero because the low type agent has only low willingness to pay the debt. Given the predetermined willingness-to-pay amount, there is still an additional decision y_i to make for each agent. The decision pertains to the actual payment that the tour operator *i* paid to the hotel. Even without reserve cash in hand, an agent can still elect to pay the debt in full, depending on maximal profit consideration. Subsequently, the type H agent is compelled to postpone payment because of shortage of funds, $\xi_i(q_i - y_i)^+$. However, because the type-L agent is unwilling to settle payment, the operator will not ask for postponement and instead incur bad debt.

To settle the payment, the tour operator can either borrow money from a bank or ask for delay payment. The tour operator *i* earn profit

$$\max_{y_i} \pi_1(q_i, \xi_i) = -\left\{ \min_{y_i \geq 0} \left[\varphi (y_i - z_i)^+ + \xi_i (q_i - y_i)^+ \right] \right\} , \quad (3.2)$$

Given the two alternatives, $(y_i - z_i)^+$ is the loan that the agent borrowed from a bank for interest rate φ while $(q_i - y_i)^+$ is the amount asking for credit with interest rate ξ_i. The notation $(\cdot)^+$ represents a positive operator, which map negative numbers to 0.

Let p be the sales prices of the hospitality product to the end-consumers and φ be the interest rate of bank lending.

$$\max_{\substack{(q_H, \xi_H) \\ (q_L, \xi_L)}} \pi_2(y) = \max_{\substack{(q_H, \xi_H) \\ (q_L, \xi_L)}} \left\{ \alpha \left[y_H + \xi_H (q_H - y_H)^+ \right] + (1 - \alpha) y_L \right\} \quad (3.1a)$$

3.1 Contract Design

With the goal of maximizing the profit of the hotel, we design a set of menu contracts for agents with high and low willingness to pay. With appropriately designed contract terms, each agent will self-select a corresponding contract to reveal their payoff intention.

Each contract(q_i, ξ_i), $i \in \{H, L\}$ comprises a discounted price q_i and a trade credit interest rate ξ_i. Offering credit is cost-effective for hospitality providers because the variable costs of hotels are low. The cooperate customers of hospitality providers (i.e., tour operators) benefit from a longer trade credit period for better use of cash flow. Roughly speaking, to design a set of self-selection contracts, the offered benefits have to be complementary. In order to meet the need of conservative customers, high price discount is considered important and high interest rate is necessary to exclude the selection from other segments. To attract aggressive customers, low interest rate should be offered but it must come with low price discount to prevent cross selection.

Two stages are involved: contracting and execution. The sequence of decisions between tour operators and the hotel in the game is shown in Figure 1. At the beginning of the contracting stage, agents hold private information in payment intention and falsely claim their willingness to pay. The hotel then designs a menu of contracts, $(q_i, \xi_i), i \in \{H, L\}$, for the agents in order to get the truth from their mind.

To implement the truth-telling mechanism, we need to resort to the revelation principle and envelope theorem (Mirrlees 1971). Given a particular type of customer, the principal hotel expects income $U(q, \xi, y, \theta) = y(\theta) + \xi(\theta)(q(\theta) - y(\theta))^+$. The principal wants to maximize the expected profit

$\Pi(y) = max_{q(\theta), \xi(\theta)} E_\theta[U(q, \xi, y, \theta)]$.

To satisfy the incentive compatibility (IC) constraints (3.1b) and (3.1c), the benefit of type-H agent accepting H-contract should be higher than that of the type-H agent accepting L-contract and the benefit of type-L agent accepting L-contract should be higher than that of the type-L agent accepting H-contract. For individual rationality (IR) constraints (3.1d) and (3.1e), the benefit of accepting a contract should be higher than that derived if it were not accepted.

III. **Analysis**

A good risk management strategy should not only minimize possible risks but also maximize potential profits. Otherwise, the best strategy could be a do-nothing strategy, which may earn nothing. Selecting a risk management strategy is well-known when information is transparent. Conventional way of risk strategy makes decision solely based on risk value, which is a multiplication of risk probability and loss value. The information on the possibility of a payment default was assumed public and sometimes can be derived from economic conditions and debt size. This measure of risk value is not only rough but also requires sure information. Our analysis helps a company reduce their transaction loss and increase their business income when facing customers with unknown intention.

To assess the cost to induce the finance truth of agents, we first need to know the maximal profit the hotel can get when all information is transparent and no pretense is allowed. With symmetric information, the hotel and agent operators know each other and the business offers to the agents are adapted to their ability. The agents have no freedom to select a best deal for themselves. However, agents can walk away the deal if the offered contract is not profitable. Therefore, the contracts offered from the hotel must ensure a positive profit for the agents. The problem (?) becomes $(y) = \sum_i \alpha_i \left[y_i + \xi_i (q_i - y_i)^+ \mathrm{sgn}(\theta_i) \right]$ s.t. $u_h(q_h, \xi_h) \geq 0$, and $u_l(q_l, \xi_l) \geq 0$.

Proposition 1. The optimal contracts $\{(q_h^\circ, \xi_h^\circ), (q_l^\circ, \xi_l^\circ)\}$ and optimal profits $\pi^\circ$for the hotel under information symmetry are shown in Table 1.

Table 1 Solutions of the optimal contracts for the hotel with symmetric information

Regimes	conditions	q_h°	ξ_h°	q_l°	ξ_l°	π°
(1)	$\mu \geq \varphi$	$\frac{p}{\varphi+c} + \theta_h$	φ	$\frac{p}{\varphi}$	c	$\alpha(\theta_h + \varphi \frac{p}{\varphi+c}) + (1-\alpha)\frac{p}{\varphi}$
(2)	$\mu < \varphi$	$\frac{p}{\varphi+c} + \theta_h$	φ	$\frac{p}{\mu}$	c	$\alpha(\theta_h + \varphi \frac{p}{\varphi+c})$

Table 1 shows the optimal contract design, which is represented as a superscript $(\cdot)^\circ$, and benchmark profits under which agents truthfully report their types. From the table, we can see that the hotel will make the most profit if it allows the type-h agents delay the payment and, later on, pay an additional credit surcharge. For type-l agents, the hotel surely hopes the agents pay immediately in full without considering extra income. When information is transparent, the hotel can easily maximize its profit according to the suggestion in Figure 1. In Regime (1), a health business environment, the hotel can allow type-h agents to defer payment for establishing relationship and induce type-l agents to pay immediately for avoiding income loss. In Regime (2), a speculative environment, the hotel remain trusting type-h agents but should refuse to perform transaction with type-l agents.

The optimal contract suggests the hotel gives a lower price to low types than high types. Because type-h agent can only accept type-h contract and type-l can only accept type-l contract, the hotel can unilaterally design an "optimal" contract that extract all agents' profits without worrying that type-h agents select a type-l contract. In a short hand notation, we write $u_{hh} u_h(q_h, \xi_h)$ and $u_{hl} u_h(q_l, \xi_l)$. The agents' profits become $u_{hh} = p - (\varphi + c)(q_h - \theta_h) = 0$ and $u_{ll} = p - \min(\varphi + c - \xi_l, \mu + c - \xi_l)q_l = p - p = 0$. However, if agents were free to choose the best contracts for maximizing their profits, self-selection may not be guaranteed. Type-h agents will choose type-l contract because $u_{hl} = (\varphi + c)\theta_h - \frac{c}{\varphi}p \geq 0$ when $p\frac{c}{\varphi(\varphi+c)} < \theta_h$, and therefore the high-types have incentive to be low-types by hiding their financial details. On the other hand, $u_{lh} = p - \min(\varphi + c - \xi_l, \mu + c - \xi_l)q_h = p - \min(\varphi, \mu)(\frac{p}{\varphi+c} + \theta_h) = \frac{i+c-min(\varphi,\mu)}{\varphi+c}p - \min(\varphi,\mu)\theta_h < 0$, and thus the low-types would rather to be what they are and hide nothing on their type. When all agents disguise as type-l, hotel profits are diminished as listed in Table 2. Comparing to the profit column of Table 1, in both Regimes, the type-h part of income decreases from $\theta_h + \varphi\frac{p}{\varphi+c}$ to $\frac{p}{\varphi}$ because of the disguise.

2.

Table 2 Profits and utilities when all agents pretending to be type-l

Regimes	u_{hl}	u_{lh}	π (disguise)
(1)	$(\varphi + c)\theta_h - \frac{c}{\varphi}p > 0$	$\frac{c}{\varphi+c}p - \varphi\theta_h < 0$	$\alpha\frac{p}{\varphi} + (1-\alpha)\frac{p}{\varphi}$
(2)	$(\varphi + c)\theta_h - \frac{c}{\varphi}p > 0$	$\frac{\varphi+c-\mu}{\varphi+c}p - \mu\theta_h < 0$	$\alpha\frac{p}{\varphi}$

The contract solutions in Tables 1 and 2 reveal a counter intuitive reaction: suspicious agents tell truth but reliable agents deceive. This is due to a relatively high contract price for type-h agents in the theoretic optimal contract design. If agents had selection, all agents would rather to choose the inexpensive one. Type-h agents anticipate additional benefit by disguising as a type-l agent. Performing selection under contracts in Table 1, all agents appear to be low-type in terms of the observation of the hotel. Type-l agents are not worry about exposing themselves because the hotels cannot distinguish good ones from bad ones. The situation that everyone admits fragility is almost as bad as that everyone admits reliability. An intuition to induce type-h agent selecting type-h contract is to reduce the price and credit rate for high types, but determining the extent of reduction is not straight forward. Before a truth-revealing contract menu can be properly designed, the hotel has no reliable way to identify the type of an agent, and anyone is equal-likely to incur bad debt or equal-likely to generate revenue stream. The resulting anti-discrimination will definitely break an ordinary risk management practice that orients on business revenue. Without discerning agents' true types, no risk management strategies can be effective.

1.2. Optimal Contract under Information Asymmetry

To create sufficient motivation while maintaining highest profit by solving the optimal contract design problem that ensures the self-selection in the informatics game, we first combine the two optimizations in (?) by applying envelop theorem where agents' optimizations are embedded into the hotel principal's optimization [?]. Given $u_{hh}u_h(q_h,\xi_h)=\Gamma_h+u_{lh}$ and $u_{hl}=u_{ll}+\Gamma_l$, we have $u_{ll}=u_{lh}$ and $u_{hl}=0$, and therefore $u_{hh}=\Gamma_h-\Gamma_l=(\varphi+c-\min(\varphi+c-\xi_l,\mu+c-\xi_l))q_l+(\min(\varphi+c-\xi_h,\mu+c-\xi_h)-(\xi_h+c))q_h+(\xi_h-\varphi)\theta_h$. Because $u_{hh}=0$ for information symmetry and $u_{hh}>0$ for information asymmetry, the hotel must concede a positive profit to type-h agents to extract their true type. By substituting the combined constraints $\xi_h(q_h-y_h)=p-\varphi(y_h-\theta_h)^+-u_{hh}$ into the hotel's profit, the informatics game becomes (1).

$$\pi=\max_{(q_i,\xi_i)_{i\in\{H,L\}}}\alpha\,[y_h+p-\varphi(y_h-\theta_h)^+]+(1-\alpha)y_l-\alpha[(\varphi+c-\min(\varphi+c-\xi_l,\mu+c-\xi_l))q_l+(\min(\varphi+c-\xi_h,\mu+c-\xi_h)-(\xi_h+c))q_h+(\xi_h-\varphi)\theta_h]. \tag{1}$$

Proposition 2. The optimal contracts $\{(q_h^*,\xi_h^*),(q_l^*,\xi_l^*)\}$ for the hotel under information asymmetry are shown in Table 3. The condition discriminating Regime (i) and (iii) is

$$\varphi=\frac{1}{2}(\frac{1-\alpha}{\alpha}+3-c). \tag{2}$$

Table 3 The solution of optimal contracts for the hotel with asymmetric information

Regimes	conditions	q_h^*	ξ_h^*	q_l^*	ξ_l^*
(i)	$\mu\geq\varphi\geq\frac{1}{2}(\frac{1-\alpha}{\alpha}+3-c)$	$\frac{p}{c}$	φ	$\frac{p}{\varphi+c}+\theta_h$	$\frac{\theta_h(\varphi+c)}{q_l}$
(iii)	$\min(\mu,\frac{1}{2}(\frac{1-\alpha}{\alpha}+3-c))\geq\varphi$	$\frac{q_l}{\varphi+c-1}$	1	$\frac{p}{\varphi+c}+\theta_h$	$\varphi+c-1$
(ii)	$\mu<\varphi$	$\frac{p}{c}$	φ	$\frac{p}{\varphi+c}+\theta_h$	$\frac{\theta_h(\mu+c)}{q_l}$

Suggested by contract theory, the optimal contract menu shown in Table 3, which is represented as a superscript $(\cdot)^*$, concedes the least share of benefit from the principal to the agents and effectively eliminate repellent disguise. Therefore, by satisfying incentive compatibility constraint and under the informatics game 1, the type-h agents lose motivation disguise themselves as type-l agents because they obtains a higher incentive from the hotel than the type-l agents do.

The cooperate customers of hospitality service, e.g., tour operators, benefit either from discount payment or from delaying payment for better use of cash flow. To design an effective contract for self-selection, the offered benefits have to be attractive to each individual. In order to meet the need of reliable customers, low credit rate is considered important but high price is necessary to exclude the selection from the other segments. To engage business with skeptical customers and not to get a bad credit, low price discount should be offered but it must come with a high credit rate to prevent cross selection.

Our optimal contract design prevents a common-sense action of hotels. When hotels are unaware of the true financial ability of buyers, they usually perform most business transaction over-prudently, that is, asking for high wholesale price q or high credit rate ξ. This intuition may not always be the best strategy in a speculative business world. As shown in Regimes (i) and (iii) of Table 3, the high price q_l may precipitate the default of type-l agents, whereas a low pricecan induce immediate payment from these risky agents, and therefore collect money originally disappeared. Our suggests do not only prevent default when it is possible but also specify a concrete quantity that ensure good profit when commensurate cost must be paid.

Based on the contract design in Table 3, we suggest a preliminary guideline for an effective set of risk mitigation strategies, as shown in Figure 2. We subdivide Regime (1) of health environment into Regime (i) and (iii) while the speculative business environment remain in Regime (ii). Because the business world is not transparent and the hotel does not know the types of agents, a concession of profits between principal and agents results to agents' confession in private information. Regimes in Figure 2 explicitly mark the types of agents. We also know that borrowing rate and bad debt rate exhibit a positive relationship because when the accounts payable due from the type-l agent q_l is large, despite of more revenue earned by the hotel, the likelihood of incurring bad debt also increase. If the external borrowing rate φ is high, the equivalent opportunity cost becomes lower and the bad debt rate of the agent will also be high.

If the goodwill loss in defaulting μ is higher than that of borrowing ($\mu > \varphi$), as shown in Regime (i) and (iii) of Figure 2, type-l agents will borrow money as the hotel expected to pay all debts and type-h agents will defer a portion of payment, that is $y_l^* = q_l$ and $y_h^* = \theta_h$. The condition discerns Regime (i) and (iii) lies in the difference between φ and α. Roughly speaking, if φ is low, the hotel must sacrifice a portion of income to keep the type-h agents from borrowing and induce them continuously to ask for trade credit. In this way, the hotel can always judge the types of agents from the credit behavior. In Regime (ii) of Figure 2, type-h and type-l agents are also well discerned by our contract menu. However, in this case, the hotel will not risk cooperating with the type-l agents because they are highly likely to incur bad debt and profits are not receivable.

IV. CONCLUSIONS

This study examines asymmetric information between hotels and tour operators due to the economic environment or their own operations within the tourism supply chain. The assumptions are that two types of tour operators exist in the market: one with high willingness to pay and one with low willingness to pay. How these two different levels of willingness result in bad debt is unknown to the hotel. To balance revenue earning during slack seasons and increase total revenue, the hotel is also likely to cooperate with agents with low willingness to pay. However, this decision presents the risk of bad debt or payment delay, making strategies for minimizing and coping with risk necessary.

The model of construction is based on contract design theory, which predicts that agents with high willingness to pay prefer a contract with low accounts payable and high interest rates for delayed payment, whereas those with low willingness to pay prefer a contract with high accounts payable and low interest rate for delayed payment. The design is also supported with information on the rent concept, aiming to increase the willingness of agents to pay and encourage them to carefully select a contract. Contract combination is also analyzed in terms of the influence and probabilities of the bad debt of tour operators. We conclude that high-reward and low-risk cooperation drives hotels to adopt the risk transfer strategy in contract design to minimize risk; risk minimization is implemented by transferring risk to some special institutions or any third party. A high-reward and high-risk cooperation prompts hotels to employ the risk adoption strategy, which focuses on how to accept risks and effectively weaken their effects before and after they occur. The risk avoidance strategy is employed under two conditions: low-reward and low-risk, and low-reward and high-risk conditions, which revolve around methods used to avoid certain special risks. In addition, a hotel should provide more preferential policies to agents (e.g., providing information rent), regardless of whether agents with high willingness to pay exhibit increased market share or whether agents with low willingness to pay exhibit increased paying ability. This way, the agents are discouraged from disguising themselves or choosing to incur bad debt for the sake of individual profit.

Being uncertain of the willingness of agents to pay, a hotel should design a contract in such a way that encourages parties to cooperate and increases willingness to pay. It should also provide information rent to agents with good or poor credit to encourage sincere cooperation and discourage incurring bad debt. Under cooperative efforts, the hotel should also consider the effect of bad debt and the probability of its occurrence. It should reject cooperation for poor profit.

For follow-up studies, we recommend using the corner point solution method to analyze decision variables and infeasible solutions. This method may obtain optimal solutions by assuming normal distribution. This paper discusses only single cooperation; future studies, can include long-term cooperation to come up with a model that more accurately fits business operations. Instead of the private information of agents—that is, their willingness to pay—other factors that may influence the benefits earned by a principal should be examined. Factors, such as economy and human nature can provide more comprehensive results.

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IDENTIFICATION AND ANALYSIS OF PERFORMANCE INDICATORS IN PRODUCT-SERVICE SUPPLY NETWORKS

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ABSTRACT
A product-service supply network is a structured configuration of people, technology and shared information that interacts with other product-service supply networks (PSSNs) to create value. In order to achieve the objective to create value, managers should understand what the value determinants in their business context are. In our previous research we have presented the process of identifying customer value in PSSNs and ideas of generic value creation determinants. We have continued our research in greater depth with a detailed case analysis, that is to say measurement and Key Performance Indicators (KPIs) in value alignment in product-service networks. This paper describes our proposed value alignment analysis method. Findings in this paper are based on the literature review and on the empirical case data from six case studies from different industries in Finland along with two expert group workshops.

KEYWORDS: product-service systems, service supply networks, value creation, performance assessment

INTRODUCTION
In our ISL2014 conference paper, we presented the process of identifying customer value in supply chains (Kallionpää et al. 2014). In the second paper at the ISL2014 conference, we presented the value creation determinants in a product-service networks context based on the six case studies (Hemilä et al. 2014). The functional, economic, emotional and symbolic value determinants are essential in understanding customer value creation (Rintamäki et al. 2007; Leek and Christodoulides, 2012). Our research has continued with a detailed case analysis, that is to say measurement and Key Performance Indicators (KPIs) in value alignment in product-service networks. In this paper, we describe our value alignment analysis method. The identification and analysis of value determinants are crucial for the successful management of product-service networks. Supply network management should ensure the value creation by controlling operations according selected performance indicators. The supply network performance assessment is traditionally done on the overall company level by using functional and economic determinants, for example service level, delivery time and inventory cost (Caridi et al. 2014). In B2B relationship, and supply chain collaboration, the communication and decisions are mostly made by humans interacting, despite that automation and digital resources can assist operations. Our purpose is to extend the traditional supply chain performance assessment with an analysis of emotional and symbolic value determinants. We propose a model if how to identify and analyze functional, economic, emotional and symbolic determinants, and to take those in to supply network performance assessments. The paper increases the understanding of supply chain performance assessment in both an academic and a practitioner perspective.

METHODOLOGY
This paper is based on a two-year project "Determinants of value and vulnerability in customer-oriented service networks." The primary objective of the

project is to identify and analyze how customer value is created in a multi-actor service supply network. The ultimate goal is to provide a management model for service supply network value creation and vulnerability. Our main research question is: How can the supply network manage the creation and vulnerability of its service value offering? Our ISL2014 papers were about answering the first research sub-question: How can the perceived value vulnerability be identified in the service supply network? This paper seeks to answer to our second research sub-question: How can the perceived value vulnerability be analyzed in the service supply network? This second sub-question focuses on the analysis of service value creation and vulnerability in service supply networks. This means that businesses need systematic analyzing models in order to evaluate service value vulnerability and therefore also their success factors and/or competitive advantages. We argue that most of businesses don't have systematic models for analyzing service value vulnerabilities and that there is a gap in the scientific discussion in this area. The findings in this paper are based on the review of available literature and on the empirical case data from six case studies of different industries in Finland plus two expert group workshops. More specifically, we have used the literature findings when trying to identify and analyze determinants for product–service value creation and performance assessment. The qualitative case study research approach was chosen in order to gain both theoretical and empirical insight into the topic (Yin, 2003). Six case studies have been interviewed with a semi-structural questionnaire. Two experts groups have been organized and members became from the same companies under study.

PRODUCT-SERVICE SUPPLY NETWORKS

Supply chain management (SCM) is the oversight of materials, information, and finances as they move in a process from supplier to manufacturer to wholesaler to retailer to consumer (Bowersox et al. 2002). Supply chain management involves coordinating and integrating these flows both within and among companies. One concept for defining and modelling supply chains is the SCOR reference model consisting of six supply-chain processes: Plan, Source, Make, Deliver, Return and Enable (SCC 2012). However, in many industries there has been a huge movement towards service business during recent years. Manufacturing firms are increasing their focus on service, which has also been referred to as the emergence of "product–service systems" (e.g. Tukker and Tischner, 2006). There have already been many studies about the development of service supply chains in manufacturing and other industries (e.g. Hemilä and Vilko, 2013). The SCOR model is the widely accepted standard for modelling product supply chains, yet it does not represent well the additional complexities of the service environment (Maull et al. 2014). Manufacturing supply chains are often long, relatively linear, and involve multiple parties, while service supply chains are short, bidirectional and only rarely have more than one supplier (ibid). The increased complexity of services represented in feedback loops between supplier and customer is not represented in the SCOR model (ibid). We look at today's business ecosystems as a network of organizations providing products and services. Some organizations provide only products, some only services, and some organizations have hybrid value offerings by providing product-service systems. Traditional supply chain management focuses on supplier-customer collaboration. That is still relevant and it can be said to be a quite easy task to manage. For better management of the company, managers should focus on how to collaborate in networks with different value adding collaboration partners providing products, services and product-service systems. We argue that in that way, managerial focus today should be on the management of product-service supply networks (PSSNs). There are no commonly agreed models yet for managing PSSNs. Our contribution is on the way for management of future PSSNs. For the management of PSSNs, managers are required to understand and identify value creation determinants, and then to analyze and measure operations.

EXISTING AND TRADITIONAL SCM PERFORMANCE INDICATORS

Performance indicators selection is a critical step in the design and evaluation of any supply chain (e.g. Beamon, 1999). Performance indicators are used to evaluate the management of supply chains, and how well the value is delivered to customers and stakeholders in order to meet their expectations. One of the main objectives of measurement is to motivate the employees and to get them to work towards an achieving of the company's goals (Chong and Roopnarain, 2014). Beamon (1999) presents the three types of performance measures that are necessary components in any supply chain performance measurement system: resources, output and flexibility. Resources include i.a. inventory levels, personnel requirements, equipment utilization and cost. The goal of the output measures is to achieve a high level of customer service; the indicators of customer responsiveness, ratio of on-time deliveries, and customer satisfaction are examples here. Flexibility measures are meaningful because supply chains must be able to respond to change and meet individual customer requirements and demands (Beamon, 1999; Gunasekaran et al., 2001). The four basic links that constitute the supply chain performance are: plan, source, make and deliver. The supply chain indicators can be also classified into strategic, tactical and operational levels of management (Gunasekaran et al., 2001).

Traditional SCM key performance indicators focus on supplier-customer collaboration. For some, KPIs are focused on how the supply chain performs in delivering service excellence and this is their priority. Typically KPIs with a higher priority in such an environment might include DIFOT (Delivery In Full and On Time), or LIFR (Line Item Fill Rate) or a Perfect or Error Free measurement. Performance is directly connected on functional value: how supply chain performs. For others, the emphasis is on measuring and monitoring costs throughout the supply chain. Included in this category are such KPIs as overall supply chain cost as a percentage of sales, total supply chain cost per unit sold (e.g. case, or kg or tons or liter, etc.), warehousing costs and transport costs per unit, labor productivity rates, etc. Here we see that the focus is on the economic value determinants. Chae (2009) had used the SCOR model and provides examples of KPIs for SCOR processes (see Figure 1).

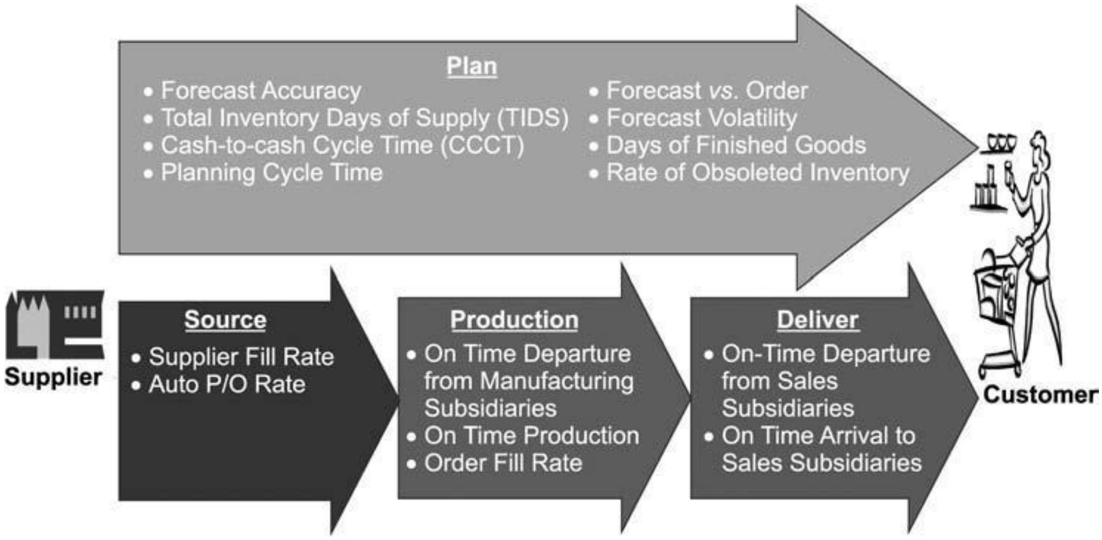

Figure 1. Supply chain KPIs (Chae, 2009)

In managing supply chains, all the indicators related to time are important. Indicators based on time also support the developments of Lean-principles

(Plenert, 2007). When companies are implementing Lean, Agile or other optimization methods into their operations, there is a risk of losing delivery accuracy and flexibility in situation where demand changes. By selecting the right KPIs, managers can lower operational risks and vulnerabilities.

EMOTIONAL AND SYMBOLIC PERFORMANCE INDICATORS

In our case studies and literature, we have found that decision makers have feelings and opinions, and experience other emotional aspects, when undergoing the process of making decisions (Leek and Christodoulides, 2012). These emotional and symbolic value creation determinants are essential for the decision making, but it is hard to create measurement indicators for those. We argue that for successful management, decision makers should not only identify and analyze emotional and symbolic value determinants, but also try to turn those into a measurable form. Customer value can be measured by collecting customer feedback. That is the easiest and the most oftenly used way. Usually questions are formed as "did you like the product or service?" or "would you recommend our product or service to someone?" Those kinds of questions do provide an overall customer satisfaction rate, but it is based on the customer experience. When developing new products or services, the customer's experience does not yet exist. In service processes, value emerges through the use of the offering in customers' value generating processes, as "value-in-use" (Aarikka-Stenroos and Jaakkola, 2012; Hemilä et al. 2014). Services cannot be put in a warehouse as inventory, but must be produced and delivered at the same time. Because of the IHIP characteristics of services (intangibility, heterogeneity, inseparability, and perishability), buying and using services has a strong emotional value that must be considered (e.g. Kelly and Storey, 2000). The service encounter is the interaction that takes place between the service (typically the front-line employee) and a customer (Dixon et al. 2014). Some scholars have argued that the key assets are the diverse expertise among service personnel and decision makers (e.g. Von Nordenflycht, 2010). Services can be implemented also without the customer being present, for instance installation and maintenance or repair, but this happens typically at customer premises. Also emotional determinants are included in the product-buying decisions and using the product. In our study, the expert group listed many emotional value determinants that have an effect on decision making and customer loyalty, for example feelings, experiences, reputation, trust, etc. Name brands create intangible benefits and satisfaction for buyers. In our study, we have looked also symbolic value determinants, because we believe those are becoming more and more important in decision-making and customer loyalty. Some examples of symbolic value determinants are recyclable materials or post-consumer recycled materials, organic food, human rights considerations in manufacturing, and other symbolic values. In a B2B context, symbolic value determinants can be CO^2 emissions and green technologies, for instance (Hemilä et al. 2014). At this point, the measurement and setting performance indicators for emotional and symbolic value determinants is a very complex task. Even the identification will help decision makers to further develop product service offerings. Quantitative measurements might be hard to realize, but we are continuing with that challenge. Qualitative data is much easier to obtain and managers can easily make decisions concerning improvement measures according qualitative feedback from customers. We have collected product-service value and vulnerability determinants from our case studies (Table 1). Vulnerabilities are factors that prevent customer value creation. The focus is especially on interaction, where a person (as contrasted with something inanimate) is involved in both the supplier and the customer side.

	Value determinant	Vulnerability determinant
Reliability	• Professional skills • Honesty • Keeping promises	• Resource availability • Lack of Knowledge • Lack of information sharing
Quality	• Expertise	• Narrow experience • Service quality not in line with product quality
Ease of doing business	• Fast learning ability • Openness • Presence • Efficient time management • Seller's expertise • Personality of service	• Slow response time • Decision making capabilities • Changing customer service personnel
Flexibility	• Living with the customer • Responsiveness • Commitment	• Do not fully understand customer needs • Business understanding • Focus on own business, fogetting the customer

Table 1. Value and vulnerability determinants in case studies

As Table 1 clearly shows, the measurement of these kind of determinants is hard. Our argument is that companies should analyze value creation elements and value destroyers in their own business context. By improving value creating elements and avoiding vulnerability determinants, businesses can be more successful and customer loyalty can be improved. Of course it helps, when managers can find measurements and KPIs for these issues, but it is not always needed.

PROCESS OF IDENTIFYING AND ANALYZING CUSTOMER VALUE IN PSSNs

In our ISL2014 paper, we presented the process of identifying customer value in PSSNs (Kallionpää et al. 2014). In this paper, we have extended out the previous process model with the part focusing on analyzing offered and perceived value. As the previous chapter described, there are traditional SCM performance indicators in the business environment in every type of business. Companies should pay attention to inbound and outbound flows. The functional and economical value determinants can be measured easily, and existing KPI used for managerial purposes. The challenging part is the performance indicators for emotional and symbolic value. If quantitative data is not available, qualitative data can alternatively be used. Qualitative data can be collected from questionnaires, direct customer feedback, or by other methods. Managers should create a set of meaningful performance indicators. After that what follows is the analysis of performance indicators phase. Companies should analyze how these determinants impact on their own company, what they should do to obtain better feedback or which processes should be changed and improved according to the data. Numerical data can be converted into target figures and can be used directly for the purposes relating to managing the activities. Figure 2 presents our proposed model.

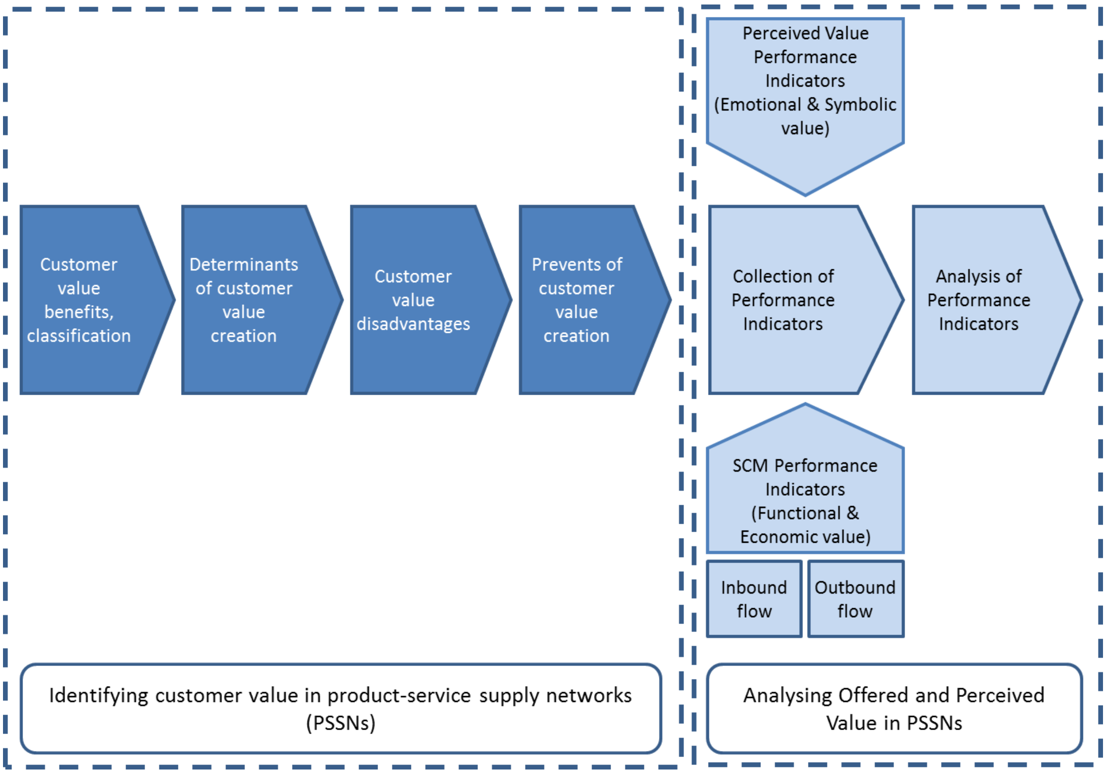

Figure 2. Process of identifying and analyzing customer value in PSSNs

As can be seen, the upper part of the analysis is the customers' point of view: what kind of perceived value they achieve. Emotional and symbolic value is created and achieved on that part, primarily by receiving and using products and services. The lower part focuses on tangible assets, the features of product and service, but also the delivery process. In the PSSN, companies can and should measure and control not only inbound flows (incoming materials, services) but also outbound flows (product and service delivery). The last part of our proposed process, which is not the focus of this paper, is management. Our research continues with the development of a management model for customer value and vulnerability, paying special attention to the identification and analysis of value determinants.

CONCLUSIONS

The study was conducted within six case studies in Finland, and their findings are combined with the findings in literature. The findings in literature are based on management, supply chain and marketing literature. Despite research concern emotional feelings and human decision-making, neither human behavior sciences nor psychology literature has been used, which is a limitation of this study. Our study increases the practitioners understanding of value creation and PSSN performance assessment. Practitioners should pay attention to organization competences, what is needed for value creation and business targets, and how resources are fit to needs. By using our proposed model, companies can identify and analyze their PSSNs performance better than by using existing models. In future research, a management model should be created based on the value creation and performance assessment findings.

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INTERPRETING THE CONCEPT OF 'VALUE' WITHIN THE LEAN PARADIGM

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Abstract

Purpose of this paper:

The Lean paradigm (Womack & Jones, 1996) remains extremely influential on operations and supply chain practice and research. The first two of the five 'Lean Principles' advanced by Womack & Jones as a prescription for becoming Lean concern the concept of 'value'. These are: (1) *Understand value from your customer's perspective* (2) *Map the value stream.* However, the significant personal experience of the authors of this paper in applying the Lean paradigm suggest continued ambiguity of this most fundamental concept within both the Lean literature and practice. Our initial investigations suggest a gap in the literature on this topic, and Lean practitioners treating the concept of 'value' as axiomatic. As a consequence and to the detriment of the project concerned, Lean intervention projects in practice invariably start at the second principle, and without any discussion, identification or consensus among the project team concerning the actual 'value' that is to be mapped. Over the past three ISLs we have presented papers that have explored and characterised the conception of 'value' within the field of Logistics and Supply Chain Management generally (see Francis *et al*., 2014). In this paper we now apply the content analysis method developed within the papers above specifically to the Lean literature. Its purpose is to yield rigorous insight into how the concept of value is conceived within this body of material, and hence provide utility to both academics and practitioners working within this area.

Design/methodology/approach:

This will be a content analysis paper with a multi-stage research design.
The first stage will involve the development of a key word (KW) search strategy to identify relevant publications (eg *'Lean thinking', 'Lean production', 'Lean supply'* etc). Our intent will be to identify the [20] <u>most highly cited</u> publications for each such KW search query. These results will be pooled and duplicate publications removed to form a focal publication set (FPS) for subsequent analysis. Please note that much of the Lean literature is *atheoretical* in nature, so the searches will not be restricted to journal papers. The KW queries will instead be run across two bibliographic database sources that provide such citation statistics: SCOPUS to identify the most highly cited peer reviewed journal papers, and GOOGLE SCHOLAR for the most highly cited publications generally (including books, conference papers and reports etc.)

Once the FPS has been established, it will be descriptively analysed in various ways (by host publication type, time span, sector etc) to cast further insight into its diffusion pattern. This will be followed by a final stage involving a thematic analysis (excavating, coding and interpreting) of the content of the FPS to characterise the way(s) that value is conceived within this body of material.

Findings:
At the time of writing, this project is a work-in-progress and findings have not yet been established. However, as indicated above, it is hoped that these findings will reveal the way(s) that 'value' is conceived within the Lean literature. It is also hoped that a by-product of the descriptive analysis stage of the research design will be to produce further insight into the diffusion and genealogy of the Lean literature and hence validate the findings of Holweg (2006); one of the most highly cited publications on Lean.

Value:
Whilst exhibiting limitations (next), the content analysis approach adopted within this paper is innovative. However, its main value lies in its challenge to the axiomatic treatment of the fundamental subject of 'value' that has characterised the Lean paradigm since its inception.

Research limitations/implications (if applicable):
There are two main limitations. The first of these lies in the construct of the KW phrases used in the search strategy. Clearly, the nature of the KW phrases used in the queries will determine the publications subsequently identified to form the FPS. The second limitation is the self-imposed practical constraint of limiting the analysis to the top [20] publications identified in each case.

Practical implications (if applicable):
Ultimately, it is hoped that this stream of work will result in the development of a new practical technique to be used at the outset of future Lean projects that facilitates an effective understanding of the conception of value of *all* the supply chain partners concerned, and hence significantly improves the efficacy of such an intervention. We believe that the framework we presented at ISL last year (Fisher *et al*., 2014) provides a useful starting point for the development of such a technique.

1. INTRODUCTION

At ISL 2012 we presented our inaugural paper in a programme of research that sought to explore the conception, communication and execution of what is perhaps the most fundamental concept for both research and practice within our field of contemporary logistics and supply chain management (SCM); the concept of 'value' (Fisher *et al*., 2012). In that paper, we specifically explored the notion of value within the practitioner-oriented literature. At ISL 2013 we extended that study into the academic literature in the guise of a comprehensive content analysis of peer-reviewed papers on the topic of value within the leading purchasing, logistics and SCM journals (Francis *et al*., 2013; Francis *et al*., 2014), before then developing a new theoretical framework for better understanding value within our field at ISL 2014 (Fisher *et al*., 2014).

In the above body of work we found that there had been significant growth in interest on the subject of value over the last three decades, and that the concept of value is undoubtedly a cornerstone of the contemporary notion of both the production system and the supply chain. However, we also found that there is currently no coherent conception of value within either the academic or practitioner SCM literatures. These findings have very significant implications for academics in our field, as it raises the question of how it is possible to study effectively something that is [so] inadequately defined? This in turn throws into question a significant proportion of the extant research within the production and SCM fields. The above findings also have significant implications for practitioners in these fields, as it also throws into question how it is possible to design an effective or efficient production system or supply chain based upon the value [delivery] principle if none of the actors have a common understanding, let alone consensus, of what that value amounts to?

This paper extends the above programme of research. Within it, we present the preliminary findings that have emerged from the first phase (*Material Collection* and *Descriptive Analysis*) of our study into the actual conception and execution of the notion of value within the Lean paradigm (Womack & Jones, 1996). At the time of writing, our study was still in progress. However, we plan to have completed this and be in a position to present the full findings at ISL in Bologna.

2. LEAN THINKING

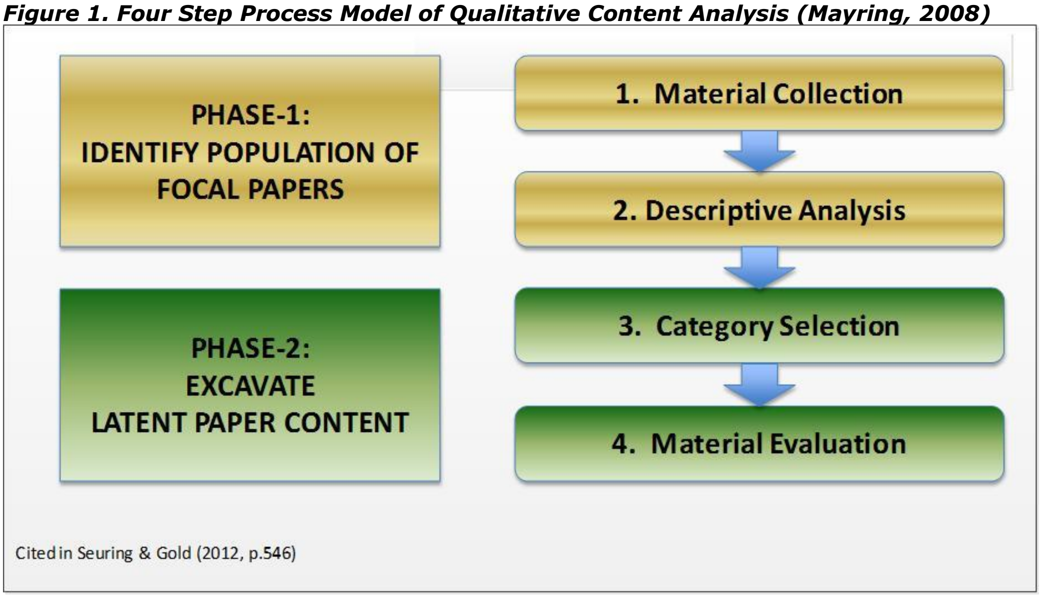
The Lean paradigm (Womack & Jones, 1996) has undoubtedly has been one of the most influential on operations and supply chain research and practice since its emergence in the early to mid-1990s. The term "Lean" itself was coined by the Massachusetts Institute of Technology researcher John Krafcik whilst he was working on the International Motor Vehicle Program (IMVP), and entered the management lexicon via his 1988 paper in the Sloan Management Review. Whilst coined by Krafcik, Schonberger (2007) notes that many people attribute the origins of the Lean paradigm to the popular book by Womack *et al*. (1990), although he asserts that Lean production-type initiatives were already well established in the US in the early 1980s albeit under different names. Even though Lean can therefore boast a lineage of over three decades, it suffers from an issue of interpretive viability (after Benders & van Veen, 2001). Samuel (2011) suggests two related reasons for this issue. The first is a lack of common definition within the literature (New, 2007; Shah & Ward, 2007; Bayou & De Korvin, 2008). The second reason is that as a concept, lean has evolved over time (Hines *et al*., 2004; Papadopoulou & Ozbayrak, 2005). To these a third reason might be added; a 'blurring of the boundaries' between the lean paradigm and similar contemporary process-oriented operations and SCM paradigms such as the Theory of Constraints (TOC), Agility and Six Sigma – not to mention the emergence of hybrid paradigms such as Leagility and Lean-Sigma.

Whilst common definition has been lacking, a common feature of publications on Lean has been reference to Womack and Jones' (1996) '*Five Lean Principles'*; bearing witness to the enduring influence of this generic prescription for achieving Leanness within the authors' seminal book on the subject. This appeal is possibly explained by the interpretive viability issue noted above, and also the logical simplicity of the prescription itself. The first principle holds that the starting point for becoming Lean is to specify 'value' from the perspective of the end customer, and usually in terms of a specific product line or product family. Principle two is to then identify the 'value stream', which the authors define as "… *the sequence of common processing steps, equipment or activities required to produce and deliver that product or product family to the end customer*". Once the value stream has been mapped, the third principle is to make the remaining (value-adding) activity steps 'flow' without delay or obstruction in order to achieve a significantly reduced manufacturing lead time. This involves eliminating the obviously wasteful steps and minimizing work queues, rework, backflows, and all other types of stoppage. Having enhanced responsiveness in this manner the fourth principle is 'pull'; meaning to produce (ie undertake value-adding steps) only in response to an actual customer demand signal, rather than making-to-forecast. The fifth and final principle is 'perfection'. This entails continuously improving the production process to produce exactly what the customer wants, exactly when they need it, with zero defects, at a price the customer is prepared to pay and with minimum waste. Therefore, as we can see from this brief summary, the conception of value is pivotal to the notion of Lean itself.

3. METHOD

The method used for this study was Content Analysis (CA). This is an established bibliographic research technique that is defined by Berelson (1952, p.55) as *"… any methodological measurement applied to text (or other symbolic materials) for social science purposes."* CA has a lineage within the SCM field, as aptly summarised by Seuring & Gold (2012). They suggest that CA typically entails two broad phases of study. Phase-1 ultimately identifies the individual articles that are subsequently to form the focus of detailed analysis from the wider population of existing articles. Phase-2 then 'excavates the latent content' of these articles; typically using some form of thematic analysis to interpret the underlying meaning and obtain insight. Seuring & Gold (*op cit*.) stress the importance of following a clear and purposeful process structure, and highlight Mayring's (2008) four-step process model as a framework for conducting qualitative content analysis. As indicated in Figure 1 the first two steps of this process model relate to Phase-1 summarised above (identify the population of focal articles), whilst the third and fourth step relate to Phase-2 (excavate latent article content).

Figure 1. Four Step Process Model of Qualitative Content Analysis (Mayring, 2008)



Step 1 in the model is *Material Collection,* during which the unit of assessment (UOA) is identified. This is usually, although not exclusively, peer-reviewed journal papers. This stage also entails a search across one or more bibliographic databases using a key word (KW) search strategy. Seuring & Gold point out that for reasons of pragmatism, the researcher will usually need to make an informed choice to condense the population of target articles to a manageable number, and that this choice needs to be justified in relation to the research objective. This typically involves being selective in the range and/or timespan of journals searched. Step 2 is *Descriptive Analysis,* during which the formal characteristics of the material are assessed to provide background information for the subsequent steps. This includes useful information about the distribution of articles across the various source journals. Identification of the population of focal articles marks the start of Step 3, *Category Selection*. This entails selecting the structural dimensions and analytical categories that are to be applied to the identified material. The last step is then *Material Evaluation*, during which the identified articles are analysed according to the dimensions established above in order to establish the requisite insight.

The method applied by the authors for the study reported upon in this paper was based upon the framework model discussed above. The scope of the material presented here equates to Phase-1 of this CA project; the identification of the set of focal articles on Lean Thinking that are subsequently to be analysed in detail during Phase-2. As indicated in the Introduction, at the time of writing this paper, Phase-2 was work in progress and is planned to be completed by the date of the symposium in Bologna so that the findings might be included in the presentation of this paper. The following section elaborates upon each of the above Phase-1 procedural steps in more detail.

4. DISCUSSION

4.1 Material Collection

The goal of this first step of the CA process was to identify the most *influential* articles on Lean for the subsequent evaluation of their treatment of the concept of 'value'. We decided to use '*number of citations'* as the proxy for an article's influence. The authors' collective experience of the Lean literature suggested that many of the most influential texts would be derived from practitioner rather than academic sources. Therefore, unusually for a CA, the UOA could not be constrained only to peer-reviewed academic journals. Given the need to identify both academic and practitioner articles and obtain citation statistics, we therefore decided to use Google Scholar (GS) as the source bibliographic database for our study.

GS is probably the largest bibliographic database. According to its press it "…*provides a simple way to broadly search for scholarly literature. From one place, you can search across many disciplines and sources: articles, theses, books, abstracts and court opinions, from academic publishers, professional societies, online repositories, universities and other web sites. Google Scholar helps you find relevant work across the world of scholarly research*" (see http://scholar.google.co.uk/intl/en/scholar/about.html). The ranking algorithm used by GS considers the full text, author, source publication and how often the article has been cited in other scholarly literature. However, it puts a particularly high weight on citation counts and the words included in the article's title, so that the first search results encountered are often the most highly cited (op cit.)

Having determined the most appropriate bibliographic source database, the next decision was to formulate an appropriate keyword (KW) search strategy. As indicated in the Introduction; Lean suffers from a particularly acute interpretive viability issue. We therefore decided to interrogate GS using the three main synonyms for Lean, whilst recognising the potentially uncomprehensive limitation of this approach. These synonyms were '*lean thinking*' (S1), '*lean production*' (S2) and '*lean manufacturing*' (S3). Three search queries (S1-S3) were duly constructed from these, with 'patents' and 'case law' excluded for each. The initial findings from these searches produced two useful insights (Table 1). The first of these is that the most prevalent synonym by far is 'lean production'. The second insight is a quantification of the sheer scale of the literature on this subject.

Table 1. Result of three keyword search queries across Google Scholar

Search Ref.	**Key Word**	**Number of Hits**
S1	*lean thinking*	About 532,000 results
S2	*lean production*	About 1,360,000 results
S3	*lean manufacturing*	About 385,000 results

Seuring & Gold's (2012) earlier suggestion for this first step of the CA process would therefore seem particularly prescient; pragmatism demands an informed choice to condense the results into a manageable number of focal articles. It was therefore decided to capture the top (ie most highly cited) 20 articles identified in each of the searches S1-S3, and combine these into a focal article set (FAS) that would form the raw material for the subsequent steps of our CA process. This in turn necessitated the 'eyeballing' of the '*cited by nnnn*' statistic for each article returned, then manual entry of the appropriate article details into an Excel spreadsheet. Once entered, they could then be manipulated. The three lists were combined and duplicate entries removed to form the master FAS list. This list was then sorted according to the number of citation (high to low). The resulting top 50 most highly cited publications on Lean are listed in Table 2, and collectively represent 29,661 citations. In addition to providing reference details the table summarises the type of publication, focal industry sector discussed within, and ABS (2015) details of each of the constituent publications. These latter details are included due to the current topicality of this journal ranking instrument within the UK higher education sector.

Table 2. Top 50 most highly cited publications on Lean

No.	Cited By	Source Search	REFERENCE DETAILS				Publication Type	Sector	ABS (2015) JOURNAL DETAILS		
			Authors	Year	Title	Publication Details			Listed?	Ranking	Subject Area
1	10,759	S2	Womack, JP, Jones, DT and Roos, D	1990/2007	*The Machine that Changed the World*	Free Press: New York	Book	GENERIC	NO	N/A	N/A
2	5,279	S3	**WOMACK, J.P. and JONES, D.T.**	1996/2010	*Lean Thinking: Banish Waste and Create Wealth in your Corporation*	Simon & Schuster: New York	Book	GENERIC	NO	N/A	N/A
3	1,521	S2	Groover, MP	2007	Automation, Production Systems, and Computer-Integrated Manufacturing	3rd ed., Prentice Hall Press: Upper Saddle River, NJ	Book	GENERIC	NO	N/A	N/A
4	1,020	S1	Naylor, B, Naim, MM and Berry, D	1999	Leagility: integrating the lean and agile manufacturing paradigms in the total supply chain	*International Journal of Production Economics,* 62(1-2), pp.107-118.	Journal Paper	GENERIC	YES	3	Operations & Technology Management
5	892	S1	Shah, R and Ward, PT	2003	Lean manufacturing: context, practice bundles, and performance	*Journal of Operations Management,* 21(2), pp.129-149	Journal Paper	GENERIC	YES	4*	Operations & Technology Management
6	719	S2	Krafcik, JF	1988	Triumph of the lean production system	*Sloan Management Review,* 30 (1), pp.41-52.	Journal Paper	AUTOMOTIVE	YES	3	General Management, Ethics & Social Responsibility
7	619	S3	Hines, P., Holweg, M. and Rich, N.	2004	Learning to evolve: a review of contemporary lean thinking	*International Journal of Operations and Production Management,* 24(10), pp.994-1011	Journal Paper	GENERIC	YES	4	Operations & Technology Management
8	560	S2	Shah, R. and Ward, P.T.	2007	Defining and developing measures of lean production	*Journal of Operations Management,* 25(4), pp.785-805	Journal Paper	GENERIC	YES	4*	Operations & Technology Management
9	472	S2	Holweg, M	2007	The genealogy of lean production	*Journal of Operations Management,* 25(2), pp.420-437	Journal Paper	GENERIC	YES	4*	Operations & Technology Management
10	386	S2	Berggren, C	1993	*Alternatives to Lean Production: Work Organization in the Swedish Auto Industry*	Cornell University Press: Ithaca, New York.	Book	AUTOMOTIVE	NO	N/A	N/A
11	385	S1	Abdulmalek, FA and Rajgopal, J	2007	Analyzing the benefits of lean manufacturing and value stream mapping via simulation: a process sector case study	*International Journal of Production Economics,* 107(1), pp.223-236.	Journal Paper	PROCESS	YES	3	Operations & Technology Management
12	370	S2	Landsbergis, PA, Cahill, J and Schnall, O	1999	The impact of lean production and related new systems of work organization on worker health.	*Journal of Occupational Health Psychology,* 4(2), pp.108-130.	Journal Paper	AUTOMOTIVE	YES	4	Psychology (Occupational)
13	362	S2	King, AA and Lenox, MJ	2001	Lean and green? An empirical examination of the relationship between lean production and environmental performance	*Production and Operations Management,* 10(3), pp.244-256	Journal Paper	MANUFACTURING	YES	4	Operations & Technology Management
14	356	S2	Karlsson, C and Ahlstrom, P	1996	Assessing changes towards lean production	*International Journal of Operations and Production Management,* 16(2), pp.24-41.	Journal Paper	GENERIC	YES	4	Operations & Technology Management
15	314	S2	Dennis, P	2007	*Lean Production Simplified: A Plain-Language Guide to the World's Most Powerful Production System*	2nd ed., Productivity Press: New York	Book	GENERIC	NO	N/A	N/A
16	314	S2	MacDuffie, JP and Helper, S	1997	Creating lean suppliers: Diffusing lean production through the supply chain.	*California Management Review,* 39(4), pp.118-151.	Journal Paper	AUTOMOTIVE	YES	3	General Management, Ethics & Social Responsibility
17	283	S2	Dahlgaard, JJ and Dahlgaard-Park, SM	2006	Lean production, six sigma quality, TQM and company culture	*TQM Magazine,* 18(3), pp.263-281	Journal Paper	GENERIC	NO	N/A	N/A
18	280	S1	Feld, WM	2000	*Lean Manufacturing: Tools, Techniques, and How to Use Them*	CRC Press: Boca Raton, FL	Book	GENERIC	NO	N/A	N/A
19	272	S3	Murman et al.	2002	*Lean Enterprise Value: Insights from MIT's Lean Aerospace Initiative*	Palgrave Macmillan: New York	Book	AEROSPACE	NO	N/A	N/A
20	264	S1/S2	**LIKER, JK**	2004	*Becoming Lean: Inside Stories of US Manufacturers*	Productivity Press: New York	Book	GENERIC	NO	N/A	N/A
21	249	S2	Lewis, MA	2000	Lean production and sustainable competitive advantage	*International Journal of Operations and Production Management,* 20(8), pp.959-978.	Journal Paper	GENERIC	YES	4	Operations & Technology Management
22	247	S2	Delbridge, R	1998	*Life on the Line in Contemporary Manufacturing: The Workplace Experience of Lean Production and the "Japanese" Model*	Oxford University Press: New York	Book	GENERIC	NO	N/A	N/A
23	235	S2	Levy, DL	1997	Lean production in an international supply chain	*MIT Sloan Management Review,* 38(2), pp.94-102.	Journal Paper	GENERIC	YES	3	General Management, Ethics & Social Responsibility
24	230	S2	Berggren, C	1993	Lean production—the end of history?	*Work, Employment & Society,* 7(2), pp.163-188	Journal Paper	GENERIC	YES	4	HRM and Employment Studies
25	229	S2	Bowen, DE and Youngdahl, WE	1998	"Lean" service: in defense of a production-line approach	*International Journal of Service Industry Management,* 9(3), pp.207-225.	Journal Paper	SERVICE	NO	N/A	N/A
26	205	S2	Nicholas, JM	1998	*Competitive Manufacturing Management: Continuous Improvement, Lean Production, Customer-Focused Quality*	Irwin/McGraw-Hill: Boston	Book	MANUFACTURING	NO	N/A	N/A
27	184	S1/ S3	**GRIEVES, M**	2005	*Product Lifecycle Management: Driving the Next Generation of Lean Thinking*	McGraw Hill Professional: New York	Book	GENERIC	NO	N/A	N/A
28	178	S1/S3	**MELTON, T**	2005	The benefits of lean manufacturing: what lean thinking has to offer the process industries	*Chemical Engineering Research and Design,* 83(6), pp.662-673.	Journal Paper	PROCESS	NO	N/A	N/A
29	175	S2	Sandberg, A	1995	Enriching production: perspectives on Volvo's Uddevalla plant as an alternative to lean production	*Munich Personal RePEc Archive (MPRA),* Paper No. 10785	Working Paper	AUTOMOTIVE	NO	N/A	N/A
30	173	S1	Pavnaskar, SJ, Gershenson, JK and Jambekar, AB	2003	Classification scheme for lean manufacturing tools	*International Journal of Production Research,* 41(13), pp.3075-3090	Journal Paper	GENERIC	YES	3	Operations & Technology Management
31	143	S1	Worley, JM and Doolen, TL	2006	The role of communication and management support in a lean manufacturing implementation	*Management Decision,* 44(2), pp.228-245	Journal Paper	GENERIC	YES	2	General Management, Ethics & Social Responsibility
32	142	S3	King, D.L., Ben-Tovim, D. and Bassham, J.	2006	Redesigning emergency department patient flows: application of Lean Thinking to health care	*Emergency Medicine Australasia,* 18(4), pp.391-397	Journal Paper	HEALTHCARE	NO	N/A	N/A
33	127	S1	Detty, RB and Yingling, JC	2000	Quantifying benefits of conversion to lean manufacturing with discrete event simulation: a case study	*International Journal of Production Research,* 38(2), pp.429-445.	Journal Paper	GENERIC	YES	3	Operations & Technology Management
34	116	S3	Jones, D.T. and Mitchell, A.	2006	Lean thinking for the NHS	*NHS Confederation, London*	Conference Paper	HEALTHCARE	NO	N/A	N/A
35	112	S1	Yang, MGM, Hong, P and Modi, SB	2011	Impact of lean manufacturing and environmental management on business performance: an empirical study of manufacturing firms	*International Journal of Production Economics,* 129(2), pp.251-261	Journal Paper	MANUFACTURING	YES	3	Operations & Technology Management
36	110	S3	Haque, B. and James-Moore, M.	2004	Applying lean thinking to new product introduction	*Journal of Engineering Design,* 15(1), pp.1-31.	Journal Paper	AEROSPACE	NO	N/A	N/A
37	110	S1	Sullivan, WG, McDonald, TN and Van Aken, EM	2002	Equipment replacement decisions and lean manufacturing	*Robotics and Computer-Integrated Manufacturing,* 18(3-4), pp.255-265	Journal Paper	GENERIC	NO	N/A	N/A
38	110	S1	Wu, YC	2003	Lean manufacturing: a perspective of lean suppliers	*International Journal of Operations and Production Management,* 23(11), pp.1349-1376	Journal Paper	GENERIC	YES	4	Operations & Technology Management
39	109	S3	Joosten, T., Bongers, I and Janssen, R.	2009	Application of lean thinking to health care: issues and observations	*International Journal for Quality in Health Care,* 21(5), pp.341-347.	Journal Paper	HEALTHCARE	NO	N/A	N/A
40	106	S1	Motwani, J	2003	A business process change framework for examining lean manufacturing: a case study	*Industrial Management & Data Systems,* 103(5), pp.339-346	Journal Paper	GENERIC	YES	2	Information Management

Table 2. Top 50 most highly cited publications on Lean (cont.)

No.	Cited By	Source Search	REFERENCE DETAILS				Publication Type	Sector	ABS (2015) JOURNAL DETAILS		
			Authors	Year	Title	Publication Details			Listed?	Ranking	Subject Area
41	104	S1	Wilson, L	2009	*How to Implement Lean Manufacturing*	McGraw Hill Professional: New York	Book	GENERIC	NO	N/A	N/A
42	102	S3	Holden, R.J.	2011	Lean thinking in emergency departments: a critical review	*Annals of Emergency Medicine,* 57(3), pp.265-278.	Journal Paper	HEALTHCARE	NO	N/A	N/A
43	101	S3	Mazzocato, P., Savage, C. and Brommels, M.	2010	Lean thinking in healthcare: a realist review of the literature	*Quality and Safety in Health Care,* 19, pp.376-382.	Journal Paper	HEALTHCARE	NO	N/A	N/A
44	100	S1	Dickson, EW, Singh, S, Cheung, DS, Wyatt, CC and Nugent, AS	2009	Application of lean manufacturing techniques in the emergency department	*Journal of Emergency Medicine,* 37(2), pp.177-182	Journal Paper	HEALTHCARE	NO	N/A	N/A
45	99	S3	Ben-Tovim, D.I., Bassham, J.E., Bolch, D., Martin, M.a., Dougherty, M. and Szwardcbord, M.	2007	Lean thinking across a hospital: redesigning care at the Flinders Medical Centre	*Australian Health Review,* 31(1), pp.10-15.	Journal Paper	HEALTHCARE	NO	N/A	N/A
46	98	S3	Young, T.P. and McClean, S.I.	2008	A critical look at Lean Thinking in healthcare	*Quality and Safety in Health Care,* 17, pp.382-386.	Journal Paper	HEALTHCARE	NO	N/A	N/A
47	97	S1	Fullerton, RR and Wempe, WF	2009	Lean manufacturing, non-financial performance measures, and financial performance	*International Journal of Operations and Production Management*, 29(3), pp.214-240	Journal Paper	MANUFACTURING	YES	4	Operations & Technology Management
48	82	S3	Poppendieck	2011	Principles of lean thinking	*IT Management Select,* Winnipeg, pp.1-7	Book Chapter	GENERIC	NO	N/A	N/A
49	81	S1	Hallgren, M and Olhager, J	2009	Lean and agile manufacturing: external and internal drivers and performance outcomes	*International Journal of Operations and Production Management,* 29(10), pp.976-999	Journal Paper	GENERIC	YES	4	Operations & Technology Management
50	80	S1	Meyers, FE and Stewart, JR	2002	*Motion and Time Study for Lean Manufacturing*	Prentice Hall: Upper Saddle River, NJ	Book	GENERIC	NO	N/A	N/A

4.2 Descriptive Analysis

Turning first to an analysis of the publication types contained within the above table, and we find that 34 (68%) of the most highly cited publications on Lean are journal articles. Thirteen (26%) are books, whilst the balance is composed of one book chapter, one conference paper and a working paper. However, when the citation data represented by each of these categories is considered, a different picture emerges. The 13 books represent 19,895 (67%) of the total citations, whilst the 34 journal papers collectively represent only 9,393 (32%) of the citations. A cursory examination of the above table reveals a very distinct skew in the data, with the top three publications accounting for 17,559 (60%) of the total citations, and all three of these being books. In fact, Womack and Jones' two seminal books (Womack *et al.,* 1990; Womack & Jones, 1996) are unsurprisingly the two most highly cited works on Lean, and on their own account for 16,038 (54%) of the total citations. These statistics highlight the highly a-theoretical nature of much of the Lean literature.

When the journal papers are further analysed with regard to their ABS (2015) status, further insight is provided. Of the 34 journal papers in total, 22 (65%) appear in ABS (2015) listed journals. These represent 7,732 (26%) of the total citations; collectively less than half the total citations achieved by Womack & Jones' two books (above). Unsurprisingly, the majority (15) of these journals are categorised under the '*Operations and Technology Management'* ABS (2015) subject code. Table 3 furthers deconstructs citation performance within each of the five ABS journal rank categories. It should be pointed out that the highest ranked journal within the top 50 Lean publications listed within Table 2 is Naylor *et al*. (1999). This is contained within an ABS (2015) '3' ranked journal and alone has 1,020 citations. Therefore 12 (35%) of the journal papers are drawn from non-ABS (2015) listed journals. These collectively represent 1,661 of the total citations; an average of 49 per paper.

Table 4 provides a sector analysis of the 50 Lean publications listed in Table 2. Each publication was scrutinised to identify the focal industry sector discussed within. The focus of many of these was very generic and did not discuss any sector in particular (or cited examples or testimonials from multiple sectors). Such publications were categorised as 'Generic'. The following table identifies the number of publications (and cumulative citation total) by publication type within each sector category. This yielded a number of interesting findings.

Table 3. Lean journal paper ABS (2015) Rank analysis

ABS (2015) Rank Category	Papers in this Category	Citations	Average Citations Per Paper
4*	3 (9%)	1,924 (6.5%)	641
4	9 (27%)	2,474 (8.3%)	275
3	8 (24%)	3,085 (10.4%)	386
2	2 (6%)	249 (0.8%)	125
1	0	0	0
TOTALS	**34 (100%)**	**7,732 (26%)**	**351**

Table 4. Lean publication industry/ sector analysis

Industry/ Sector	TYPE OF PUBLICATION				
	Book	**Book Chapter**	**Conference Paper**	**Journal Paper**	**Working Paper**
AEROSPACE	1 (272)			1 (110)	
AUTOMOTIVE	1 (386)			3 (1,403)	1 (175)
GENERAL	10 (19,032)	1 (82)		17 (5,766)	
HEALTHCARE			1 (116)	7 (751)	
MANUFACTURING	1 (205)			3 (571)	
PROCESS				2 (563)	
SERVICE				1 (229)	

The first of these findings was the highly generic nature of much of this Lean literature, with 27 (54%) of the identified publications accounting for 24,798 (84%) of the total citations falling into this category. This again supports the a-theoretical assertion made earlier. Given the origins of the Lean paradigm, it was very surprising that only five of the identified top 50 Lean publications <u>specifically</u> addressed the Automotive industry. Likewise, we were surprised to find that seven of the identified publications were specific to the Healthcare sector. This latter point underpins the extent of the diffusion of the Lean paradigm and growing interest in its potential healthcare applications.

5. CONCLUSIONS & FUTURE WORK

As we stated in the Introduction, this paper summarises only the preliminary findings that have emerging from Phase-1 of our current study into the notion of value within the Lean paradigm. Our immediate future work will be to complete Phase-2 of this CA in time for presentation at Bologna. With reference to Figure 1, this will involve completion of the *Category Selection* and *Material Evaluation* steps. To cast some light on our planned approach, we intend to search through the content of all 50 of the publications listed in Table 2; identify every instance of a reference to the term 'value' or 'values'; then copy and paste the host sentence/paragraph (as applicable to contextualise each such instance) into a separate file per publication.

We have already conducted a systematic literature review and have identified a number of conceptual and theoretical papers that specifically characterise and categorise the evolution of the conception of 'customer value'. We have built an affinity map of the most comprehensive, extensive and commonly cited of these. This body of literature will be used as a point of reference for evaluating the content extracted from each of the Lean publications, to see if it is possible to establish a prevailing conception of value within the Lean material; how this stands in relation to the wider theory on customer value (above); and (maybe) how this Lean conception has evolved over time.

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IMPLEMENTATION LEVEL OF SHIPPER AND TRANSPORT PROVIDER PRACTICES WITH AN IMPACT ON THE LOAD FACTOR

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ABSTRACT
The purpose of this paper is to examine current practices of load factor utilisation of road transport. An interview study of five shippers and two transport providers were conducted. The research shows that transport providers seem to work efficiently with operational practices to improve the load factor, but the load factor seems not to be highly prioritised when it comes to strategic decisions. The overall potential to improve the load factor through collaboration described in the literature is only obtained to a limited extent. The shippers and the transport providers seem to lack insight into each other's businesses, which hinders improvements in load factor from collaboration.

Keywords: Collaboration, Environment, Load factor, Transportation

INTRODUCTION

Sustainable road transport has been in the spotlight of attention in recent years, both in practice and in policy. From an environmental perspective, the focus has primarily been on setting and finding ways to obtain long-term environmental targets of emissions from freight transport. From an economic perspective, the focus has been to increase the transport efficiency to reduce costs. One key to sustainable road transport is the load factor (Kamakaté and Schipper, 2009). By improving the load factor, the environmental impact and transportation costs can be reduced.

The load factor depends on practices performed by shippers and transport providers. In a literature review, Santén and Rogersson (2014) found that shippers affect the load factor within warehousing, order and delivery, packaging management, and logistics structures (e.g. warehouse size and localisation, plant localisation and storage strategies). Transport providers affect the load factor mainly through transport planning (consolidation, backload management and route planning). The load factor is also affected by collaboration between the two types of actors, e.g. in terms of information sharing (e.g. load matching) and aligning production operations with transport operations.

The current literature provide some insights into the way companies consider the load factor in these areas. In a benchmarking study in the food supply chain in the UK, McKinnon and Ge (2004) found wide variations in vehicle utilisation, which partly were explained by variations in the operating performance of transportation. They concluded that applying the best practice of vehicle fill and empty running can improve the transport efficiency of low-performing companies, thus reducing the environmental impact and distribution costs. In another study Sanchez-Rodrigues et al. (2014) found that uncertainty in terms of delays, variable demand, poor information, delivery constraints and insufficient supply chain integration affected the load factor negatively. They concluded that to reduce the uncertainties, more collaboration and information sharing between shippers and transport providers are needed. In an environmental approach, a study by Colicchia et al. (2013) showed that packaging management practices are quite limited, particularly those related to the volume and weight efficiency of packaging.

This study aims to provide more insights into how shippers and transport providers work within these areas to improve the load factor, which is limited in current literature (Santén and Rogersson, 2014). This extends the current knowledge about the implementation level of practices affecting the load factor. It also provides an empirically-based problematisation of challenges of the less implemented factors. The purpose of this paper is to examine current practices of load factor utilisation of road transport. The research question is: To what extent and how do shippers and transport providers consider operational and strategic factors that affect the load factor?

METHOD

A literature review identifed factors affecting the load factor. To what extent and how these factors were considered in current practices were examined in a study of two large transport providers and five large shippers in transport-intensive industries in Sweden. Data were captured in two interviews at each company with the transport manager and the environmental manager, and from environmental reports of the companies. The transportation manager provided insights into operational and strategic practices related to the load factor. The load factor can also be viewed from an environmental perspective, in the sense that it affects the environmental performance of transportation. The environmental manager provided insights on the role of transport, particularly the load factor, in the environmental work of the companies. The environmental reports were reviewed to triangulate the information gained in the interviews. The companies included in the study are shown in Table 1.

Company	Industry	Turnover (mSEK)	Employees
Chemical company	Chemical	2 200	4 500
Food company	Food and drinks	4 800	1 500
Ore and metal company	Ore/metal	6 700	1 700
Pulp and paper company	Paper/forestry	20 000	4 300
Wholesaler company	Wholesale trade	6 500	4 300
Transport provider 1	Transport provider	40 000	39 000
Transport provider 2	Transport provider	26 000	20 000

Table 1: Companies interviewed in the study

Data collection and analysis strategy

The data were collected between October 2014 and December 2014. In total, 14 semi-structured interviews were conducted. They interviews were carried out over the telephone. Each interview took 45-60 minutes. They were recorded and transcribed. Prior to the interviews, a short summary of the questionnaire was sent to the respondent to facilitate preparation. The interviews were guided by the interview guide. The analysis strategy was inspired by coding in Strauss and Corbin (1998). The steps conducted were:

1. Read all interviews separately.
2. Based on the purpose and the literature review, a number of areas were determined.
3. Each interview was colour coded and carefully read. All sections that related to the areas in point 2 were marked according to area.
4. Sections of text related to the different areas from the different interviews where put together, keeping the colour coding to trace the source.
5. Each section was analysed and synthesised for shippers and transport providers.
6. For the discussion chapter, the synthesised text were combined with the other sources of information.

ANALYTICAL FRAMEWORK

Several factors can affect the load factor. It can be restricted by weight or volume. The volume can, in turn, be restricted by the size and design of packaging and load carriers. Furthermore, the load factor can be affected by delivery frequencies, warehouse localisation etc. To identify and structure potential practices of load factor utilisation, a framework summarising factors affecting the load factor was used which is based on a literature review where the factors are grouped in six areas (Santén and Rogersson, 2014) (Table 2).

Area	Factors	Actor
Transport planning	Consolidation, backhaul, route planning, vehicle selection, network design	Transport provider
Logistics structures	Warehouse size, warehouse centralisation, number of warehouses, location of warehouses, storage strategies.	Shipper, Transport provider
Packaging management	Load unit selection, packaging system	Shipper
External information sharing/collaboration (align production strategies and operations with transport operations)	Demand fluctuation, delivery frequency, time-window, order lead time, customer service agreement, application of JIT, load matching services, IT-based scheduling systems, computer-assisted loading	Shipper, Transport provider
Regulations	Coordinated distribution, time-windows, vehicle restrictions, load factor controls, limits on vehicle carrying capacity, regulations supporting consolidation	Transport provider

Table 2: Factors affecting the load factor (modified from Santén and Rogersson, 2014)

The factors in Table 2 are related to the transport providers, the shippers or both. The factors in the area of *transport planning* are mainly considerations for the transport provider; those in the packaging management area are mainly related to practices by the shipper. Warehouses can be controlled by either one of the actors. Thus, factors in the area of *logistics structures* are either related to the transport provider or the shipper. The two areas involving external collaboration include both actors, but in the area of *aligning production strategies and operations with transport operations* it is mainly the shippers that need to adjust their operations. For instance, the shipper may align ordering patterns and delivery frequencies with the transport provider's demand so that the transport provider can facilitate consolidation of goods between different shippers. A prerequisite for doing this is that the shipper receives information from the transport provider. The other area involving external collaboration is *information sharing* to obtain, for instance, load matching. In this area, it is the transport provider that needs information from the shipper in order to take action. The final area, *regulations*, affects mainly the transport operations and thus the transport provider.

FINDINGS

It should be noted that most of the respondents report that a major portion of their goods are transported in full truckloads (FTLs) and that only a small portion in less than truckloads (LTLs). However, there is room for improvement in FTL as well. As stated above the FTLs between terminals have a load factor of 80-85%, but if the load factor was 100% by weight, a mixed load of heavy and light goods could improve the volume load factor. Such issues are more complex and more strategic in nature than many other actions to increase the load factor in LTL shipments.

Load factor practices

In relation to the factors found in the analytical framework, the interviews revealed that:

- The factors related to transport planning are well applied by the transport providers, particularly factors of a technical character. A particular practice that improves the load factor that the transport providers have started to apply is double stacking of pallets. Either the floor can be raised so that new pallets can be put underneath or bars are used to obtain the same function. This means that 0.6 metres extra height, which equals 23% of the loading volume, can be utilised in the vehicles. The extent to which this is implemented was not stated.
- The shippers do not seem to work with factors related to warehousing and order and delivery to increase the load factor, but some mention factors related to order and delivery as constraints, for example, time-window and demand fluctuation.
- The transport providers use the factors related to information sharing and IT, but mainly within their own organisation.
- Packaging and loading are only considered to a limited extent.
- Regulations only seem to be regarded as limiting the load factor to some extent.

The load factor appears to have a high priority among transport providers, but a rather low priority among many of the shippers. For both the shippers and transport providers, the load factor is primarily regarded as being economically important, and secondarily as being environmentally important. Some examples follow. The chemical company tries to adjust the deliveries to obtain full vehicles according to weight. The food company and the wholesaler trade company stand out as they are the only shippers that actively work with packaging to increase pallet utilisation. They try to reduce the packaging volume and standardise packaging to increase the stackability on pallets. Unfortunately, the food company has many circular-shaped packages that add space on pallets, and open boxes with bottles that are difficult to stack due to fragile necks. A common problem is that the pallets are not stackable because of the characteristics of the goods. Another issue that can affect pallet efficiency is customer requests for packaging, request that are fulfilled by the food company. The wholesaler trade company points out that the load factor on pallets is highly dependent on the skills of the staff who fill the pallets in the distribution centres. The ore and metal company considers that they have done what is possible to optimise the load factor, which is limited by weight. Further improvements require regulatory changes regarding the weight in vehicles. The wholesaler trade company also stands out because it considers load factor in strategic planning and in purchasing due to the significant impact it has on the company’s business. A high load factor is key for the transport providers because it is the core of their business. The load factor is considered by transport provider 2 when the company designs its distribution networks, but it is unclear whether provider 2 follows up on it. The load factor is measured both in terms of weight and volume by the transport providers. However, the volume is measured in terms of floor area and number of pallet locations utilised, which means that the height is not considered.

Three general results to further increase load factor were identified in the interviews:

1. Actions to increase the load factor are often of a strategic nature, but managers on the strategic level appear do not appear to be aware of such detailed issues as the load factor.
2. When companies outsource transportation (i.e. use transport providers), the shippers usually pass on the challenges related to load factor, which means that few companies work to improve it with things likes order patterns, freight sizes, packaging, etc..

3. Factors that require interorganisational information sharing do not seem to be implemented due to a lack of visibility.

Empty running
All the companies in the study seem to have empty running due to unbalances in the flows. The shippers are aware that some of their flows generate empty running in the return shipment, either due to imbalances in the flows or to specially-designed vehicles, such as wood chip trailers. However, in general the shippers appear to have limited insight into the proportion of empty running. The responsibility for empty running is placed on the transport provider. For instance, the food company uses transport providers but has no insight into their empty running. Instead, the food company relies on marketing mechanisms and means that the transport price indicates if a transport is efficient or not, such as having an empty return transport.

As for the transport providers, transport provider 2 states that the average vehicle utilisation is 65-70% of the vehicle volume. Shipments from terminal to terminal, which represent the majority of the transportation, have a higher load factor (85-90%), but there are some empty transports due to imbalances. For example, transport provider 2 has a lot of assignments northwards in Sweden, but not as many southwards. They have been struggling to find solutions to these imbalances. A Norwegian example is salmon from northern Norway down to Italy, and fruit and empty roll containers on the return. However, there are still imbalances. For shipments to local production units, the load factor is generally lower. Another aspect is that transport providers do not always seem to have full control of their empty running. One reason is that many different hauliers are hired from point A to point B. After the assignment, the transport provider has no control over what the hauliers do. However, trailers and semi-trailers must be returned because they are owned by the transport provider, which also generates empty running.
A general result seems to be that there is a lack of visibility in each interface between different actors. This is emphasised by the shipper's limited insights into empty running at the transport provider, and the transport provider's limited insights into what the hauliers do before or after their assignment with the transport provider.

Collaboration between shippers and transport providers
Consolidating goods with competitors can be an opportunity for shippers, but it appears to be uncommon. The shippers do not seem to consolidate goods with other shippers. The food company and the ore and metal company have carried out minor trials without success. In the case of the latter, the trial was about 15 years ago. The main reasons for not consolidating with other shippers were problems related to planning in terms of coordinating customer orders and the unloading times at different customers. The ore and metal company also does not want to risk delays or destroyed packages because when containers are co-loaded they must be opened before reaching the final customer to split up goods. The wholesaler trade company stated that even though they do not consolidate goods with other shippers themselves, the transport provider does for the distribution part of their transport. However, there is no adjustment of delivery times or other transport parameters.

The collaboration between shippers and transport providers seems to be limited. The data sharing is of an operational character. For instance, it is quite common to have EDI solutions and to share detailed data regarding delivery address, weight, number of pallets, customer name and product data. However, it is unusual (non-existent in this sample) to share more strategic data, such as ordering patterns. Except for EDI solutions, none of the companies have reported that they have integrated IT solutions between shippers and transport providers. The core of the business models of transport providers is to consolidate goods. They typically receive orders from different shippers and try to match these as well as possible. They are constantly trying to make improvements. For instance, both transport providers have started to find synergies between different types of goods, such as letters, packages, light goods and pallets. These types were previously considered independently. Instead of having separate terminals, they now have combined goods and packaging terminals. A limitation for the transport providers is that the shippers do not want their goods stacked on the pallets, which limits the potential to increase the load factor. The transport providers also have a more active dialogue with the shippers regarding minor operational modifications. Transport provider 2 in the study has established partnerships with a few packaging suppliers to help develop more volume-efficient packaging. Based on this knowledge, transport provider 2 has together started to advise other shippers on packaging selection. This transport provider's aim is to further develop collaborative setups, but feels that there is a culture of being static rather than innovative, which takes time to change.

Collaboration between shippers and their customers

The shippers try to get their customers to increase the load factor to a minor extent, mainly by price mechanisms. Smaller consignments are charged at a higher price, but customer requests for deliveries are usually fulfilled. The food company also informs their customers when they have another delivery in the area. Regarding the transport providers, provider 1 discusses delivery issues, such as times of delivery and pick up, with those shippers that bring it up on their own. Transport provider 2 is more proactive. They have staff that with the shippers analyse the deliveries to achieve improvements. Provider 2 emphasises that the shippers should continuously work with the load factor on pallets including volume-efficient stacking, avoiding pyramid stacking, stacking as high as possible within height restrictions and working environment restrictions, and not starting on a new pallet until the previous one is finished. The pallet load factor is reflected in the shipping cost resulting in the shippers being rewarded if they do a good job of stacking.

DISCUSSION

Prioritising the load factor seems quite low when it comes to strategic decisions. On the other hand, the load factor is a key for transport providers to be profitable. Thus, they seem to work a lot with factors that have a direct impact on the load factor, such as number of pallets in the vehicle, but factors that have an indirect impact on the load factor, such as packaging design, ordering patterns and storage strategies, are less considered. Factors with an indirect impact are most important for goods that are sent as LTL. Such factors are relevant for FTL as well, but to a lower extent. For LTL, the indirect factors can facilitate the utilisation of the total capacity of a vehicle. FTL vehicles are already considered full, but here, the indirect factors can increase the loading capacity by, for instance, improving the volume efficiency of packaging.

These kinds of indirect factors often require interorganisational collaboration and strategic decisions. However, there seems to be limited collaboration and integration between shippers and transport providers regarding the load factor and the factors that affect it. In addition, the people making strategic decisions appear to be unaware of such detailed issues as a low load factor.

The load factor is a core consideration of transport providers' business models. In this study, the transport providers put considerable efforts into having as high a load factor as possible, but they mainly consider the shippers' demands as fixed. This means that there is little communication between transport providers and shippers about aligning transport shippers' demands with the transport providers' transport flows to improve the load factor.

When shippers outsource transportation they also seem to outsource the load factor challenges meaning that the shippers consider that the load factor is mainly a challenge for the transport providers. It may be difficult to argue against such a standpoint, given the structures and business models of shippers and transport providers. In broad terms, the transport providers' business models aim to consolidate shipments from different shippers, but not necessarily to minimise the volumes (or number of pallets) to be shipped by a shipper. Shippers, on the other hand, often outsource transportation to be able to focus on their core competence, such as developing and producing their products. More collaboration could also be an opportunity to even out some flow unbalances, but it should be noted that some unbalances are not possible to reduce due to uneven demand in different geographical areas.

There are, however, some examples that collaboration is practiced among the companies in the interviews, but the overall potential to improve the load factor through collaboration described in the literature has only been obtained to a limited extent. This is in line with the results of Sanchez-Rodrigues et al. (2014). The shippers and the transport providers seem to lack insight into each other's businesses, which hinders improvements in load factor from collaboration. The transport providers state that they carry out transportation in line with shippers' demands. The transport providers have not reported that they try to affect the shippers' ordering patterns, delivery frequencies, packaging, etc. The shippers, on the other hand, do not make changes in, for example, ordering patterns to increase the vehicle full rate because the transport providers do not inform them about the potential of such changes.

CONCLUSIONS AND IMPLICATIONS

Currently, transport providers seem to work efficiently with operational practices to improve the load factor, primarily from an economic perspective and secondarily from an environmental perspective. Having a high load factor is essential for the business model. The transport providers have started to work with, for instance, double stacking enabled through technical solutions. The shippers affect the load factor indirectly, but these factors are considered much less.

This research shows that the overall potential to improve the load factor through collaboration described in the literature is only obtained to a limited extent. The paper also discussed that factors with an indirect impact on the load factor, such as packaging management and ordering patterns, are often overlooked. The shippers and the transport providers seem to lack insight into each other's businesses, which hinders improvements in the load factor from collaboration. To obtain the unused potential of vehicle fill companies should improve strategic information sharing and communication.

To further improve the load factor, more collaboration between shippers and transport providers is needed. In that way, strategic considerations can be considered. More collaboration between different transport providers is also needed. There is a need for information transparency within companies. Thus, it would be possible to align and highlight constraints in the order and delivery process and within packaging management on the load factor. Finally, improved models for cost and benefit sharing are also needed to increase the load factor. This can be linked to Arvidsson et al. (2013) who found that many practices need to be adopted by the hauliers with an increased cost, but "most cost reductions have been fully passed onto the forwarder and much of that further to the shipper" (ibid. p. 124).

This paper extends the current knowledge of the implementation level of factors that affect the load factor. Particularly, it highlights the role of and implementation level of shippers' practices that affect the load factor. Future studies should examine the constraints and incentives of working with the indirect factors and develop cost and benefit sharing models. A limitation of this study is that the empirical data are from a limited amount of companies in Sweden, but with an international presence. To reduce the geographical factor, studies in other countries should be conducted.

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TRIAL OF UNATTENDED STORE SERVICE IN TEMPORARY HOUSING IN A DISASTER AREA

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ABSTRACT
We report on our trial to set up an unattended store service with a POS system with prepaid cards, designed for a use in a trusted community, in temporary housing at disaster area after the Great East Japan Earthquake and Tsunami on March 11th, 2011. As the location of temporary housing is decided presumably according to the availability of space in which a hundred small houses could be built, they are located far from town without easy access to shops and transport services in disaster area. Survivors living at such housing found it inconvenient for daily shopping. Mobile shop services are coming once or twice a week. Some could go and buy good at supermarket by car. Many cars and drivers have gone this time. Elderly women without driver's license are left.

We tried and solve this problem by setting up a self-service system with a prepaid card. We have been running the service more than two years and found some issues. The paper discusses the issues and findings.

INTRODUCTION
The Great East Japan Earthquake on March 11th, 2011 caused severe damage to the northern coast of the main island in Japan. 15821 people died, 2651 are missing and 4690 were injured (National Police Agency of Japan 2013). Three prefectures, Fukushima, Miyagi and Iwate were affected mainly. In Iwate Prefecture, while the population of the coast area of the prefecture was 1330147 as of 2010 (Statistics Bureau 2015), 4673 people died, 1145 are missing and 212 were injured by the disaster. Those survivors whose houses were swept away or damaged were accommodated in shelters for several months and then moved to temporary housing. By the end of July 2011, 10235 temporary houses as well as 3344 private and 1065 public flats and houses were provided to accommodate 36544 people.

The survivors are still coping with inconvenience in their daily life. As the location of temporary housing is decided presumably according to the availability of space in which a hundred small houses could be built, they are located far from town without easy access to shops and transport services in the disaster area. Mobile shop services are coming once or twice a week. Some could go and buy good at supermarket by car. Many cars and drivers were swept up by the tsunami, so that elderly women without driver's license were left.

We tried and solve this problem by providing unattended store service with a self-checkout system with a prepaid card, in temporary housing. The system has been in an experimental use in our university laboratory environment for many years. We brought the system in a temporary housing in the disaster area, Aka Mae, Miyako City with 74 flats in November 2012 and provided the service experimentally for a month. Afterwards, we had a strong plea from the residents and started the service again in September 2013. We have been running the service ever since. This paper reports on our trial to set up an unattended store service, designed for a use in such a trusted community as the one in temporary housing at the disaster area. We tried and helped them out with our trial store system and have found some issues. The paper discusses the issues and findings.

MOTIVATION FOR THE UNATTENDED STORE SERVICE

The original idea of our unattended store service came from those on country roads in Japan run by local farmers as shown in Figure 1. In such a store, there is a cash safe box and a customer would buy any of the vegetables and flowers with one a hundred-yen coin or two coins putting coins in the safe box. With this simple setting, one cannot expect any changes. Presumably this system works only in a community in which people trust each other.

Figure 1: Unattended service by a local farmer in Iwate Prefecture

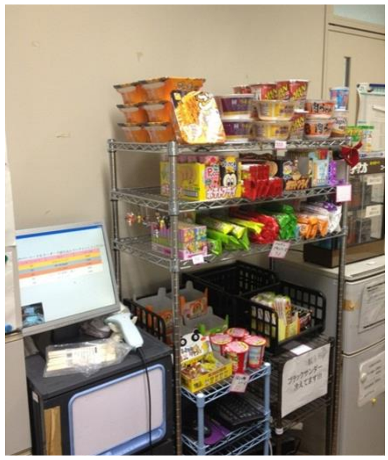

Figure 2: Unattended service in the students' room

We started our experimental unattended store service may years ago in Iwate Prefectural University as in Figure 2. We located our store in a student room with around 30 undergraduate students. Our university was founded in 1998 in Takizawa, Iwate. The university is located in a remote area far from town and we did not have easy access to shops. We have a campus store which closes at 7:00pm in the evening, while the students in Faculty of information and Software Science would stay much longer to use computers for their assignments. That is why the students started an experimental store service with a self-check-out system using student ID cards as the prepaid card.

Temporary houses are located far from town as well without any public transport. One could call a taxi but that would be expensive for daily life. Survivors in younger generations decided to live in the town for their convenience in terms of accessibility to work, shops and all that. Elderly people were left in temporary housing; most of them are women without cars. Mobile shop services are coming once or twice a week, but the residents needed a place to shop on a daily basis.

What we need to support shopping in temporary housing is as follows:
1. customers can buy items according to their urgent needs
2. the service is expected to be sustainable

For the 1 above could not be coped with by mobile shop services. Our service could fulfill 1 almost, because our shop in temporary housing is located in the common room which is open from 8:00am to 7:00pm and the head of community with a key to the room controls access to the room.

For 2 above, our solution was to provide unattended service so that one has not to attend the shop. It would have been ideal that we could have a shop attendant if we could have enough budgets to employ. However, unattended service worked well in a trusted community like this one with 74 households and less than 200 residents, in which everyone knows each other well and they do not expect anyone from outside the community so often.

A BASIC SELF-CHECK-OUT SYSTEM USED IN THE UNIVERSITY

Our self-check-out system is a client-server system as follows:

1. a *customer client system* used by customers to purchase goods
2. a *manager client system* used by managers to manage goods
3. a *main server system*
4. a *back-up server system*

The *customer client system* lets the customers check out by themselves. It is necessary for customers to ask the store manager to create an account with their university ID numbers and input some amount by paying in cash before they start using the self-check-out system. After that they can log onto the system using their university ID cards which are used as prepaid cards. Our university ID card has an individual ID number in bar code. The *customer client system* has a bar-code reader as an input device, so that the customer uses the bar-code reader to input the ID number. The customer's account information is shown on the display. Then, one can pick up an item form the store shelf and input the item's bar code using the bar-code reader.

The *customer client system* is communicating with the *main server system* to receive the customer's account information as well as to send back the purchase information. Accordingly the *main server system* updates information on inventory as well as customer accounts and keeps track of purchase transactions.

Through the *manager client system*, a manager creates customer accounts with user names and the associated ID numbers, increases the balance of accounts according to the cash payment from customers and inputs information on merchandise, such as the product's bar code and name, cost price, retail price, number of purchased products and their expiration dates. After the manager inputs such information on products, those items can be displayed on the shelves with price tags. The information is kept in the *main server system*. All the information on the *main server system* is copied periodically to the *back-up server system*.

Those client and server systems used in the university are interconnected through the intra-domain internet environment in a university student room. On the other hand, the system for use in temporary housing, we locate most of the systems in temporary housing but the *manager client system* which is used by the managers in our university. The main server system is connected to the manager client using a commercial internet service. Moreover, because in temporary housing, a customer has not such an ID card as in our university, we provide customers with prepaid cards of a specific amount of money, such as five-hundred-yen and one-thousand-yen cards. We shall explain the service model in the next section.

A MODEL FOR UNATTENDED STORE SERVICE IN TEMPORARY HOUSING

In the university environment, the managers make a purchase and perform inventory control by inputting the information on inventory onto the *main server system*, and finally display merchandise on shelves. On the other hand, in our service model in temporary housing, we have the managers in the university and the local manager in temporary housing with the following functions:

- the local manager
  - to sell the prepaid cards to customers
  - to display merchandise on shelves
- the managers in the university
  - to produce prepaid cards and send them to the local manager
  - to make a purchase and send it to the local manager
  - to perform inventory control by inputting the information to the system

We make a use of commercial transport service to send merchandise to the local manager from the university. The local manager sends us proceeds from sale of prepaid cards through bank transfer. The figure 3 shows the model of our service.

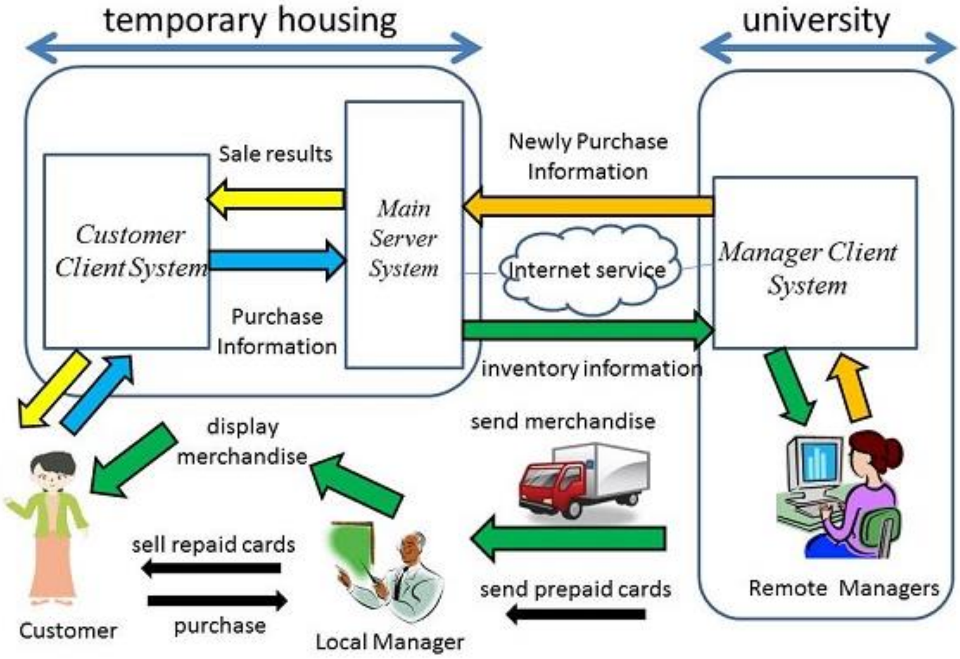

Figure 3: A Model of Unattended Store Service in Temporary Housing

OPERATIONAL RESULTS IN TEMPORARY HOUSING IN AKAMAE

When we decided to set up our service in the disaster area, we asked a social welfare council in Miyako City, one of the cities in the disaster area in Iwate Prefecture. Following their recommendation, we started our service in the temporary housing in Aka-Mae zone in the city. The place is located in the suburbs of the city. Our university is located inside the prefecture and it takes two and a half hours to visit AkaMae by car.

In the beginning, we ran the service using our basic check-out system used in the university, in which the managers in the university had no remote access to the main server in AkaMae. We operated only for a month in November 2012. Through the experimental use, the local manager recognized the usability of the store service. Following his request, we implemented a temporary housing version of the system with remote access by the managers in the university over the internet, and restarted the service in August 2013; we have been running the service ever since. Figure 4 shows the store in AkaMae.

We also provide a safety box for cash, since some elderly people would not like to use the check-out system with prepaid cards, but cash. However, it is difficult for us to keep track of inventory status remotely though the management client system when a customer shops with cash. Accordingly the local manager lets us know when they need to refill the goods.

In our model, it is important to have a reliable and trustworthy local manager who is dealing with inventory control and financial matters. The local manager in temporary housing in AkaMae is the head of the local residents’ community and helps us to a great extent.

Our store in the university is experimental and operated mainly for student customers. As we do not have any license to deal with perishable goods such as fresh vegetables, our selling goods include some confectionaries such as packets of chocolates and biscuits as well as instant foods such as cup noodles. On the other hand, in the temporary housing, we provided such confectionaries and instant foods as well as household goods such as toilet roles, tissue papers, washing liquids and so on. We also provided some seasoning such as soya source and ketchup and mayonnaise sources by request from the residents. We provide around 40 items and a dozen for each item. We need to send those items once fortnight. A monthly sale is around 50000 yen.

We used to visit AkaMae once a month to see the local manager and customers to hear the feedback directly. However it took so long to visit there, so that we tried and did most of the work remotely later. Nevertheless, we visit them once three months to keep in face-to-face contact with them.

Figure 4:Our Store in temporary housing in AkaMae, Miyako City

THE STORE SEVICE IN RECOVERY HOUSING IN KEROBE, KAMAISHI CITY

We started the second store service in disaster area on 28 Aptil 2014 in recovery housing at Kerobe, Kamaishi City, south of Miyako City in Iwate Prefecture. The place was newly built in January 2014 with thirteen flats. Recovery housing is built for the people from temporary housing to move in. When we opened the store in Kerobe, eleven flats were occupied mostly by elderly women. Including nearby houses, the number of households of this local community is one hundred. Before the opening, we visited them twice to present them how to use the check-out system. The residents near by recovery housing also came to see us.

The store service model in Kerobe is slightly different from the one in AkaMae in terms of merchandise delivery. In AkaMae, the managers in the university purchase goods and deliver them to the local manager in temporary housing. On the other hand, in Kerobe, the regional coordinator offered to act as the local manager who would purchase the goods locally and input the inventory information by himself. Therefore most of the store management is performed locally, whereas the managers in the university report on financial statistics such as total number of transactions, the ranking information on merchandize and the prepaid card balance information by request from the local manager.

In Kerobe, as the local manager offered to support the customers to use the check-out system using the prepaid cards, so that they did not need the safety box for cash. What has happened is that residents are happy with their own flat, they seldom come down to see the others in the common room in which the store is located. Recovery housing is more habitable compared to temporary housing, in terms of quality of building, residents stay in their own flats and would not get together so often in a common room as in temporary housing. Once a week on Monday when they have a health class, the residents get together and buy some goods at the store with the support from the local manager to use the prepaid cards. Otherwise, as they cannot use the prepaid card by themselves they would not shop at all.

COMPARISON OF AKAMAE AND KEROBE

Table 1 shows the comparison of two cases, viz. the store operational results from AkaMae and the one from Kerobe. In Kerobe, the frequency of shopping is only once a week. Moreover, the number of the customers is much smaller in Kerobe compared to the one in AkaMae. The sale in AkaMae results more in cash than in prepaid cards --- i.e. the average monthly sale is 39381 yen, which includes the sale with cash, 27581 yen. In the other words, about seventy percent of the sale in Akamae was made in cash. It shows that most of the customers are favour for a use of cash. Even in Kerobe, the customers cannot use the check-out system with prepaid cards, they only shop on Monday when the local manager helps them to shop with the prepaid cards. We will need some way to give any incentive for the customers to use prepaid cards as well as to modify the user interface of the check-out system.

item	***AkaMae***	***Kerobe***
Type of housing	Temporary housing	Recovery housing
Size of households	74	11
Store Service Availability	Daily 7:00am-7:00pm	Monday Morning
Observation Period	2 months 26/07/14-30/09/14	9 months 28/04/14-26/01/15
Average monthly sale (in cash)	39381(27581) yen	8700(0) yen

Table 1: Comparison of two cases, AkaMae and Kerobe

FINDINGS AND FUTURE WORK

Our trial has revealed interesting facts that the service has been successful in temporal housing in which people tend to get together in a common room in which the store is located. On the other hand, in recovery housing which is more habitable compared to temporary housing, in terms of quality of building, residents stay in their own flats and would not get together so often in a common room as in temporary housing.

We have had another issue that elderly people would not be willing to use prepaid card or any system oriented interface, however, once they saw young children such as their grandchildren using, they become more willing to learn how to use from them and started using the system.

We need a local manager for the unattended store service at disaster area. We presented two in which the local and remote managers' job functions are difference as follows:

1. in AkaMae, the remote managers purchase the goods and send them to the local manager
2. in Kerobe, the local manager purchase and most of the work can be dealt with locally

With the first model, it costs to transport the goods to the disaster area. We paid with our research project budget as well as from the university budget for disaster support. However, it would not sustainable in future. With the second model, the local manager has to deal with many things and would not be practical when we have more stores in the region. We may well need the third model to collaborate with the local retailers so that the service could be sustainable.

Our store service could be used as a storage for emergency in which the goods are renewed often enough to keep the goods fresh all the time.

Another application is to use the store service in a shelter at emergency response to distribute foods to the victims. Prepaid cards could be passed to the people who comes into the shelter and used as a card with the distribution records.

RELATED WORK

Unattended store service for fresh products from the farm was the original motivation of our project. A farm store in larger scale in which several producers can get together and provide their products is available throughout Japan. In such a store, producers need to make management decisions on products' prices, shipping volume and shipping schedule. Hanzawa et al. (Hanzawa at al. 2007) implemented a Farm-Planning Management Support System to let the producers know of the sales information from the POS system as well as to let the consumers know of the products. Takeno et al.(Takeno et al. 2009) proposed an information system to provide more analytic information to the producers.

Wagon retailer provides another way for shopping support with a car to bring merchandise to the customers' residences (Akasaka et al 2012). The professional retailers can deal with perishable goods. On the other hand, the space is limited to carry the goods. Moreover a customer can expect the service only at specific occasions.

Delivery services are provided by super markets or retailers on the network. In our case in the disaster area, most residents in temporary housing and recovery housing are not quite familiar with systems and have no experience of internet access. One may act as an agent for the residents to use those services to order the required items.

Jillson(Jillson 2009) points the problem at emergency response that essential goods are not defined. It would be difficult as the emergency could be caused by various factors and each situation would require different kinds of items. The author also raises the ethical problem on the fair distribution of resources and supplies. It is also a problem how one can research the needs and provide them in a fair manner.

Supply chain management is concerned with the management of logistics from suppliers to customers (Cooper et al. 1993) and one of the important strategies for current logistics industry (Mentzer et al. ,2011). On the other hand, supply chain could be influenced by disaster (Wagner et al. 2010).Hale et al. (Hale et al. 2005) dealt with supply chain incorporating disaster response and Lamelenn et al. (Lamlenn et al. 2011) researched on relied supply chains based on humanitarian support.

CONCLUSIONS

We report our trial service of unattended store service for a support for shopping in the disaster area in Iwate Prefecture, Northern Japan, which was hit by tsunami in 2011. We have provided the victims with unattended store service in temporary housing in AkaMae and recovery housing in Kerobe. We support two places with the difference support models. In AkaMae, we purchase the goods and send them to the local manager in temporary housing, whereas in Karobe, the local manager purchases the requested goods and control inventory and all that. In the latter case, we at the university only have to support systems and provide the local manager with some reports on statistics by request. In future, we need to collaborate with local retailers to make the service sustainable.

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OFFSHORING AND BACKSHORING IN THE BRITISH FASHION AND APPAREL INDUSTRY: A LITERATURE REVIEW

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ABSTRACT
For decades, manufacturing has been offshored from high- to low-cost locations. However, there is now evidence of backshoring to some advanced economies (Kinkel, 2012). Yet, both phenomena are not well understood. The aim of this paper is to investigate how the literature explains the mechanisms of development and restructuring of production networks, and provides reasoning for alternative locations of its parts, including possible causes of backshoring. The example of the British fashion and apparel industry is chosen. The paper is concerned with the issues of agility and leanness (Christopher et al., 2004; Bruce et al., 2004) typical of this industry as well as related locational decision making including the reasoning given for backshoring. This research reviews academic and practitioner literature on offshoring, outsourcing, FDI and related subjects, for the fashion and apparel industry.

INTRODUCTION
Backshoring has become a popular topic in recent years (Economist, 2013). It is argued that the backshoring of previously offshored manufacturing capacities is quite common (Kinkel, 2012). However, in the US, where the manifestation of backshoring is strongest (Gray et al., 2013) there is evident ambiguity in relation to the degree of, and reasons for, 'manufacturing returning home'. The Boston consultancy report (Sirkin et al., 2011) advocates support for what it sees as a strong reshoring trend, whereas others see reshoring as a part of a cycle rather than a structural change (Nager and Atkinson, 2015). This ambiguity is mirrored in Europe with consultants in Britain (Wilkinson et al., 2015) expressing clear hopes for an increase in manufacturing jobs and European analysts doubting whether Europe really follows the reshoring trend (Heymann and Vetter, 2013). Reshoring needs to be examined in the context of a prior offshoring decision (Gray et al., 2013). There are several reasons which underpin offshoring in the first place (Jahns et al., 2006), including wage and operator costs differentials between developed and developing countries (Gibbon, 2002), the liberalisation of global trade, and radical improvements in communication systems. However, offshoring increases the costs associated with management time consumed in the acquisition and monitoring processes, in rework and the costs of lost sales, in transportation delays (Popp, 2006) and in monitoring ethical trade practices and standards. Costs of shipping are also increased, together with delays and stockholding costs due to slow import/export procedures, the need to consolidate full container loads, the documentation necessary for multinational transactions and customs clearance procedures (Christopher *et al.*,2004). Solutions, such as 'model stock replenishment', which are designed to reduce supply chain inventory (Eroglu and Hofer, 2011), increase flexibility and responsiveness, reduce lead times and stock-outs, thereby increasing customer loyalty (Davis-Sramek et al., 2008) often fail at a distance (Gibbon, 2002).

The comparative advantage of offshoring to South-East Asia, especially to some parts of China has been waning, as the cost of labour there has risen (Kinkel, 2012). Offshoring to the less developed countries has other hidden costs arising from lower levels of skills and poor management infrastructures (Holweg et al., 2011). Other industry-specific trends such as the emergence of fast fashion and its requirement for speed to market, the shortening of seasons, new trends in customers' interest in products 'Made in the UK' especially from countries where notions of Britishness are aspirational (Petah, 2012), as well as concerns about risk management and quality control issues across stretched supply chains (SCs) and increasing concerns from consumers about the lack of ethical practices and environmental controls in some parts of the developing world are all contributing to a view that some aspects of the fashion manufacturing could return to the UK (Livesey and Thompson, 2013) in the process termed ‘backshoring’ or ‘reshoring’.

It is timely to ask whether and if so, why and how, the reshoring of apparel manufacturing is happening in the UK and whether the process is happening on a significant scale. This paper takes the first step in answering this question by analysing the literature on offshoring and reshoring.

DEFINITIONS

Definitions of both off- and backshoring contain references to two important dimensions of business: location and ownership/control. Offshoring is defined as the transnational relocation or dispersion of activities. The term also refers to different control situations, ranging from international sourcing and purchasing to the operation of wholly owned offshore re-export platforms (Mudambi and Venzin, 2010). Backshoring activities can be categorised using the same dimensions, as they are also location and make-or-buy decisions on the part of companies (Kinkel, 2012). Production relocation, as the move of a manufacturing process from one place to another, can be defined in terms of spatial and ownership boundaries (Kinkel, 2012). When making locational choices there is an associated decision about whether to internalize the offshore activity through various types of FDI or to outsource it (Gray et al., 2013). The control strategy can be further disaggregated into the various entry modes, which may influence the levels of embededness or, conversely, the footlessness of companies and affect their willingness to relocate and the ease with which they can do so. Entry modes are classified according to the share of equity taken by the foreign investor and are joint ventures or wholly owned subsidiaries. Non-equity entries include contractual agreements and exports (Schwens et al., 2011). Equity based market entries imply less flexibility for the firms. When entering foreign markets with a challenging institutional context, they may best safeguard their strategically important international activities by market entries that are not equity based. Flexible and dynamic behaviours are then maintained. The positive relationship between the choice of equity based entry modes weakens when informal institutional distance and formal institutional risk are high (Schwens et al., 2011).

Entry mode is influenced by the firm’s characteristics and capacities. For example, the level of a firm’s <u>proprietary know-how</u> can be a determinant of foreign market entry strategy. A company can protect its specific knowledge in foreign uncertain and risky contexts to minimize transaction costs by integrating foreign operations and selecting equity based entry modes as a control mechanism (Schwens et al., 2011). An <u>industry’s technological level</u> influences a firm’s entry mode decision. The majority of software firms, for example, choose to carry out their sales transactions through either direct exports or through agents and distributors; few firms engaged in FDI, and when this did occur, they were preoccupied with setting up marketing and sales subsidiaries (Burgel and Murray, 2000). For <u>family enterprises</u> it is important to have full market control and to preserve independence; they are less willing to share control and prefer to establish a wholly owned subsidiary or to choose non-equity based entry modes (Schwens et al., 2011). Firms with <u>international experience</u> prefer equity based entry modes (Schwens et al., 2011). International experience of off-/reshoring influences the level of firms’ spatial mobility (Kinkel, 2012). Some firms by the nature of their product, business model and their innovative organizational structure are more prone to internalize than others: they seek to gain competitive advantage from the use of resources and sales in multiple countries by establishing a controlling position in a network or by using hybrid arrangements involving subcontractors and intermediate sellers (Burgel and Murray, 2000). Changes in ownership can be differentiated according to whether production capacities are transferred to, or from, locations within their own company (internal or captive mode) or whether they are transferred to, or from, external suppliers (external or out-/in-sourcing mode). Relocation of production capacities can be defined as the relocation to, or from, own locations abroad (captive backshoring) as well as to, or from, foreign suppliers (offshore outsourcing or offshore insourcing). Backshoring covers all transfers of production capacities from foreign countries back to the home country's manufacturing firms (Kinkel, 2012).

Off-/backshoring decisions are not static. Since firms aim to maximize the value they create for their stakeholders, they need to adapt their location and control strategies as change occurs in the market landscape and in the firm's conditions. Location decisions are made considering firm level dynamics and external dynamics stemming from the competitive environment (Mudambi and Venzin, 2010). When choosing locational strategy firms have to consider the interplay of the various factors. First, their own business strategy and capabilities are important when making relocation (Macchion et al., 2015). Second, the conditions in the country of origin can 'push' the company away or 'pull' it back. Third, the conditions in the countries of destination can attract or be an obstacle and risk. All three sets of factors vary for companies of a different size, industry and activity/product specialisation, country of origin. Moreover, the practice of decision making is such that two companies of very similar profile can take opposite decisions.

Research on company-related obstacles for internalisation is important for understanding off-/backshoring dynamics: factors, which prevent a company from internalising can be the same as those which force it to withdraw from international operations. Lack of know-how, capacity and competent personnel for cross-border management, a low level of capital accumulation and the absence of experience in knowing how to overcome bureaucratic hurdles are acknowledged barriers (Kinkel, 2012; Gray et al., 2013). The relocation or creation of additional capacity abroad can entail the risk of misjudgements and wrong decisions. Inexperienced firms can run into problems with their involvements abroad, which drain away their international investments (sunk costs) and can lead to the termination of the internationalisation. This can be termed divestment of foreign production locations leading to closure of foreign units (Kinkel, 2012).

Specific factors, which affect location choices are tax rates, tariffs, wage rates, energy costs and currency changes. Some of these relate to changes in the levels of different types of risk (quality risk, disruption risk, currency risk, intellectual property risk) and some to network externalities. Some reflect the difficulties of foreign operations due to the differences between locations in culture and/or language (Gray et al., 2013). 'Pushing off' factors relate to unfavourable conditions in the home country, such as high labour costs, strong trade unions, absence of government support, strong environmental and labour regulations (Lane and Probert, 2009). The attraction of foreign countries is from favourable conditions of low labour costs, access to new markets, proximity to key customers, access to new knowledge, no trade unions, government support, subsidies, tax incentives; weak environmental and labour regulations (Gray et al., 2013).

THEORIES

There are three theories most used in explanations of the locational and control choices of firms (Ellram et al., 2013). They are:

<u>Transaction Cost Economics (TCE)</u>, which focuses on the make-or-buy decision and attempts to balance the costs of transactions and specific asset investments with the potential risk of buying the item rather than making it (Williamson, 2008). TCE suggests that individual firms will tend to move away from higher cost to lower cost regions, all else being equal. In addition, areas with greater cultural differences or limited intellectual property protection may create a high potential for opportunism and will also be less attractive (McIvor, 2013; Ellram et al., 2013). TCE predicts that the degree of vertical and spatial integration tends to rise with higher uncertainty of economic activity (Williamson, 1985). Empirical studies of relocation behavior have shown that uncertainty has a negative impact on the probability of relocation. TCE is often used when explaining

firms' entry mode choices (Schwens et al., 2011). Transaction costs have significant firm-level and industry-level components. The former gives rise to differences among firms within a single industry in terms of the control of activities that underlie the firms' value propositions. The latter drive firms in one industry to differ in terms of organization from those in another industry (Mudambi and Venzin, 2010).

New Institutional Theory (NIT), which focuses on social actors embedded in the institutional environment, which provide the rules of the game in a society (North, 1993) and control economic activities and resources. NIE has been frequently applied to study entry mode behaviour (Schwens et al., 2011) and is useful for understanding reasons underlying reshoring. NIE distinguishes between informal and formal institutions. The former relate to issues of trust, collaboration, identity, and subordination and include socially sanctioned codes of conduct and norms of behavior, which are embedded in culture and ideology. The latter are manifested in political rules, legal decisions, and economic issues. They determine the nature of private property rights, access to finance, the development of skills and knowledge, and labour relations. Both types of institutions influence modes of entry. Informal institutions are the core in understanding the 'distance' (Ghemawat, 2011) between home and host country (Schwens et al., 2011). It is commonly acknowledged that large informal institutional distance increases the challenges of doing business in the host country, increases costs and risks of doing business and make it more difficult to transfer the management models and adapt to local practices and preferences (Schwens et al., 2011). Strong established formal institutions provide support for efficient business transactions, whereas weak ones may cause restrictions and constraints. For example, when property rights are not granted, repatriations of earnings are not ensured, and business rules are variable, the formal institutional set-up implies high risk and hinders a firm's economic acting. The higher the formal institutional risk of the host country, the more the firm is challenged to adapt its business to insufficiently functioning political, legal, or economic institutions (Schwens et al., 2011).

Dunning's *Eclectic Paradigm (EP)*, which combines issues of ownership, location and internationalisation advantages (Dunning, 1988, 1998). The choice of a firm to internalize its product markets is determined by the costs and benefits of adding value to these products in the new locations. When making the decision about relocation, firms consider a combination of possible advantages: resource seeking, market seeking, efficiency seeking, strategic asset seeking. Recently there was a move away from resource seeking, primarily cost advantage toward strategic asset seeking, or more complementarity of assets and activities (Cantwell, 2009). This includes greater interest in knowledge creation and value creation and capture (Gereffi and Lee, 2012). However, there are reasons to believe that the location decision is both about controlling costs and leveraging capabilities (Mudambi, 2008; Ellram et al., 2013).

SUPPLY CHAIN THEORY

SC theory conceptualises production as a series of interlinked stages. It emphasises that an increased use of outsourcing creates an increased reliance of the company on suppliers and other SC partners; thereby competition is characterised not so much as between companies but between SCs (Christopher, 2000). Maximising the performance of the SC as a whole requires that all the stages of the SC are managed as an integrated whole, which in turn requires establishing and maintaining close working relationships between all parties involved in order to realise benefits from lower transaction costs, increased efficiency, improved responsiveness and higher quality (Cao and Zhang, 2011). The business management literature introduced the concepts of 'lean' (Womack and Jones, 1996) and 'agile' (Christopher, 2000) SCs, which in some combination (Naylor et al., 1999) may improve the link between retailer and manufacturer and increase efficiency of the SC. Lean aims to eliminate the 'waste' of inventory by enabling production to take place synchronously so that products are made and delivered 'just in time' to meet demand as it arises at each stage of the SC (Lamming, 1996). A lean SC operates in concert as an integrated whole, and is able to meet customer demand more speedily and with greater efficiency than if it acts as a series of separate more loosely coupled stages buffered by inventory. Agile aims to construct a SC that is able to respond speedily and flexibly to market volatility. An agile SC is market sensitive, information-driven, flexible in its make-up and highly integrated. In such an operating environment, the choice of SC partner is of vital importance (Wu and Barnes, 2012).

At the same time supply interruption risk becomes crucial as interruptions can increase costs and decrease revenue, thereby reducing the firm's profit. The negative risk of SC interruption associated with the movement of manufacturing to numerous regions indicates that this is becoming a differentiating factor (Ellram et al., 2013). The demands of 'leanness' and 'agility' exert specific and often contradictory constraints on locational choices of companies involved. In general it is true to say that the closer companies in the SC locate to each other the easier it is to maintain flexibility, trust and control (Popp, 2006). This contradicts other locational factors, cheap labour supply in particular, which is the main reason for 'off-shoring' of manufacturing.

THE FASHION AND APPARE INDUSTRY

Fashion is one of the UK's most successful industries, with 8% of GDP (£21bn) and over 800,000 employees (BFC, 2012). It enhances the country's image and boosts economic growth via exports and on-line sales as well as through direct sales to visitors. The UK has world leading capabilities in both fashion design and retailing but not in domestic apparel manufacturing, which makes little contribution to industry success. UK apparel manufacturing has been in 'catastrophic' decline over the last two decades, with garments being increasingly sourced from overseas (Jones and Hayes, 2004). In 2003/04, 40% of UK manufacturing companies offshored (Dachs et al., 2006). It is predominantly larger companies whose sales depend heavily on old products and who have only slight improvement potential in their production process, which tend to offshore parts of their production (Dachs et al., 2006). The most obvious consequences of offshoring were a loss of manufacturing jobs in some of the UK's most deprived areas, once the heartlands of the industry (Taplin and Winterton, 2004). The mass exodus of apparel manufacturing to countries with cheaper labour has led to a significant gap in apparel manufacturing capability in the UK. The apparel industry has become globalised and fragmented leading to managerial discontinuities and knowledge gaps between designers, retailers and manufacturers.This has resulted in in a vulnerability of the UK's fashion industry to competition from companies and countries that have more consolidated production chains with more effective and efficient linkages between participating parties (Karra, 2008).

Fashion is a cultural good, with products bought as much for their symbolic or associative power as their functionality. New ranges need to be replaced or updated several times a year. 'Fast fashion' companies such as Zara, have up to twenty 'seasons' in a year. Demand is unpredictable, with small numbers of 'winning' products and a long tail of also-rans. Products are driven by fast changing trends and have to be created, manufactured and delivered on the basis of 'real time' demand from customers (Bhardwaj and Fairhurst, 2010). There is a complex mixture of product types, from basics without symbolic meaning to highly trend-driven items, and a mixture of short versus long shelf life garments. The fashion industry is characterised by short product lifecycle, high volatility, low predictability, and high impulse purchase (Fernie and Sparks, 1998), which requires highly flexible relationships in the SC. Lean and agile SCs are seen as crucial for fashion industry's success (Christopher et al., 2004; Bruce et al., 2004).

Fashion industry SCs are buyer-driven (Gereffi, 1994, 1999) and non-linear as the industry has a complex 'triangular' relationship between the retailer/merchandiser, the manufacturer and the designer (Lane and Probert, 2006, 2009). It contains a complex mixture of company types, including own-brand retailers, who design and manufacture to their own quality and brand specifications, and retailers who sell other designers' branded (or in some cases unbranded) clothes. Some own-brand retailers self-manufacture and some buy in from other manufacturers. Some manufacturers may supply more than one retail or design company. Some manufacturers 'upgrade' by employing a designer and trying to establish their own brands becoming so called 'designer manufacturers' (Evans and Smith, 2006). In majority of cases fashion designer brands and major label retailers hold the power over the SC (Reimer, 2009) and it is they who make decisions on sub-contracting, off- or re-shoring, acquisitions, capital investments, etc. Within Europe, the UK has the largest proportion of large companies in the clothing industry (Dunford, 2002). Companies like M&S and Asda hold considerable market share and dominate the scene in terms of locational decisions. This power relates to the ability of these companies to collect higher rents and access the 'resources' most important in the fashion industry: product design, new technologies, brand names and consumer demand. The literature also suggests that the manufacturing stage of the SC in fashion industry is also complex and non-monolithic. There are a number of established intermediaries between retailers and designer houses on the one hand and actual production factories - on the other, such as clothing importers, converters and trading houses (Gibbon, 2002). These agents hold good overseas market intelligence and are prepared to function as stockholders and source from suppliers, located at different distances: low cost countries, 'Greater Europe' or UK's factory in order to satisfy the fluctuation in demand. Some former British manufacturers serve as `brokers' between retailers and trading/buying houses, on the one hand, and cut-make-trim production units on the other (Evans and Smith, 2006). These production units can be located anywhere in the country or abroad and they can range from large factories to SMEs and individuals working from home. Changing fashion trends, short product lifecycles, fierce competition from low labour-cost countries, and the growth of emerging markets have distorted the industry's traditional business models (Abecassis-Moedas, 2006). The adoption of worldwide production and supply networks has been the companies' practical response to their newly changed needs. From a retailing perspective there are differences in the types of supply network implemented by diverse clothing retailers and there is a strong significant association between the type of retailer and the type of supply network (MacCarthy and Jayarathne, 2013). Thus, the search for low-cost production and the subsequent transfer of activities to other areas of the world have redrawn the boundaries of the existing fashion industrial districts and their supply and production networks (Macchion et al., 2015).

When offshore manufacturing is chosen the companies monitor and control quality and design specifications of the products and timing of supply operations via feedbacks from local entrepreneurs and/or via establishing their offices abroad and/or via sending their representatives there on a regular basis. Literature suggests that not only separation of retail headquarters but also designers from manufacturing can be damaging for the industry (Kincade et al., 2007). Product designs that take no account of manufacturing constraints risk higher production costs, lower production quality and longer times to market (Da Silveira, 2011). Negotiation of these constraints and specificities of designs can be made more difficult because of personal, cultural, language, physical and organizational differences (Vandevelde and Van Dierdonck, 2003). To overcome these difficulties designers and manufacturers have to work closely together, often being physically co-located (Swink et al., 1996). Complexity in fashion production chains creates higher negotiation and coordination costs in comparison with other industries. As Christopher *et al.* (2004) suggest once the transaction costs are factored in, sourcing based on manufacturing costs alone becomes far less attractive. Transaction costs can be reduced if the cooperating parties, move to co-managed inventory systems (Eroglu and Hofer, 2011). Such networks of small producers, the membership of which changes according to requirements are 'orchestrated' by large leading companies (Economist, 2011; Purvis et al., 2014, 2013). These companies align their systems and processes carefully with their suppliers. The UK fashion industry could concentrate on quick response methods such as flexible delivery through domestic sourcing, reduced levels of stock within the SC and increased net margins (Bruce *et al.*, 2004).

The fashion and apparel industry is considered to be a candidate for reshoring (Wilkinson et al., 2015). High-end brands that can capitalise on the 'Made in Britain' image have 'a good reason' to relocate manufacturing to Britain. For those at the lower end, where cost reduction is the main driver of profits, reshoring is unlikely. Supporting evidence however remains anecdotal. Apparently Jaeger intends to bring 5-10% of its production back to the UK from Asia (Wilkinson et al., 2015). Other large British retailers, such as George at Asda, Marks and Spencer and John Lewis are also reconsidering their outsourcing networks and increasing the share of orders allocated to domestic apparel manufacturers (Petah, 2012). British retailers see re-shoring of production as a means to meeting the rapidly increasing demand for shoppers for up-to-the-minute fashion as onshore manufacturing allows for shorter lead times and provides retailers with greater flexibility in repeat runs and short orders, especially retail brands, that need to translate styles from the catwalk to the shop floor quickly. The UK is also becoming more attractive to them due to its higher quality of production, simpler transport connections and better communication with suppliers (Petah, 2012). British labour has also become more flexible and prepared to work longer hours and night shifts (Economist, 2013).

There are barriers for successful backshoring in the UK, such as a limited capacity and difficulties in recruiting and training new staff (Petah, 2012). Multinationals may decide to base their operations in Poland, or Estonia, where workforces are well-educated, hard–working and cheap, and where products can be transported cheaply to UK stores within hours. This would be near–shoring, rather than on-shoring to the UK itself (Heath, 2013). There is also a strong competition from the fashion industry in mainland Europe, Germany, Italy and France in particular (Lane and Probert, 2004, 2006, 2009). There are further considerations of land prices, tax, labour regulations and bank lending.

CONCLUSIONS

The processes of backshoring and manufacturing renaissance can be triggered by strong productivity growth, innovation in new products, and the ability, cost-efficiently, to produce short production runs (Nager and Atkinson, 2015). It is important to identify the sectors of the fashion and apparel industry, which can develop these characteristics. The fashion and apparel industry in the UK is dominated by large branded retailers with fewer companies, which can be classified as 'fast fashion' or 'luxury brands', both of which despite very different business models and sources of competitive advantage, have potential to backshore some manufacturing activities. Only a few of the dominant industry players in Britain were researched from the point of view of their locational and control strategies (but see for Burberry: Moore and Birtwistle, 2004; McColl and Moore, 2011). Attention should also be paid to the large number of smaller players, which successfully internalise but have different control and locational strategies all together, one of which is a high proportion of FDI (from e.g. Japan, Italy, etc.) into their companies. Another issue which influences a firm's locational strategies is the increasing upgrading of the apparel industry in developing countries toward design activities (Frederick and Gereffi, 2011; Fernandez-Stark et al., 2011). These issues will inform the agendas for the future research.

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MOVING TOWARDS INTEGRATED SOLUTIONS IN LOGISTICS SYSTEMS – EMPIRICAL EVIDENCE ACROSS SERVICE SUPPLY CHAINS

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ABSTRACT
The purpose of this paper is two-fold. First, it aims to contribute to the continuing discussion about systems integrators and solution providers. Second, it aims to explore transaction cost related constructs in the domain of service provision in order to understand outsourcing and organisational boundary decisions within the context of the logistics industry. The research builds on and is inspired by the recent shift in operations and industrial marketing management from providing sole products and services to providing a bundle of services and solutions. Therefore, a multiple case study design was adopted in order to develop knowledge and build on existing theory in operations management.

INTRODUCTION
Academic literature on outsourcing is extensive, including numerous studies that reveal the drivers, benefits, challenges, and risks for organisations that are linked to the practices of outsourcing of any process or function (Lonsdale, 1999; Lonsdale and Cox, 2000; Kremic et al., 2006). Research in the area of outsourcing mostly focuses on the selection process and the evaluation criteria of outsourcing partners from a focal firm's perspective. Conventional economic theories that explain outsourcing in the strategic management literature address questions and issues such as whether or not a firm should outsource in the first place, which function is the most appropriate to source externally from third parties or suppliers, and how the resulting relationships and contracts should be governed.

The starting point for the contribution of this paper is to differentiate, based on literature, between conventional outsourcing practices and that of the integration of systems (a systems integrator approach). Both streams of literature propose theoretical assumptions that explain the existence of providers for outsourced services and contractual outsourcing relationships. Determining the right governance form for logistics activities became crucial and these arrangements with service providers are an attempt of the focal firm to exploit and lever the development of logistics capabilities (Halldorsson et al., 2007). The consideration of both literature streams is a key element developing an a priori model that distinguishes three different categories of logistics services. First, s*tandard logistics activities* that are conventionally outsourced in a dyadic relationship and sourced as a simple market transaction; second, *highly integrated activities* that are sourced internally or through a close relationship with a service provider of such systems in a hierarchical form; third, *continuous adaptation of logistics systems* is enabled through the use of a systems integrator that exceeds the hierarchical integration, considering the environmental and behavioural uncertainty and changes of customers and the market itself. The explanatory nature of this paper is grounded in economic theories such as the resource-based view (RBV) of the firm, the theory of transaction cost economics (TCE), and builds on a systems integrators approach.

The management of logistics outsourcing lacks of a universal theory that explains the role and positioning of service providers, hence this paper aims to fill this gap by developing of theory-based model that helps understanding the governance of service provision. The unit of analysis therefore is the service provider firm that offers specific logistics transactions to their customers. Empirically, this paper uses case studies of different service provider firms and as the primary source of data in order to illustrate the adaptation and governance form of logistics outsourcing relationships. In order to meet this paper's purpose of (1) identifying theoretical perspectives of outsourcing relationships and (2) explaining the governance forms in for service provision, the following two research questions are raised:

- *RQ 1: How do economic theories explain outsourced service relationships?*
- *RQ 2: How do provider firms govern different levels of service provision?*

OUTSOURCING AND THE BUSINESS OF SYSTEMS INTEGRATOIN

Recently, the development of third party logistics (3PL) providers has received increasing attention amongst practitioners and scholars as a result of continuing academic debate about outsourcing practices (Holcomb and Hitt, 2007). Contractual relationships and interactions between multiple parties increase the complexity and risk of the supply network from a focal firm's perspective. Following the high water mark of outsourcing in the 1980s and 1990s, there is now a trend for firms to again consider re-integrating previously outsourced operations and services due to a loss of control and profitability. To date there is no universal model that explains the choice between a conventional logistics service provider and an integrator of these systems (a systems integrator approach). Systems integration as a core capability for instance is discussed and outlined by Prencipe et al. (2003), Davies (2003), and Hobday et al. (2005).

Given the fact that the practices of outsourcing logistics and supply chain related activities, such as transportation, distribution, warehousing, material handling or packaging, and demand and supply planning, became more and more common amongst manufacturers and producers, the market for third party logistics (3PL) provider grew significantly. In these markets, the logistics activities themselves became a core competence and provider of logistics services offer a wide range of both standardised and customised products and services. Today, the landscape of service provider is large and they distinguish not only in the scope and scale of their provided services but also in their ability to adapt to customer requirements and environmental uncertainty. The logistics market volume in terms of revenue reached over 900 bn. Euros in 2010, with logistics contracts being the biggest segment (381 bn. Euros) (Klaus et al., 2012). Over the next few years, logistics has room for development in strategic relationship building, which will improve the quality of services, offered to the final customer. Langley and Capgemini (2014) highlight the growing importance of logistics outsourcing and the challenges for 3PL providers to cope with the changing requirements of retailers and manufacturers in terms of sourcing strategies and geographical reach.

Explaining outsourcing with conventional economic theories

Prescriptions for outsourcing services usually derive from economic theories (Holcomb and Hitt, 2007), such as the resource-based view (RBV) (Wernerfelt, 1984; Barney, 1991), transaction cost economics (TCE), (Williamson, 1975; Williamson, 1985) and agency theory (AT) (Mitnick, 1973; Ross, 1973). The integration of systems can be explained by applying a systems theoretical approach and following a more holistic view. These conventional outsourcing theories explore the use of 3PL providers in order to achieve a competitive advantage from a focal firm's perspective. When, what and how to outsource are the main questions that are considered. On the other hand, a systems approach explores the integration of activities and elements amongst different partners and the environment in order to understand the relationships and interactions within a system. Multiple objects and elements are considered, and the impact of behavioural changes on the whole network is the main focus.

Literature on the outsourcing of organisations' logistics systems lacks of theoretical frameworks (Bolumole et al., 2007) and little attention has been placed on the strategic importance on formulating and evaluating outsourcing decisions (Mello et al., 2008). Therefore, this paper focuses on the different governance choices, from contractual market transaction, to integrated third party relationships or institutional alliances, to hierarchy or full internalisation. Madhok and Tallman (1998) argue that vertical relationships with service providers provide collaboration-specific rents, where both parties must adapt their outputs and inputs. In order to maximise the perceived performance, logistics capabilities and resources must be strategically adapted as a core competence (Olavarrieta and Ellinger, 1997) as explained by the RBV of the firm. TCE theory proposes that integrated governance form such as in an institutional hierarchy and a collaborative integration with a third party are more appropriate when transaction specific investments and the environmental uncertainty increase.

How can logistics activities be seen as a system?

Opposed to the outsourcing trend and the use of third parties, Prencipe et al. (2003) propose a more customer centric approach that is determined by the provision of pure service outcomes and integrated end solutions to the customer. Rather than just making the physical product itself, a more customer centric strategy, i.e. looking downstream the supply chain, forces firms to provide high-value services (Wise and Baumgartner, 1999; Davies, 2003; Hobday et al., 2005). The combination of several services with products in bundles as integrated solutions then will result in a sustained competitive advantage (Slywotzky, 996; Slywotzky et al., 2007). An integrator of logistics systems must not only play a supporting role, but also needs to create value for the final customer, which is often achieved by combining and exploiting different resources as a bundle (Huemer 2012). Knowledge and assets such as vehicles, warehouses and information systems are then managed and coordinated in addition to the simple transportation and distribution task by such an integrator.

Literature summary of logistics outsourcing and service provision

The distinction between three different levels of service provision is the starting point for the contribution of this paper as mentioned in the introduction. Standard outsourcing activities in the context of logistics activities are strategically less important and require little transaction specific investments, as the uncertainty is low due to the stable nature of demand for these transactions in terms of volume and frequency. Highly integrated relationships require either a strong and close collaborative governance arrangement with a third party or must be integrated in the hierarchy of the institution. These are transactions of lower frequency and higher uncertainty, with greater strategic importance. The highest form of integration requires logistics activities and systems, which need to be continuously adapted towards customer requirements and environmental changes. The use of a systems integrator can provide highly complex bundles of resources and services (Davies, 2003; Prencipe, 2003). These activities include transactions that offer high-value to the customer. A systems integrator learns how to specify and maintain its services more downstream the value chain (Davies, 2004). The first two levels of integration or outsourcing relationships are usually explained with the presented economic theories and relate to the standard governance question of insourcing or outsourcing. However, the third, more abstract level also is based on the constructs of the conventional theoretical explanations but complements these with a systems integration approach that goes beyond the binary make-or-buy discussion.

This paper proposes that such a systems integrator approach can be applied to service providers and is not exclusively applicable to manufacturers of physical products. Hence, a theoretical contribution is made by adopting this view to the context of logistics outsourcing, complementary to the conventional perspective on outsourcing regarding the RBV of the firm and TCE.

RESEARCH METHOD

A comprehensive review of the literature was conducted, considering relevant academic journals within the discipline of operations and logistics management, in order to identify the current state of the research targeted towards the outsourcing and integration of logistics activities, following a three stage refinement process as introduced by Seuring and Müller (2008).

This study employs a qualitative research design methodology, including multiple providers for logistics services. Case study research is a suitable approach to justify theory and support literature findings in logistics management (Mentzer and Kahn, 1995). The different opportunities are outlined by Ellram (1996), who recommends the method for understanding the decision making process and organisational structures and the role of logistics in an organisation. Opposed to survey strategies that are limited to a few variables case study research collects data more accurately and reliable (Voss et al., 2002) and can focus on various aspects of a phenomenon by evaluating numerous variables as well as relationships.

A total of eleven firms (see Table 1) within Europe were selected, based on their availability and accessibility for interviews. According to Eisenhardt (1989) any number between four and ten case studies is ideal for qualitative analysis and getting in-depth insight into a phenomenon. Multiple case studies predict similar events and show contrasting results due to their ability to better replicate findings (Eisenhardt 1989, Voss et al. 2002).

Case	***Interviewee's role***	***Service provision characteristics***	***Industry***
1	CEO	Standard outsourcing	Food industry
8	CEO	Standard outsourcing	Paper bulk industry
6	Assistant Transport Manager	Standard outsourcing	Steel industry
2	Key Account Manager	Highly integrated	Oil and Gas industry
3	Head of European Logistics	Highly integrated	Food industry
4	Key Account Manager Parcel	Highly integrated	Mail and Parcel
10	Head of Logistics	Highly integrated	Food industry
11	Head of Logistics	Highly integrated	Industrial products
5	Head of CEP Services	Systems integrator	Fashion retail
7	Account Coordinator	Systems integrator	Fashion Retail
9	Transport Manager	Systems integrator	Fashion industry

Table 1: Summary of case study interviews

All organisations and interviewees met the following selection criteria. First and foremost, the firm must operate in the service industry, offering logistics services to all kind of customers that include transportation, distribution, warehousing, or any additional logistic services such as packaging, or material handling. Second, the firm must have a department or a representative that actively deals and finds solutions to the customers' requirements and enquiries. Third, the availability of an interviewee, who has several years of experience in the managing and selecting logistics services, is crucial as an inclusion criterion for the company as a selected case. Furthermore, the company generates reasonable revenue in order to contribute to the representative sample. The industry, where the case companies conduct their businesses in is not considered as a selection criteria as the unit of analysis is the service supplier within any supply chain focusing on specific logistics transactions.

We contacted the potential participants directly via mail or phone and arranged face-to-face meetings for an interview. A total of eleven interviews were conducted over a period of two months. All interviewees were in a managing or representative position. Table 1 provides a summary of the case companies and the adequate interviewees. We made sure that the interviewees had most knowledge and experience about the issue of governing logistics transactions. The aim of the interviews was to explore similarities in the organisation and governance structure of services and logistics activities according to their specification and strategic capabilities. The interviews followed a semi-structured interview guide and focus on the case firms' range of service offerings and relationship with their clients and customers. This technique is appropriate as the researcher can change the questions accordingly but still follows a certain pattern in order to address the theoretical constructs (Bhattacharya et al., 2003).

Data analysis method follows a coding scheme, where categories are developed. The interviews were recorded and transcribed. Data was coded according to the a priori model and the themes from the literature. Since the unit of analysis is the service provider firm, different themes that emerged were categorised accordingly, based on similarities and differences between the respondents. This method has been endorsed and established as an appropriate tool of qualitative data analysis (Miles and Huberman, 1994).

Reliability and validity of the study is ensured. First, consistency in the interview guide guaranteed the proper addressing of RBV and TCE related constructs. Second, the interview transcripts were sent to the participants in order to increase the accuracy of the findings. Third, by using conceptual constructs, the study can be replicated by other researchers. Fourth, all interviewees were informed about confidentiality and anonymity of the study. Finally, the researchers' knowledge and experience also justified the codification of the theoretical constructs into the conceptual matrix. Hence, the findings of the study ensure a high level of validity and reliability.

CONCEPTUAL FINDINGS

The initial distinction helps to better understand the various choices for organisations and managers to govern certain outsourcing activities and the logistics function. The distinctions made between (1) standard outsourcing activities, (2) highly integrated relationships, and (3) continuously adaptation of systems serves as a basis for the further analysis of the case study interviews. Drawing on the theoretical constructs from RBV, TCE, and the business of systems integration, this paper aims to understand the best governance choice for each category service provision in order to increase the network performance. The findings from analysing the case interviews support and underline the different theoretically derived themes such as strategic capabilities, transaction assets specification, and systems integration capabilities (see Table 2).

The following Table 2 presents the findings from the case study analysis. Relating to the theoretical assumptions that suggest the relational governance for different levels of integration, empirical findings support or contradict what theory says.

Level of integration	*Strategic capabilities /RBV*	*Governance forms / TCE and AT*	*Systems integration capabilities*	*Empirical findings*
Standard outsourcing activities	Capabilities that are required to offer standard transportation and warehousing activities are of little strategic importance. Providers' resources are rarely scarce and can easily be imitated by competitors. Exploitation of resources is limited to an extent that requires little human or organisational skills.	Providers generally invest into assets to maintain their capabilities rather than further exploit them. Nature of transaction is frequent and predictable in a stable and certain environment. Switching and monitoring costs are little due to the high degree of competition in the logistics industry and the high availability of service providers.	Providers rarely offer bundled services or any specific value adding services; they focus on their basic core competences of standardised outsourcing activities. Performance measurability is suggested to be of little importance as negotiation of contracts is simple due to the less complex relationships.	Standardised services are offered by the most case firms. Provider 1, 6, and 8 focuses on these activities as their core business, acting as a supporting supplier in manufacturing and production industry. Despite the little transaction specificity, investments tend to be customer oriented and exploitation of resources is done by consolidating multiple customers.
Highly integrated relationships	Providers invest more specifically in customised capabilities and resources in order to gain a sustained competitive advantage; resources are scarce and more costly to imitate and require higher level of organisational skills. Exploitation of resources is high through economies of scale and scope.	Processes are characterised by much higher asset specification and therefore increase the complexity of the outsourcing relationship. Relational governance is very close and more integrated, therefore it is very difficult, costly, and time consuming to switch and maintain suppliers.	Contractual relationships are longer and more complex in the specification of performance outcomes. Provider and suppliers. Providers usually offer more integrated solutions in terms of bundled services including physical products or services plus the adequate communication and software tools or enhanced customer service offerings.	More integrated solutions are provided by case firms 3, 4, and 11, 2, and 10. However, integration takes place in two ways which have to be distinguished. First, a hierarchical outsourced form, where the suppliers provide sophisticated logistics functions. Second, a hierarchical institutional form, where the focal form integrates the logistics functions within its boundaries.
Continuous adaptation of systems	Resource heterogeneity is very high and core competences include the provision of multiple services and capabilities. Offered products are customised and highly complex. Investments are made on the exploitation of capabilities in order to generate highly scarce and valuable resources and assets that are unique in the market place.	Transaction specification is extremely high. Advanced information sharing increases the costs for switching and monitoring suppliers and partners. External environmental factors such as changing customer requirements influence the performance of the processes and present high uncertainty and little predictability of activities.	Focus on customer-centric rather than product-centric relationships involves long-term partnerships and complex contractual arrangements. Performance measurability is crucial and in order to evaluate and coordinate the whole system. Value adding services from the customers' perspective is emphasised.	Offering complex logistics and supply chain solutions is represented in the cases 5, 7, and 9. These providers act as full integrators for the whole system. Core focus is the provision of solutions and communication and information platforms rather than the physical products or logistics services.

Table 2: Theoretical assumptions and empirical findings on different types of service provision

CONCLUSION AND IMPLICATIONS

The key to understanding why firms integrate and continuously adapt logistics systems such as distribution networks, warehousing activities, and order specific consolidation, is due to recognise that there are multiple governance solutions to the general problem of outsourcing relationships.

Addressing research question 1, conventional economic theories do not properly explain the integration of outsourcing relationships. The RBV of the firm and TCE focus on the focal firm's competitiveness and the firm's decision whether to outsource or not, rather than explaining the integrated adaptation of systems. The conceptual model adopts the theoretical constructs regarding strategic capabilities and transaction specification. However, further themes such as performance measurability and customer-oriented service offerings must be taken into account in order to understand and explain the potential role of service providers as systems integrators. The case study findings show that more complex activities and long-term relationships need to be controlled and monitored constantly in order to achieve higher network performance.

Addressing research question 2, different activities must follow specific governance forms from market transactions for standard logistics processes, to highly integrated relationships, to the continuous adaptation of logistics systems. First, firms must consider the value-adding chain for their own services and their own position in the market following conventional economic theoretical assumptions, also to what extent each value-adding or supporting activity is best sourced in-house or outside the firm (Mudambi and Tallman, 2010). Second, strategic advantage cannot only be gained by outsourcing processes and functions through contractual market dyads and arm's length transactions. Therefore, a systems integrator approach is crucial in order to govern more complex processes that purposely address the customers' requirements and end consumer needs.

Through the development of an initial conceptual distinction and the exploration of integration issues, this paper contributes to the development of theory in the area of service outsourcing and the emergence of systems integrators. RBV and TCE both contribute to a richer understanding of this complex phenomenon. Deciding whether or not to source internally or to engage in service integration is a major decision for a firm. Perhaps even more challenging is how to structure and manage this integration for maximum benefit. As conditions change, firms must be able to reassess its organisational structures and adjust them appropriately. The model presented here uses resource-based theory, and transaction cost economics as a *"reasonably parsimonious theoretical approach"* (Mudambi and Tallman, 2010, p.1451) to the idea of integrating logistics outsourcing relationships.

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OVERCOMING THE CHALLENGES OF BEING INNOVATIVE IN OUTSOURCED LOGISTICS PROVISION

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ABSTRACT
Logistics service providers (LSPs) have traditionally been characterised as possessing a poor reputation for innovation. There has been a "Catch 22" scenario where LSPs have needed to be innovative to provide better value for their customers, but have been restricted by contracts where their customers have been unwilling to pay for research and development. The overall purpose of this research will be to empirically investigate whether LSPs are recognising this fundamental flaw in their basic business model, as well as other potential barriers to logistics innovation and, if so, to examine how they are going about overcoming these issues to become more proactive in developing innovation strategies. A case study methodology is adopted. A world-leading freight forwarder, Panalpina Ltd., is chosen as it has recently developed a logistics arm to their organisational structure. The study observes how the company identified innovation in logistics as a gap in the sector that they wanted to attack on developing their logistics business and explores how they went about tackling this challenge. The study has benefit for both research and practice. In terms of research, Flint et al. (2005) noted, "logistics research has largely ignored the concept of innovation" and highlighted that research is lacking in determining how innovation in logistics occurs: in short, whether it is "purposefully managed or more ad-hoc". This research will contribute to this neglected area. For LSPs, the need for innovation is increasing, as competition amongst them intensifies due partly to increased globalisation, deregulation and the increasing demand from shippers for them to extend their range of service solutions. There is consequently a practitioner interest in how LSPs can be better at being innovative, which this research will help to address.

Keywords: Logistics, LSPs, Innovation

INTRODUCTION
Logistics Service Providers (LSPs) need to adapt to the dynamic markets they operate in if they are to meet the challenge of staying ahead of their competition. To achieve this, many LSPs are becoming more self-reflective and asking how they can better manage their innovation processes. This paper focusses on this, identifying what challenges LSPs face in developing their innovation strategies and investigating if LSPs are becoming more "innovative at being innovative".

Busse and Wallenburg (2011) emphasise that logistics is invariably outsourced. However, in recent years concern has been raised about the lack of innovation inherent in outsourced logistics provision. This has been characterised as being primarily caused by the gap that is left between the shipper and the LSP in regard to innovation. Shippers, after outsourcing their logistics provision, have invariably not retained the capability to drive innovation, while LSPs have concentrated on executing the contract they are employed on. Consequently, there has been little incentive to pursue research and development (R&D) as innovation activity has not naturally fitted into the short-medium term business plans of LSPs. LSPs are thus commonly characterised as being "not very innovative" (Busse and Wallenburg, 2011) and the whole logistics provision sector has arguably suffered as a result. There are however early signs that this is changing with a number of LSPs placing a much higher priority on the quest to be innovative.

There has been a gap in the academic literature in this area too. Flint et al. (2005) asserted that, "logistics research has largely ignored the concept of innovation" adding that, "…essentially, we do not know much about how logistics innovation occurs today and whether or not innovation is purposefully managed or more ad-hoc". Grawe (2009) added that there has been a distinct lack of empirical research focussed on the field of logistics innovation. Flint et al. (2005) proposed a model framework that could guide a LSPs system of innovation, but no follow up study has been undertaken to examine how applicable this is in practice. This paper looks at this, taking a case study approach to review the applicability of this framework to the actual logistics innovation strategy adopted by a world leading freight forwarder, Panalpina Ltd., who moved into logistics provision in recent years and envisaged that developing a highly innovation-orientated approach would be at the heart of their strategic rationale underpinning this move. The study aims to identify in practice what challenges and barriers are perceived to exist that may inhibit innovation for an LSP and to investigate how these can be overcome. In short, the study aims to identify what an innovation strategy for LSPs can look like.

The paper is structured as follows. After the literature review examines how innovation in logistics is defined and explores how different types of innovation can be categorised, the main challenges identified in the literature in LSPs developing an innovation strategy are summarised. The Flint et al. (2005) logistics innovation framework, proposed for LSPs to overcome these challenges, is presented as a template to focus the research around. The case study method is then introduced, explained and justified. The findings present, from Panalpina's perspective, the identified inhibiting issues to being more innovative and how these recognised challenges have been overcome in practice in developing and implementing their logistics innovation strategy. The results are then related to established theory, before conclusions are drawn.

LITERATURE REVIEW

Introducing Logistics

Today, in many sectors, logistics is conceived as representing a key cog component in the supply process of providing products for consumers. An effective logistics operation can add value to the output of the firm and improve their competitive advantage allowing them to potentially increase market share (Mentzer et al., 2001). This value-add can be derived by contributing to decreased costs, but also by other dimensions, such as through timeliness of service, quality of delivery, value-adding services and/or enhanced convenience provision. Logistics is an activity that is invariably outsourced to specialised LSPs rather than being retained in-house by suppliers of products. The logistics provision sector is characterised as being highly competitive as many of the core services it provides have steadily become more commoditised. Developing innovative solutions has therefore increasingly become a key objective for LSPs keen to develop more differentiated businesses. It is also increasingly demanded by the customers of LSPs, who are keen to build their supply chains' performance levels through better logistics capabilities so that they are able to better compete.

Defining Innovation

Innovation, which is commonly recognised as being critical for a firm's on-going success, is an umbrella term which covers a range of areas such as change, improvement, development, learning, new product development (NPD), new service development (NSD) and process enhancement. In a very broad sense it can hence be defined as, "an idea, practice, or object that is perceived as new by an individual or other unit of adoption" (Rodgers, 1995). Flint et al. (2005) consequently argued that logistics innovation covers "any logistics related service from the basic to the complex that is seen as new and helpful to a particular focal audience". Innovation is argued as being a core component of the Resource

Advantage Theory (Hunt and Morgan, 1996). By developing comparative advantages in resources (assets, processes, information and/or knowledge) a firm can develop a differentiating advantage in providing efficiency or effectiveness (Barney, 1991) or both. By being proactive in developing innovations a firm's efforts to develop this will be supported (Grawe, 2009, Sakchutchawan et al. 2011).

Categorising Innovation

Innovation has received much academic coverage in many settings beyond the logistics arena. It can be envisaged that there is a spectrum of innovation which ranges from "new to the world", very radical innovations, to smaller incremental changes in a particular setting. In the middle of this range sits many mid-space innovations. In a logistics setting examples of new to the world innovations have included the shift to inter-modal containers (Grawe, 2009) or the adoption of RFID, while mid-space innovations are typified by developments such as new customer relationship management systems and incremental improvements can be exemplified by smaller, step by step enhancements, achieved through continuous improvement systems. This has been termed the exploration – exploitation framework where exploration encapsulates the more radical, ground-breaking research that allows firms to compete for new customers, while exploitation innovation covers the more incremental changes that allow providers to serve their customers better step by step (Benner and Tushman, 2002).

The Innovation Process – the challenges and how they can be overcome

Overall, it is commonly agreed that the innovation process is sub optimised if it is left to just naturally occur in an organisation. So, much research work has been undertaken to better comprehend the innovation process, or system that one would commonly expect to see exhibited in an organisation that innovates. As a result, a number of processes in the overall innovation system can be delineated:

- Idea Generation;
- Product / Service / Process Development;
- Pilot Testing;
- Managing the Rate of Diffusion.

Knowledge is seen as an important antecedent of innovation. In logistics innovation, Chapman et al. (2003) argued that this was a key factor. However, it should be noted that the predominant focus in the general field of innovation research has been more at the diffusion end and less at the idea generation end. This research will take a broad view, taking the full definition of logistics innovation noted earlier and will also seek to examine the whole logistics innovation system from the perspective of a provider.

Flint et al. (2005) found that there are a range of reasons why LSPs are characterised as being poor innovators. Firstly, they highlight that although LSPs are invariably spatially close to customers this also means that they are inclined to decentralise their organisations, leading to much dispersed peripheral decision making. The company culture of LSPs can also act as a barrier to innovation as it often tends to be rather down to earth, very operationally focussed and reactive. This leads to an emphasis on easy to execute, repetitive tasks. Logistics can also possess a low skill requirement for many activities in logistics operations and this is not conducive to innovation.

On the opposite viewpoint Flint et al. (2005) argued that the logistics sector possesses a number of advantages that supports the objective to develop successful approaches to innovation. LSPs are boundary spanning, they are closely linked with material flows of their customers and their customers' customer. Being close to customers and market orientated should make it easier to develop coordinated innovation. Indeed, adopting such a "market orientation" has been cited as being positively associated with growth and profitability (e.g. Matsumo et al 2002). But converting this accessibility to valuable knowledge to actual innovation and learning is a challenging step. What constitutes customer value is contentious and complex and there are often highly contingent, situation dependent, customer demands which may vary over time or circumstance in their perception. The complexity often revolves around how customers evaluate trade-offs: e.g. between price and quality, or service benefits.

This, Flint et al. (2005) argued meant that it was important that LSPs developed the skills of a learning organisation. Organisation Learning (OL) can be seen as a strategic resource creating a differential competitive advantage if handled well. They identified four factors to consider. First, learning can occur at a variety of levels – the challenge being for LSPs to be able to be able to directly respond to low level stimuli in the basic operation while at a higher level being able to translate this into organisation wide learning. Logistics innovations will vary depending on the level at which the LSP learns about customers' desired logistics value. Secondly, this sharing of knowledge across the organisation can be problematic for LSPs. This is because knowledge can be tacit and embedded in employee's experience making it hard to articulate. It is also often filtered and manipulated, as for instance, there may be a reluctance to act on negative information or large organisations can be bureaucratic and thus stifle efficient knowledge sharing. So, if sharing is a problem, logistics companies will struggle to sense their changing environment and customer values and innovations will not emerge. Thirdly, the learning process for an organisation may be broken. Fundamentally, how does the organisation tap into the knowledge of its employees whether they are established or new to the organisation. A process needs to be in place where their insights and views can bring about managerial behavioural changes for organisational learning to be harnessed. The problem is that often this process is ill-developed as too much focus is placed on short-term response than building this kind of long-term capability in logistics organisations that move from contract to contract. Fourthly, organisational learning may be highly idiosyncratic, contingent to unique factors such as organisational structures, culture, situations etc. So LSPs should accept that whilst there may be some innovations which are applicable across the organisation there will also be many that need to be much more contextually contingent.

To help guide LSPs in becoming more proactive in their approach to being innovative, a five step framework to generating innovation was proposed by Flint et al. (2005). It stresses these twin pillars of understanding customer value and developing organisational learning capabilities to optimise the impact of innovation for the benefit of the customer. The research will use a case study method to review in practice the actual challenges perceived by an LSP that it faces in being innovative, and contrast how they are overcoming these challenges with the ideas established in the literature. Does this innovation process model work in practice?

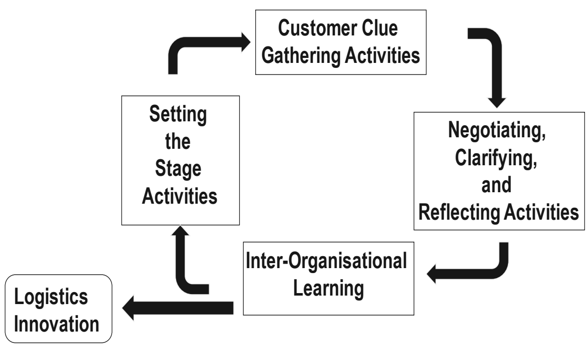

Figure 1: Logistics Innovation Process (Flint et al, 2005)

METHOD

A case study approach is taken to better understand how a purposeful approach to innovation can be adopted by a leading LSP and how this compares to the established knowledge in the current literature base. The study seeks to identify what challenges to being innovative does the LSP perceive exists and to examine how the firm has faced up to these challenges to incorporate an innovation strategy into their overall business model proposition. The chosen LSP has developed from scratch a logistics arm to their leading global freight forwarding business in recent years. Their aim has been to focus on ensuring innovation is at the heart of this new business venture as they foresaw that this was an area that the sector had been traditionally characterised as being weak and hence represented a potential competitive gap. The adopted case study approach included a range of mixed methods which included interviews with senior personnel and the accessing of qualitative and quantitative secondary data obtained from a range of company sources.

Panalpina's history is built on its expertise in international freight forwarding services, particularly air but also ocean freight services. In 2011, the company decided to add logistics services to this. They recognised that simply introducing a new logistics offering into an already crowded and competitive market would not succeed. Furthermore, the wider logistics industry was, and is suffering from an increased level of commoditization, putting pressure on margins, particularly for those logistics companies who only offer standard warehousing services (store, pick, pack). Subsequently, before launching the new service, Panalpina decided to invest time to identify and develop new innovative approaches, looking for ways the company could differentiate itself from existing players in the market and identify niches that offered the opportunity to target higher margin business.

FINDINGS

Identifying the Challenges to being Innovative?

The major steps Panalpina took to develop their new innovative approach to innovation is explained below. At the outset, one of the key identified points was that it was normal in the 3PL industry for logistics companies to follow, rather than to lead the industries in which they operated in. This attitude was seen as a key reason why little innovation had occurred in the logistics industry. Further analysis concluded that there were 4 drivers to the lack of logistics innovation:

There was no motivation to invest in new ideas and innovation: increased globalisation together with a growing trend to outsource logistics services had meant that the demand for freight and logistics services had increased exponentially since the 1970's. 3PL's found themselves in a constantly growing market, and one in which they did not need to innovate to survive;
Lack of investment in R&D and commoditisation: the 3PL industry is a service industry: it has no tangible product. It offers transportation and logistics services: moving and storing customer's product is how income is generated. The industry is heavily commoditised with freight forwarding and standard contract logistics being highly competitive and price sensitive. The effect that had developed was that much of industry was based around tight cost control, which again in turn led to there being little incentive or desire to invest in R&D;
Logistics is an insular industry: many leaders in the logistics industry had built their career in the industry. This limited the appetite to challenge existing ways of doing things and limited the ideas coming from external industries;
Logistics was not an attractive industry for new talent: for many graduates logistics was a conservative industry, surviving on low margins (and therefore only offering low salaries), and providing limited options for training and career development. Unfortunately, this had become a vicious circle; the lack of innovation in the industry had resulted in a lack of interest from new graduates, which in turn led to a lack of graduates and thus innovation in the industry.

Overcoming the Challenges to Develop a Proactive Innovation Strategy

Despite the negative findings from the initial research, the lack of a true innovative 3PL in the industry provided a potential niche to create a competitive position. Although in 2011 the company did not know exactly what the logistics strategy would be, they knew it had to avoid falling into the traps identified above, so had to develop a fundamentally different business proposition with innovation at its heart. The image below shows some of the initial ideas Panalpina used to develop a new approach to logistics.

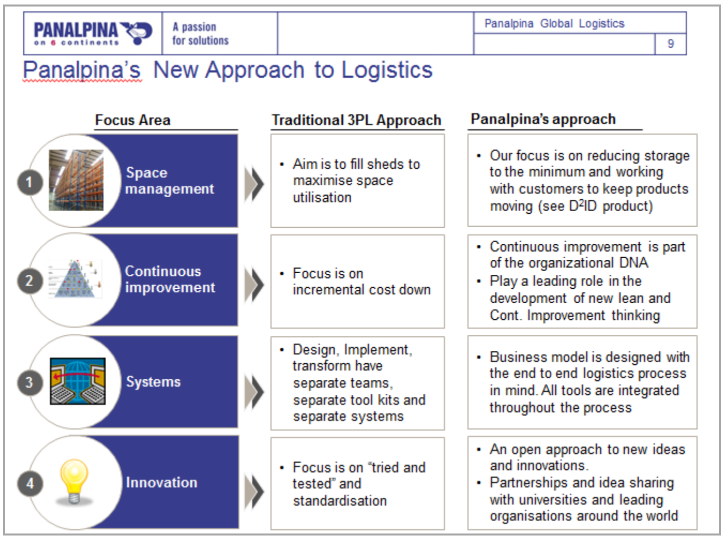

Figure 2: Panalpina's New Approach to Logistics

Panalpina's approach initially featured a number of actions to support this different approach and create a fresh knowledge bank and attitude for the new logistics business. These first steps are summarised below:

- The recruitment of a Senior Executive to lead the new logistics business, who had previously worked in an innovative manufacturing sector;
- The recruitment of manufacturing specialists;
- The creation of a new mind set (supported by the influx of new personnel) with a fresh focus on the role a logistics provider could play;
- The agreement of a strategic partnership with a world leading research institution: Cardiff University.

These changes laid the foundations for many new initiatives. For instance, it helped change the focus away from using warehouses to store goods, to facilities that could be used to add value to customer's products with the aim to remove inventory. This lead to investment in a methodology to help customers forecast demand to reduce inventory levels. This would be an anathema for traditional logistics companies who aim to fill their warehouse space with inventory. Panalpina secured funding from the UK Technology Strategy Board to develop a new inventory forecasting method (Demand Driven Inventory Dispositioning - D^2ID), making Panalpina the first logistics company to develop an in-house approach specifically designed to help customers reduce inventory levels.

Panalpina also took a lead in developing LMS (Logistics Manufacturing Services). The LMS service allows customers to combine part of their manufacturing processes with their order fulfilment process, drastically reducing lead times and allowing last-minute software personalisation, immediately prior to customer delivery. This reflected that shortening product life-cycles and speed to market were having increasing influence on supply chains together with the era of mass-personalisation creating fresh opportunities for logistics companies to fulfil and add value through initiatives like LMS.

New technology was also influencing supply chains. For instance the development of additive manufacturing meant that products in the future will essentially be manufactured anywhere in the world. The full impact of this has yet to be realised. Greater emphasis is also being placed on recycled and re-useable components, materials, and sources of energy as part of the circular economy; advances in robotics, new materials, nano-technology all means that product design and manufacture can be re-thought, and the fundamentals of traditional supply chain thinking will be further challenged.

A further example of different thinking was in seeing information as an asset. Logistics companies have a wealth of information at their fingertips. From macro-economic information related to the flow and volume of trade between companies, to product information about what products are selling and which are not. In some cases, the logistics company has more information about their customers supply chain than the customer. Furthermore, the accumulation of information across different customers and across different industries places logistics companies in a unique position. There were clear opportunities to look at ways of using this information to help customers and commercialise the information available. Panalpina have recently launched a new "Data Analytics" service, where they help customers identify how they could make better use of the information they have available in their supply chain, and also tap into the wider information sets that Panalpina have available to benchmark and drive business improvements.

At the more incremental level Panalpina logistics also launched a programme of continuous improvement, which it named LogEx (Logistics Excellence). Initially the focus of the programme was to instil a culture of continuous improvement, but increasingly, the programme has been used to generate ideas from all across the company.

CONCLUSIONS

Using the above methods and framework Panalpina has recognised some clear reasons why logistics companies do not have a strong reputation for being innovative and identified and followed through some proactive and instrumental steps to ensure innovation is at the heart of their approach to develop their logistics business. A number of examples of specific initiatives that have arisen from this fresh approach have been highlighted in this paper.

The reasons identified for LSPs not being innovative partially concurred with previous research findings but also highlighted a few new points. Flint et al., (2005) had identified the inherent low skill rate in LSPs, highlighted in this case too, but the findings that there was no motivation to invest in innovation due to the on-going growth the sector had experienced, the lack of R&D due to the commoditisation of many of the activities in the sector and the fact that it was a fairly insular industry not able to attract new talent are all new findings.

These findings of the challenges also resulted in actions in developing an innovative strategy that supplements the framework model proposed by Flint et al. (2005). The key, identified by Panalpina is to produce a fundamental mind-set change, which is not currently a part of the Flint at al. (2005) model. This was brought about through important steps such as recruiting personnel, including senior management, from manufacturing customers and creating a supportive environment for creative thinking via, for example, supporting collaborative links with a leading research university in this field: Cardiff University. The energy and advances this has produced was evidenced by the raft of initiatives at the heart of Panalpina's distinctly fresh approach to logistics which was very different to traditional logistics companies'. LMS and D^{2}ID are examples of service products which are the most advanced available on the market. There is also a pipeline of new innovations already in development or at pilot stages around the world, which are too commercially sensitive to be presented in this paper.

The research found that there are three key antecedents to creating a successful innovative strategy for a LSP.

- the need to reconceptualise their role in modern supply chains, to see how they can provide value for the customer from their perspective rather than the traditional business model;
- a change from being a very insular organisation to being more open to taking on people and views from outside the norms of the sector; and,
- to be more willing to invest in innovation.

Confronting the traditional approach to innovation LSPs had been characterised as adopting before, the case study has presented new opportunities for Panalpina Ltd. to be innovative. To have the commitment of top-level management support has also been vital for this, which concurs with previous findings on innovation (Russell and Hogg, 2004). To build a competitive logistics business, and potentially to be an influence in this regard to the whole industry, innovation is now at the heart of Panalpina's strategy. This is already producing positive commercial results and better value performance for its customers.

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WHETHER THE PROCESS IS IMPORTANT IN LOGISTICS OUTSOURCING: AN EMPIRICAL INVESTIGATION IN CHINA

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Abstract
This study aims to empirically examine the impact of top management support on logistics outsourcing (including logistics outsourcing intensity and formalized process for logistics outsourcing) and the impact of logistics outsourcing on firm benefits using data collected from 250 manufactures operating their business in China. The results show that top management support can positively influence logistics outsourcing only when they participate in those related activities, namely top management participation totally mediate the relationship between top management beliefs and logistics outsourcing. What's more, both logistics outsourcing intensity and formalized process for logistics outsourcing have positive and significant effect on firm benefits. The results provide managerial implications for practitioners who are responsible for logistics design that process is an important factor to help manufacturers get competitive advantages through logistics outsourcing.

1 Introduction

Higher customer expectations, increased global competition and the development of e-commerce have prompted manufacturers to outsource their logistics activities to get competitive advantages through reducing costs, improve service quality and focus on core activities (Chu and Wang 2012; Lau and Zhang 2006). In the 2015 19th Annual Third Party Logistics Study, (Langely and Capgemini 2015) suggested that 51% of shippers' transportation spend and 36% of their warehouse operations spend were outsourced. However, existing research showed mixed results about the effects of logistics outsourcing. Most previous research focus on antecedents of logistics outsourcing, activities to outsource and outcomes of logistics outsourcing (Lau and Zhang 2006; Selviaridis and Spring 2007). Numbers of studies have examined how top management support impacts firms' supply chain practices (Chen et al. 2010). However, even in more developed western countries, top management is often not heavily involved in logistics outsourcing planning (Chen et al. 2010). In addition, formalized process for outsourcing is important for outsourcing success (Han et al. 2008), but few studies have examined the role of formalized process for logistics outsourcing success. What's more, a quick review of existing literature about logistics outsourcing shows that most are conducted in western context and that inquiry in China context is limited. Considering China's booming economy, social transaction and unique culture shape consumer behavior(Zhao et al. 2006), there is a challenge in applying western-derived theory in China's logistics research (Tian et al. 2008).

This study extends previous research by examined the impact of top management support on logistics outsourcing, including logistics outsourcing intensity and formalized process for logistics outsourcing and also examined how logistics outsourcing influence outcomes, including cost advantage and service advantage.

2 Theoretical development and research hypotheses

The conceptual model was proposed, as shown in Figure1.

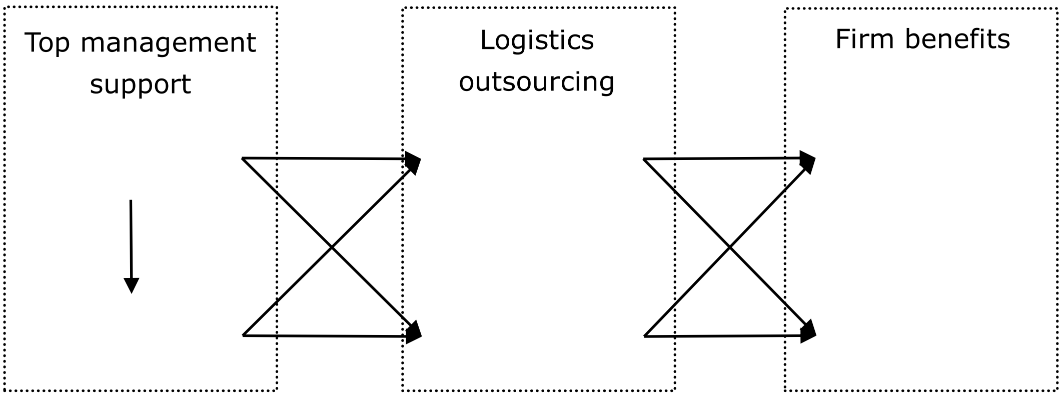

Figure 1 Research model

Notes: Intensity denotes logistics outsourcing intensity; Process denotes formalized process for logistics outsourcing; Cost denotes cost advantage; Service denotes service advantage

Top management support is defined as a firm's top executives' belief in logistics outsourcing and their active involvement, participation, and leadership in these outsourcing activities (Chen et al. 2010). It can be viewed as a unique intangible firm resource according to the classification of tangible and intangible resources of (Hall 1992). The importance of top management support for logistics outsourcing lies in that senior management determines the relative allocation and prioritization of other organizational resources to logistics outsourcing and influences how logistics performs in satisfying customer requirements (Novack, Rinehart, and Langley 1996). Since formalized process for outsourcing is vital to outsourcing success (Han et al. 2008), so top management support not only enhance logistics outsourcing intensity, but also influence logistics outsourcing process. In addition, top management who believes logistics outsourcing can bring benefits to firms will participate in those related outsourcing activities. Thus, the following hypotheses were proposed:

Hypothesis 1a: *Top management belief has a significant and positive impact on logistics outsourcing intensity.*

Hypothesis 1b: *Top management belief has a significant and positive impact on formalized process for logistics outsourcing.*

Hypothesis 1c: *Top management participation has a significant and positive impact on logistics outsourcing intensity.*

Hypothesis 1d: *Top management participation has a significant and positive impact on formalized process for logistics outsourcing.*

Hypothesis 1e: *Top management belief has a significant and positive impact on top management participation.*

Firms using logistics outsourcing services can get cost advantages through reducing capital investment in logistics facility, labor and equipment maintenance costs (Lau and Zhang 2006; Rajesh et al. 2011), and economies of scale (Damme and Amstel 1996). In addition to cost advantages, collaboration with 3PL suppliers can lead to operational benefits such as reduction in inventory levels, order cycle times and improvement in order fill rate and order accuracy (Hsiao et al. 2010; Rajesh et al. 2011). Formalized outsourcing management processes, control process and work evaluation principles can reduce 3PL suppliers' opportunistic behaviors. formalized process is also required for better communication and information sharing (Han et al. 2008), facilitating the 3PL suppliers' participation in the logistics outsourcing. Thus, formalized process for logistics outsourcing is important to reduce cost and improve service quality to end customers. Thus the following hypotheses were proposed:

Hypothesis 2a: *logistics outsourcing intensity has a significant and positive impact on cost advantage.*

Hypothesis 2b: *logistics outsourcing intensity has a significant and positive impact on cost advantage.*

Hypothesis 2c: *Formalized process for logistics outsourcing has a significant and positive impact on cost advantage.*

Hypothesis 2d: *Formalized process for logistics outsourcing has a significant and positive impact on service advantage.*

3 Research methodology

3.1 Sample and data collection

Our sample unit is subsidiary of China publicly listed manufacturing companies that independently operates its businesses in mainland China. After a series of efforts, a total of 6299 questionnaires were sent out and we finally got 250 effective questionnaires, among which 200 from Mainland list and 50 from HK. We tested non-response bias and common-method bias based on (Armstrong & Overton, 1977; Podsakoff & Organ, 1986), and the results showed that non-response bias and common-method bias was not an issue in our research.

3.2 Measures

3.2.1 Logistics outsourcing intensity

After surveying related literature and in-depth interviews with domain experts and practitioners, we got a comprehensive list of logistics activities (Table 1) which may not contain all logistics activities in which those firms may be engaged but do an enough job to capture the phenomenon under study. The respondents were asked to indicate the proportion of each outsourced activities that was doing by 3PL suppliers. The percentage of the value of each outsourced activity were summed up and averaged as logistics outsourcing intensity.

Table 1 List of logistics activities

Logistics activities	**Logistics activities**
Express delivery of document, samples, critical components etc.	Product Design
Transportation	Final Assembly
Distribution/delivery	Improvement and Optimization of Supply Chain Processes
Warehouse management	Purchasing
Inventory Management	Financial Services
Custom Clearance	Logistics information system improvement/integration
Order Processing	Reverse logistics
Labeling, re-packaging and other customized services	Other types of consulting services related to logistics and supply chain management
Less Than Container Load	

3.2.2 Other variables

Respondents were asked to indicate the extent to which they agreed to the statement on a Likert scale ranging from strongly agree (1) to strongly disagree (7) for other variables. Six items drawing from (Chatterjee, Grewal, & Sambamurthy, 2002; Chen, Tian, Ellinger, & Daugherty, 2010) were used to measure top management support (three for top management belief and three for top management participation). Formalized process for logistics outsourcing was measured with five items from (Han, Lee, & Seo, 2008). Cost advantage was measured with three items from(Han et al., 2008) and service advantage was measured with three items from (Boon-Itt & Wong, 2011; Hsiao, Van Der Vorst, Kemp, & Omta, 2010; Ward & Duray, 2000).

3.3 Reliability and validity

The cronbach's alpha and composite reliability were used to measure the reliability of the measures. Table 2 shows that the Cronbach's alpha values range from 0.787 to 0.937 and the composite reliability values range from 0.875 to 0.960, which are all above the recommended threshold value of 0.70 (Bernstein & Nunnally, 1994)(Bernstein and Nunnally 1994), suggesting that all constructs are reliable. The estimates for the average variance extracted (AVE) were higher than o.5 for all constructs (Table 2), demonstrating convergent validity (Fornell & Larcker, 1981). The squared root of average variance extracted (AVE) was greater than the correlation between that construct and the other constructs (Table 1), suggesting accepted discriminant validity (Fornell & Larcker, 1981).

4 Results

Table 2 Mean, standard deviations, and correlations of variables

	belief	cost	intensity	participation	process	service
Belief	**0.886**					
Cost	0.289	**0.837**				
Intensity	0.141	0.196	1.000			
Participation	0.616	0.263	0.169	**0.865**		
Process	0.314	0.293	0.152	0.383	**0.874**	
Service	0.298	0.552	0.247	0.263	0.362	**0.943**
Mean	5.453	5.408	0.263	5.193	5.138	5.383
Standard deviation	1.307	1.423	0.178	1.398	1.508	1.338

*Notes: * Correlation is significant at the 0.05 level (2-tailed); **Correlation is significant at the 0.01 level (2-tailed). Squared root of average variance extracted (AVE) is shown on the diagonal of matrix in bold; inter-construct correlation is shown off the diagonal.*

Table 2 shows the descriptive statistics. The hypotheses were tested by structural equation model using PLS 3. The results were shown in Figure 2. Top management belief does not has a significant effect on both logistics outsourcing intensity (β =0.060, P>0.1) and formalized process for logistics outsourcing (β =0.126, P>0.1). Thus hypothesis 1a and hypothesis 1b were not supported. However, top management belief has a significant and positive effect on top management participation (β =0.616, P<0.001) and top management participation has a positive effect on logistics outsourcing intensity marginally (β =0.131, P<0.1) and a significant and positive effect on formalized process for logistics outsourcing (β =0.306, P<0.001). Hypothesis 1c, hypothesis 1d and hypothesis 1e thus received support. Logistics outsourcing intensity has a positive effect on both cost advantage (β =0.155, P<0.01) and service advantage (β =0.197, P<0.001). Formalized process for logistics outsourcing also has a positive effect on both cost advantage (β =0.269, P<0.001) and service advantage (β =0.332, P<0.001). Thus hypothesis 2a, 2b, 2c and 2d were all supported.

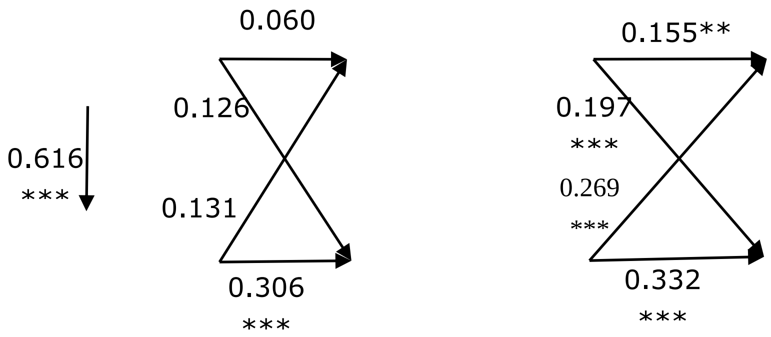

Figure 2 Model results

Table 3 Measurement and reliability and validity of constructs

Measurement	Factor loadings
Belief (Cronbach'a=0.864;C.R.=0.917;AVE=0.786)	
Top management believes that logistics outsourcing can significantly improve efficiency	0.879
Top management believes that logistics outsourcing can significantly improve competency	0.894
Top management believes that logistics outsourcing can significantly improve productivity	0.886
Participation(Cronbach'a=0.832;C.R.=0.899;AVE=0.748)	
Top management actively participates in formulating a strategy for logistics outsourcing	0.859
Top management actively participates in establishing goals and standards to monitor the logistics outsourcing	0.865
Top management has a clear vision for the logistics outsourcing	0.871
Intensity	
Formalized process of logistics outsourcing(Cronbach'a=0.922;C.R.=0.942;AVE=0.763)	
We have formalized processes to select 3PL	0.836
We have ability to evaluate the performance of logistics outsourcing	0.850
We have management processes for logistics outsourcing projects	0.900
We have systematic processes to manage outsourcing contracts with 3PL	0.898
We have systematic processes to control 3PL	0.882
Cost advantage(Cronbach'a=0.787;C.R.=0.875;AVE=0.701)	
We have enhanced economies of scale in logistics technological resource	0.835
We have increased control of logistics expenses	0.894
We have decreased total cost of logistics	0.779

Service advantage(Cronbach'a=0.937;C.R.=0.960;AVE=0.889)	
We have reduced delivery lead time	0.931
We have improved delivery reliability in our firm	0.955
we have enhanced on-time delivery in our firm	0.943

5. Conclusions and implications

We found that both logistics outsourcing intensity and formalized process is pivotal to firms to get competitive advantages through logistics outsourcing. In addition, top management participation mediates the relationship between top management belief and logistics outsourcing, which means that top management support is helpful only when they participate in logistics outsourcing related activities. The results provide managerial implications for logistics managers who are responsible for logistics design. If they want to outsource logistics activities to third party logistics suppliers, formalized process for logistics outsourcing is an important governance mechanism to make logistics outsourcing a catalyst rather than another problem to solve. Top management support is an important factor to promote logistics outsourcing only when they participate in those related activities.

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Section 10: Food and agriculture logistics

FOOD SUPPLY CHAIN RISK ASSESSMENT THROUGH BAYESIAN NETWORKS

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ABSTRACT
Safety in the food supply chain has received much attention recently due to the issues related to public health. As such, food supply chain risk assessment is becoming more important. Using Bayesian networks, a partial risk model of the food supply chain is established to assess the risk. We present a case to show the feasibility of our algorithm.

Keywords: Food supply chain, Risk assessment, Bayesian network

1. INTRODUCTION

A Taiwan news report mentioned that tainted food scandals and extensive media publicity has damaged the image of Taiwan's food products, and affected the reputation of the food industry (Popular newspaper, 2014). Though serious, it is not new as attested by Table 1, which suggests that many similar incidents over in the downstream food supply chain occur in Asia. This naturally raises much concern in the context of the food supply chain and its management. Indeed, the recent news on McDonald's, KFC and other companies in China have been on food security, which invariably have created a financial impact and market reputation of the companies concerned. For instance, the 2012 winter outbreak of the chicken incident on KFC decreased KFC's 2013 sales by 20%. On 10 Nov 2014, criminals in eastern China sold 100 metric tons of toxic tofu (Yuba) in China by adding an industrial bleaching agent Rongalite (a carcinogenic substance banned in food production) to make the dried tofu sticks appear brighter and chewier. The Center for Disease Control and Prevention estimates that more than 76 million people fall sick from food related illnesses yearly, leading to more than 300,000 hospitalizations and 5,000 fatalities (Surak, 2007). There is a need to study the risks in the food supply chain. Through our Bayesian model, we hope that a better understanding can be obtained from the inherent risk in the food supply chain especially the issues on process and quality. The rest of the paper is organized as follows. Section 2 reviews the extant literature. Section 3 develops the model. Section 4 provides the case example and Section 5 concludes.

Table 1: Ten major ten food safety incidents in China (2010-2013)

	1	2	3	4	5	6	7	8	9	10
2010	Chemical Hot pot, chemical additives	Shandong Province, toxic additives derived from chemical synthesis	Hubei province, Synutra a food nutrition firm added hormones into milk powder	Hebei, Qinghai and other provinces, excess melamine milk powder making a comeback	Beijing, Mushrooms bleached with a fluorescent whitening agent	McDonald's, Chicken McNuggets, containing rubber chemical composition "PDMS"	A purple sand clay pot used for steamboats is made by mixing normal clay with chemicals	2-3 mil. tons of gutter oil produced yearly contains cancer causing aflatoxins, 100 times more toxic than arsenic.	Hainan province, poison cowpea, pesticide residues exceeds bid badly	Cakes, cookies and other food enterprises, hydrogenated oils (margarine), trans fatty acids harming health
2011	Shenyang, bean sprouts poisoned with illegal additives	Hubei province, poisoned ginger poisoned by 1 m.t. of sulphur	European baby food sold in China had excessive heavy metals (arsenic, lead and cadmium)	Fuzhou, Guangzhou, Nanjing, fake beef patties	Hualian and Lianhua supermarkets in Shanghai had tainted steamed buns	Chongqing, 2.5 tons of duck's blood soaked in formalin	Henan province, Jiyuan Shuanghui Food Co. involved in the Clenbuterol case	Beijing, popcorn buckets used in movie theatres, contain a carcinogenic fluorescent whitening agent	Taiwan, "net yuan probiotics" plasticizer （DEHP）	Ajisen Ramen, KFC, Shanxi mature vinegar," bone soup" incident, "soya-bean milk" incident, blending liquid
2012	Red Bull, additive	Old yogurt, jelly containing industrial gelatin	Hebei, a medicinal pill had industrial gelatin with chromium	"LaiYiFen" preserved food had product additives exceeding a threshold amount	Lipton tea, Green tea, Jasmine and Tieguanyin tea bags contain excessive pesticides	Jiangxi artificial pig ears made from gelatin and plastic	Shenyang, the largest black beans mill was found with 2,300 m.t. of toxic additives	Foshan, condiment companies, purchased 760 tons of industrial salt to make soy sauce	China made Strong jelly contains harmful preservatives	Yili Industrial Group had milk powder, containing Mercury
2013	New Zealand's Fonterra group's milk powder whey protein sold in China contained botulinum, a toxin	Wal-mart in Jinan, Shandong was caught selling fox meat and had donkey head hanging.	Excessive antibiotic residues found in milk in Taiwan President,	Rotten fruits used to make fruit juice for the HuiYuan brand, a large Chinese firm	Old oil re-used by Taiwan's Datong	Retail fast food (KFC, Real Kung Fu) had excessive bacterial colonies in their food	Vitamin C tablets had toxic ingredients	Presence of fake brands of milk such as Hero Nutradefense	Poisonous starch found in food additives	Cadmium rice and consumer panic, and disclosure of information

Sources: Various newspaper reports

2. LITERATURE REVIEW

The Bayesian network, also known as the Belief or Causal network, is an acyclic graph used to depict the probabilistic relationships among the variables of interest (Timo and John, 2009). It provides causal information, with nodes representing the variables, and vectors representing the relationships among the variables (Castillo et.al, 1996). Usually applied in uncertainty reasoning, Bayesian networks provide a flexible structure to frame, model and evaluate causal relationships under uncertainty. Pearl (1986) first proposed the notion of a Bayesian network to study the problem of uncertainty in artificial intelligence.

Indeed, there have been various applications of Bayesian Networks. For instance, Friedman et al. (1997) developed a Bayesian network model using a learning set to model the variables' risk categories as nodes with binary values. Thereafter, an augmented naive Bayesian algorithm was applied to learn a model structure, and to characterize their outcome variable of quality. Bayesian methods is already an attractive tool decision support system used in the medical sector (Lewis et al., 2011). On humanitarian logistics, Mitroff and Alpaslan (2003) have through Bayesian networks categorized emergencies and crises into three categories: natural disasters, malicious activities, and systemic failures. Studies have also been conducted to determine the indicators deemed useful to design for Food Chain Information in pigs (Blaha et al., 2007) and in poultry (Habtemariam and Cho, 1983; Lupo et al., 2013).

Likewise, there is a rapidly growing body of literature on supply chain risk management e.g. Goh et al. (2007), Narasimhan and Talluri (2009), Wu and Olson (2009), and Flynn (2009). The extant literature involves a number of approaches, including frameworks, categorization of risks, processes, and mitigation strategies. To manage the uncertainty involved in supply chain risk, different models have been proposed to assess risk. For instance, Li and Chandra (2007) have proposed using Bayesian analysis to model information and knowledge integration of complex networks. Wu et al. (2008) use Monte Carlo simulation to evaluate the risks associated with vendor selection. Tang et al. (2008) apply a fuzzy genetic algorithm to evaluate the logistics strategies to lower supply chain risk. Bogataj and Bogataj (2007) use parametric linear programing based on net present values to estimate the vulnerability supply chain. Goh et al. (2007) apply a stochastic bi-criterion algorithm to analyze a multi-stage global network problem, maximising profit maximization and minimizing risk. Zhang et al. (2011) contribute to the research on supply chain visibility from an inventory visibility perspective.

As food safety risk exists in every part of the food supply chain, our paper therefore seeks to focus on food safety evaluation and food supply chain risk. We choose to do so as food safety is affected by the process of handling and transportation, and the quality of the product transformation process from farm to table.

3. MODEL DEVELOPMENT

We first begin with some mathematical preliminaries. Consider a finite set **U** $=\left\{X_1, X_2, \ldots X_n\right\}$ of discrete random variables where each variable X_i may take on values from a finite set, denoted by $V\left(X_i\right)$. We use capital letters such as X, Y, Z for the variable names, and lower-case letters such as x, y, z to denote the specific values taken by those variables. The variable sets are denoted by boldface capital letters such as **X,Y,Z,** and assignments of values to the variables in these sets are denoted by lowercase letters **x,y,z.** We use **V(X)** in the obvious way. We let P be a joint probability distribution over the variables in **U**, and let **X,Y,Z** $\subseteq$ **U**. Then, **X** and **Y** are conditionally independent given **Z**, if ∀ **x**∈V(**X**), **y**∈V(**Y**), **z**∈ V(**Z**), P(**x**|**z,y**) = P(**x**|**z**) whenever P(**y,z**) > 0 (Pear 1988; Friedman, et al. 1997).

The Bayesian network over a set of random variables **U** is a pair defined as follows.

$$B = \langle G, \theta \rangle \tag{1}$$

The first component, *G*, is a directed acyclic graph, whose vertices correspond to the random variables $X_{1,} \ldots, X_n$, and whose edges represent the direct dependencies between the variables. Each node in *G* denotes a random variable, while the edges denote the probabilistic dependencies among the corresponding random variables. *G* encodes independence assumptions, in which each X_i is independent of its non-descendants given its parents in *G*. The second component θ denotes the set of parameters that quantify the network. For each value x_i of X_i, $pa(X_i)$ is the set of parents of X_i in G. It contains a parameter

$$q_{x_i | pa(x_i)} = P\left(x_i \middle| pa(x_i)\right). \tag{2}$$

So, a Bayesian network *B* defines a unique joint probability distribution over **U** given by

$$P_B\left(X_1, X_2, \ldots X_n\right) = \prod_{i=1}^{n} P_B\left(X_i \middle| pa(X_i)\right) = \prod_{i=1}^{n} q_{X_i | pa\left(X_i\right)} \tag{3}$$

If X_i has no parents, then its local probability distribution is said to be unconditional, else it is conditional (Ben-Gal, 2007). If the variable represented by a node is observed, then the node is said to be an evidence node, else the node is said to be hidden or latent.

We now introduce the Bayesian Network method into food safety evaluation according to their processes and dependencies, to derive the conditional probability of a particular food safety risk. The steps for doing so are as follows:

(1) Identify risk factors: For a specific food, analyze the risk factors in the material, information and capital flows. Evaluate them and select the risk factors based on a set of possibilities.

(2) Analyze the initial risk events: The initial event (risk factor) is the starting point of downstream risk consequences in time and space.

(3) Build Bayesian Network model: For different initial events, the food supply chain will offer different responses. Therefore, we identify the development process of the different responses to the risk events.

(4) Evaluate the probability of each node: To obtain the conditional risk probability of each node in the Bayesian Network, we apply methods such as expert judgment, or experience.

(5) Analyze the consequences: Different chains of events will lead to different consequences. These consequences include the event at the time of impact and the long-term effects on personnel and environment. So the consequences of the same food safety risk of an incident should be analyzed since they may be different.

(6) Rank the risks: The occurrence probability of a food safety risk is determined based on Bayesian networks. For the same consequence, the different risk factors can be ranked. The comparison of the result of risk assessment and food security objectives can be used by a decision maker to choose or modify the food risk control measures or to take preventive measures for a potential food safety risk incident.

To establish the food risk assessment model, the interaction and the relationship between each link in the food supply chain must be considered. After establishing the corresponding network model, and using historical data to determine the relationships between the various risk factors, the conditional probability of each node in the network can be determined. Based on the Bayesian network of a food supply chain, and using a probability distribution corresponding to each risk factor, the value of each risk factor can be calculated.

Risk assessment of a food supply chain is a prerequisite for risk control, which is the foundation to developing and implementing risk planning. However, building a good partial model based on a Bayesian network is difficult, as the data on the conditional probabilities of the risk factors are hard to obtain.

4. CASE EXAMPLE

We visit the toxic tofu case (Yuba) as an example for analysis. The major processes of Yuba include: pick/choose beans, remove the peel/peel, soak beans, grind pulp, fling pulp, boil pulp, filter pulp, extract Yuba, dry, and pack. In the Yuba case in China, illegal additives were added during the process of cooking the pulp. Figure 1 shows the Bayesian Network for this example.

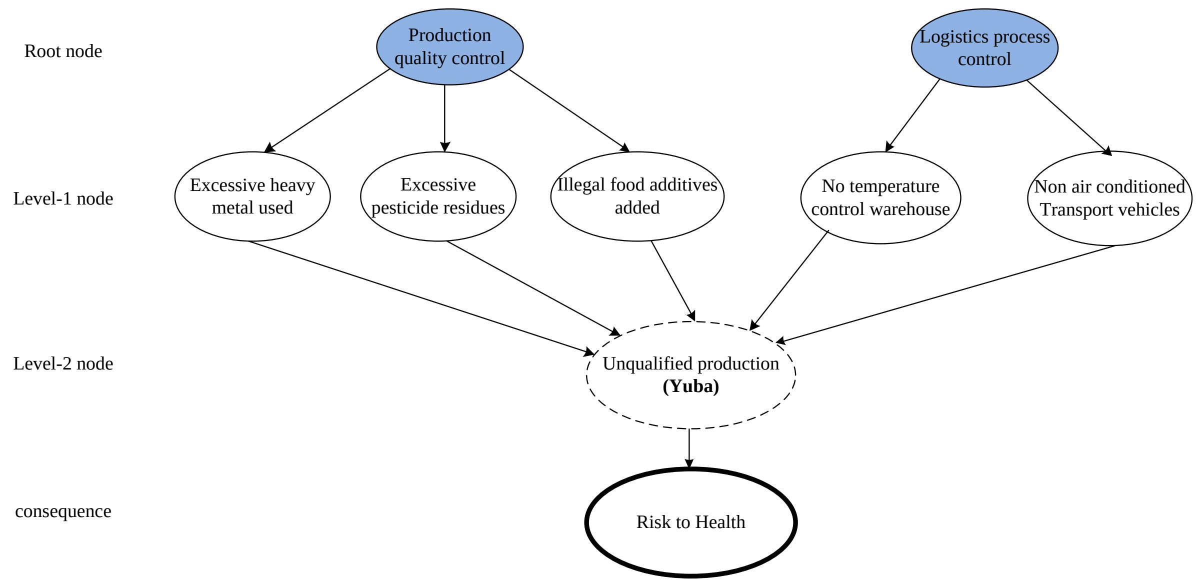
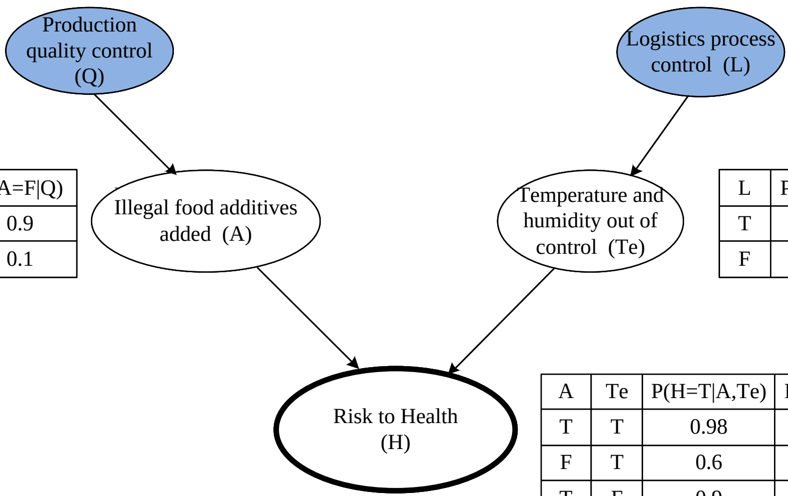


Figure 1: Yuba supply chain risk assessment model based on Bayesian network

Note that even in the binary case, the joint probability distribution has size O(2^n), where n is the number of nodes in the graph making it NP-hard computationally. Hence, in Figure 1，there are O(2^9)=512 probability distributions. In the Yuba case, illegal food additives is the most important factor in chemical contamination, and temperature control is more important for food in both the storage warehouse and transport vehicles, we remove the other nodes. Figure 2 shows a partial Yuba supply chain risk assessment model and the probability calculations based on a Bayesian network, and Table 2 describes the symbols. The relationship between nodes Q, L and H in the partial Yuba supply chain risk assessment model are now mapped accordingly.

Table 2: Meaning of Symbols

Symbol	Meaning
T/F	True/ False
Q	Production quality control
L	Logistics process control
A	Illegal food additives added
Te	Temperature and humidity out of control
H	Risk to health



Q	P(A=T|Q)	P(A=F|Q)
T	0.05	0.9
F	0.95	0.1

L	P(Te=T|L)	P(Te=F|L)
T	0.2	0.9
F	0.8	0.1

A	Te	P(H=T|A,Te)	P(H=F|A,Te)
T	T	0.98	0.02
F	T	0.6	0.4
T	F	0.9	0.1
F	F	0	1

Figure 2: Partial Yuba supply chain risk assessment model based on Bayesian network

Next, Table 3 shows the posterior probability of node H under given the likelihood estimates on nodes Q and L. Clearly, event Q dominates in that regardless of the effort put in to manage the logistics process of transportation and warehousing well, controlling for the product quality of the food production is more important as shown by row 1 of Table 3. Further, from Table 3, clearly if we do not focus on improving the logistics process control, but instead improve on the production quality control, then the likelihood of a safety risk drops from 0.88 to 0.56 (36.4%). However, if we focus on storage and handling and ignore the production quality, the likelihood of a supply chain risk decreases by only 11.4% (from 0.88 to 0.78). In short, in the Yuba case, controlling for production quality at source is important.

Table 3: Posterior probability of node H=T based on nodes Q=T and L=T

P (Q=T) \ P (L=T)	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0.1	0.88	0.87	0.86	0.84	0.83	0.82	0.81	0.79	0.78
0.2	0.84	0.82	0.81	0.79	0.78	0.76	0.75	0.73	0.72
0.3	0.80	0.78	0.76	0.74	0.73	0.71	0.69	0.67	0.65
0.4	0.76	0.74	0.72	0.70	0.67	0.65	0.63	0.61	0.59
0.5	0.72	0.70	0.67	0.65	0.62	0.60	0.57	0.55	0.52
0.6	0.68	0.65	0.63	0.60	0.57	0.54	0.51	0.49	0.46
0.7	0.64	0.61	0.58	0.55	0.52	0.49	0.46	0.42	0.39
0.8	0.60	0.57	0.53	0.50	0.47	0.43	0.40	0.36	0.33
0.9	0.56	0.52	0.49	0.45	0.41	0.38	0.34	0.30	0.26

Note: Entries in the above represent the values of P (H=T)

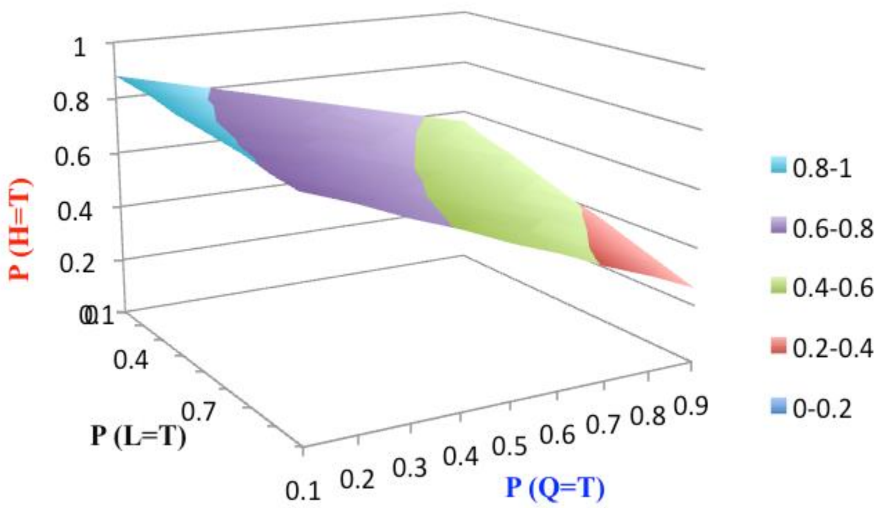


Figure 3: Relationship between nodes Q, L and H

5. CONCLUDING REMARKS

In this paper, we have applied Bayesian network modeling to food safety in food supply chain management. Through our illustrative case study, we show that managing the product quality control in the manufacturing cycle is still more important than ensuring compliance in the logistics process. Future work will look at the extended supply chain to include more variables of interest.

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SUPPLY CHAIN FOOD CRIME & FRAUD: A SYSTEMATIC LITERATURE REVIEW OF FOOD CRIMINALITY

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ABSTRACT

There is a growing awareness by businesses, consumers and Governments of the need to understand and police food crime and fraud - underpinned by an extensive evidence of the scale of the challenge of food fraud and food crime. To achieve a cross-functional appreciation of these topics will require a multi-disciplinary approach and a process of collating and mapping information to facilitate support to both academics and practitioners. This paper uses the systematic literature review process (Denyer and Tranfield, 2006) to navigate through and provide a gap analysis from multidisciplinary sources of literature with the keywords 'food fraud' and 'food crime'. The focus of the paper is on considering the variables known to affect these two domains and subsequently the information available to help understand and secure the food supply chain. The analysis of the literature found demonstrates divergence in views across different research areas (particularly in terms of articles versus peer reviewed research), and in doing so identifies areas for future research.

INTRODUCTION

Modern organisations have received much attention on the subject area of Supply chain risk management (SCRM), which is a significant field of study for both researchers and practitioners alike (Sodhi et al, 2012). However, the extensive scope of current SCRM research, allied to a lack of industry specific focus that spans abundant numbers of global business sectors, engenders indecision and trepidation in terms of how to holistically secure Supply chain operations are (Sodhi & Tang, 2012).

Therefore, the traditional view of SCRM greatly underestimates the scale of real challenges to their security, and principally (merely) encapsulates aggregate event-driven cause and effect relationships, which restricts an organisation's ability to comprehend vulnerability in their operations in order to mitigate risk (Bacon, 2014; Christopher and Lee, 2004; Punter, 2013). Complexity and a lack of SCRM appreciation is magnified when coupled to increased interest in and concern from businesses, Governments and consumers to understand the vectors of food supply-chain criminality. This when seen in the context of the anticipated 50% increase in food demand by 2030 (House of Commons International Development Committee, 2013), and intensifying global trends in food criminality, lead the authors to argue that the 'perfect storm' is brewing for today's global society.

Although food criminality is concomitant with the risks that any supply chain is exposed to, Spink and Moyer (2011) suggest that effective mitigation strategies will arise from a multi-disciplinary approach (e.g. consumer activity, food law and food science). Therefore, in order to achieve a cross-functional appreciation of research, the current extensive body of knowledge ('food fraud' 7,623 articles, 1,456 peer reviewed & 'food crime' 9,839 articles, 1,150 peer reviewed) requires collating and mapping to facilitate its use to support academics and practitioners in achieving an all-inclusive value chain approach to combating food criminality. This will require focusing on the gaps in current research to eradicate the opacity and lack of comprehension of SCRM in the global food supply chain marketplace.

The purpose of this paper is to explore the current evidence base in the areas of supply chain 'food crime' and 'food fraud'. The process will explore topics covered within academic literature and compare and contrast these against live themes that are developing within the industry and popular press to identify areas of future research.

LITERATURE REVIEW - TRADITIONAL SCRM

The lack of a focus on the significant challenges to global supply chains is supported by the Organisation for Economic Cooperation and Development (OECD), who explicate supply chain risks as encompassing infectious disease, natural disaster, technology or terrorism/crime. These are measured as aggregate events, fostering greater ambiguity within the SCRM field about antecedent drivers of the risk event itself (OECD, 2003). In an attempt to espouse a greater understanding of supply chain risk, the Allianz risk register (Allianz, 2014) categorises supply chain events, asserting that the majority of business disruption can be directly related to supply chains.

Nevertheless, these conclusions do not yield clarity around cause and effect relationships that could be leveraged by academic and practitioner communities alike to develop a deeper understanding of how to practically achieve SCRM mitigation to some acute forms of risk. Nevertheless, Allianz's register allows academia and industry to identify developing themes in the SCRM field of study such as fraud and terrorism, now a top 10 risk and an area that comprises 25% of overall business risk.

The rise of fraud & terrorism as a business risk is further validated by a report from the risk management group Kroll, who conclude that 70% of global organisations encounter criminality in the guise of fraudulent activity, with 67% of these instances involving at least one insider. Furthermore, 56% of European companies were exposed to supply chain fraud in 2012 versus 77% in 2013 (Kroll, 2014), conveying an appreciation as to why Forbes 500 company chief executives and World Economic Forum are reported to have serious concerns over resilience supply chains (World Economic Forum, 2013).

LINK BETWEEN SCRM AND FOOD SUPPLY CHAINS

Our analysis of the literature indicates that within the areas of business risk and resilience, publications focus on aggregate event-driven cause and effect relationships. Events in the food supply chain over the past two years has evidenced a disconnect between outcomes of research and actual impact. Little is being done to limit the exposure to risk and provide support to the food businesses of Europe, of which a majority are food manufacturing companies, with the UK food manufacturing alone comprises 310,000 food businesses, 3.8 million employees and £96 billion (7.3% GVA), (European Commission, 2014). In a bid to close the gap, DEFRA (2013) cites the need to embrace collaborative practices that augment nutrition, safety and quality of food products through enhanced innovative platforms which leverage research tools to understand and foster development of global food security databases, predominantly for the SME.

Compounding the issues around traceability in food supply chains, Nelleman et al (2009) claim that 1.3 billion tonnes of food disappears without trace within food supply chains annually. This finding, which elicits questions as to *where* does this food disappear and - if we cannot track what goes out of the food supply chain - how can we be sure about what comes in? They [Nelleman et al., 2009] further report how, upstream in food supply chains, under-developed regions have commenced efforts to curb risk by prohibiting food exports. However the Africa Research Bulletin (2013) argues that this has only driven threats and risks to food security deeper underground, fostering greater black market cross-border trading and allowing legislation to fund the threat they are trying to avoid and strengthening the traceability challenge around food supply chains. Perhaps this black market issue and the possibility of increasing rather than reducing opacity, is why DEFRA has been reticent to engage in tougher regulation relating to food supply chain traceability, citing concerns over price and nutrition being a higher priority for the public than food crime (DEFRA, 2013).

This lack of a cohesive understanding relating to current research and methodology is stifling accountability and traceability within the global food supply chain and is an area that academia and practitioners need to understand building upon and strengthening current research.

METHODOLOGY

The systematic literature review (SLR) process employed in this research, provides a structured understanding and research gap identification for prospective researchers (Denyer & Tranfield, 2006). Further supporting the need for adopting the SLR approach, Tranfield et al (2003) claim that masses of subjective and often inconsistent literature resides within fields of study and through this process [systematic literature review] clearer identification of gaps and data will become prevalent. In doing so, systematic classification of current literature was carried out which deployed an iterative process of define, interpret and perfect across many databases manually assessing significance of literature (Clark & Oxman, 2001; Tranfield et al, 2003).

The keywords used for the SCRM search were "Governance", "Inventory", "Procurement", "Resilience", "Risk" and "Traceability" all prefixed by the term "Supply chain". FSCRM while using the same pre-fix [Supply chain] employed "Food crime" and "Food fraud" as the search criteria. These keywords were selected owing to the authors preceding experience in the SCRM discipline, coupled to wider dialogue with academics and practitioners within the Supply chain field of operation.

In the case of this Systematic literature review (SLR) a variety of databases and journals were initially screened and in order to maintain relevance to the subject field, inclusion criteria was concentrated on the Association of Business Schools (ABS) journal listings due to their global acceptance, impact and standing in business research.

The final phase of screening appraised outputs from the UK Governments report into Supply chain Food criminality (Elliott, 2014). A comparison was made of SCRM keywords against those contained in the report to indicate relevance with current practitioner versus academic output to gain an understanding of the research gaps, which were categorised as either food crime (e.g. counterfeiting) and food security (e.g. food shortages).

PRESENTATION OF FINDINGS

Significant research areas of SCRM concern inventory, procurement and risk (Fig.1) practices. However within the food supply chain risk management (FSCRM) sphere there is insufficient correlation to risk management (Table 2), which is of concern, given the acknowledgement of the role of inventory and procurement strategies in mitigating supply chain risks (Sodhi & Tang, 2012).

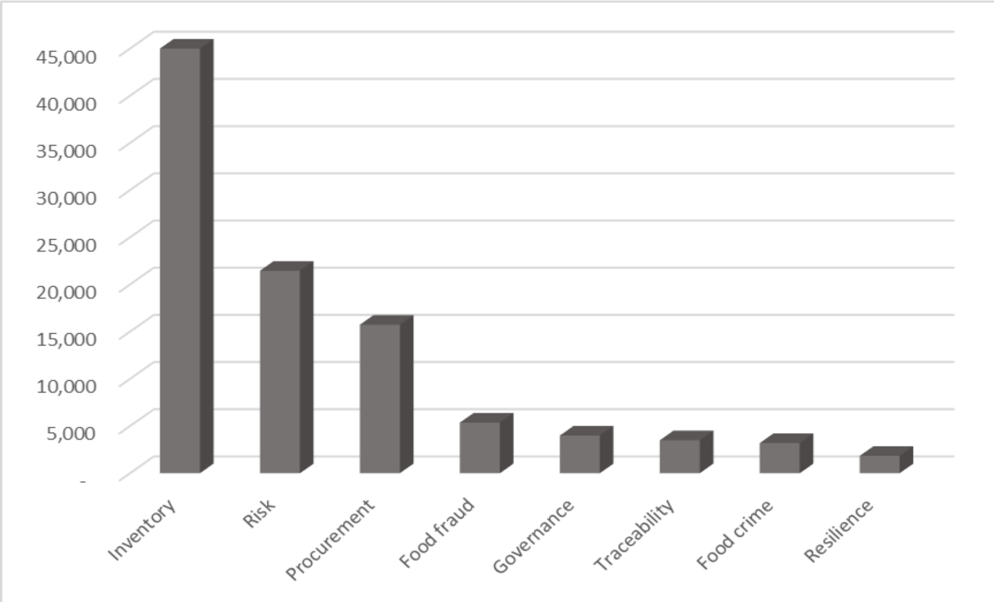

Fig.1: Supply chain journals by type and number

Furthermore, the amount of published academic research associated with the topics of supply chain food fraud and food crime's relatively low when compared to those articles published within the business and popular press (Fig.2). A clear divergence between the two [Press & Academia] suggests a need for academia to support the needs of business and Governments in the area food criminality and the impact on the supply chain. It should be noted that the increased press interest has been on the rise since the horse meat scandal of 2013, and the trend is still ascending and something that should not be overlooked by academia.

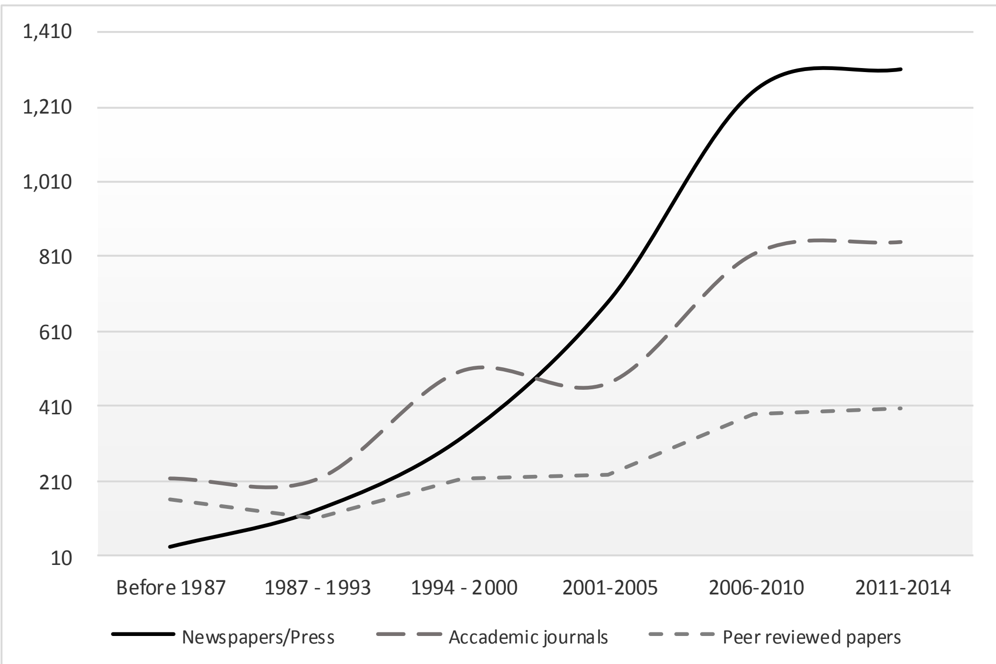

Fig.2: Academic research versus business and tabloid publication 'Food crime'

Topic	Count	Percentage
Crime	155	18%
Sociology	128	15%
Public Health	80	10%
Economics	73	9%
Food	71	8%
Obesity	61	7%
Food Supply	39	5%
Criminology	34	4%
Diet	34	4%
Violence	33	4%
Criminal Law	21	2%
Fraud	19	2%
Food Safety	18	2%
Food Contamination	17	2%
Adolescents	15	2%
Food Industry	13	2%
Food Inspection	10	1%
Food Law	10	1%
White Collar Crime	10	1%

Table 1: Themes within peer reviewed 'Food crime' journals

It is one thing recognising the clear divergence between academic and business literature on this topic, but quite another to examine existing research to investigate current SCRM thinking to support further research in the field of FSCRM. Therefore when the topics of 'supply chain food crime and fraud' are explored, an identifiable abundance of topics pertaining to areas of public health and diet are observed, validating the DEFRA position (DEFRA, 2013) that the public are more anxious about matters of diet and security of supply rather than criminality. Furthermore, one could argue that if academia is not cognizant of current market trends (Fig.1) then incorrectly targeted research could be driving opinion and thus creating inconsistent and less relevant focus areas for FSCRM.

Topic	Count	Percentage
Business logistics	10,520	14%
Supply Chain Management	8,321	11%
Supply Chains	7,082	9%
Transportation Management	6,203	8%
Experiment/Theoretical Treatment	5,435	7%
Management Research Network	4,505	6%
Management/Marketing	4,462	6%
Risk management	3,622	5%
Operations research	3,416	5%
Experimental/Theoretical	3,318	4%
Inventory control	2,622	4%
Supply Chain	2,496	3%
Purchasing	1,544	2%
Stockpiling	1,254	2%
Demand	1,165	2%
Electronic commerce	1,134	2%
Retail trade	1,087	1%
Inventory	920	1%
Production management	738	1%

Table 2: Key themes in traditional SCRM not within the 'Food crime' field of study

Perhaps the most surprising elements concerning FSCRM is the lack of relation to traditional SCRM models and theories. The Chartered Institute of Procurement and Supply (CIPS, 2013) cite the importance for industry to be more transparent when it comes to trading and educating supply chain partners in the need to identify fraudulent activity such as bribes. However, areas that underpin the defense mechanisms in SCRM are devoid within the FSCRM arena, arguably identifying another gap that academia and practitioner should focus research efforts on closing.

RECOMMENDATIONS FOR FUTURE RESEARCH

A change in the manner in which food supply chains are investigated is essential, particularly in the underrepresented SME sector (99% of European food businesses are SME's). At present a high priority area for DEFRA is to cultivate research that delivers a framework for businesses to collaboratively understand and mitigate against food supply chain risk. Elliott's (Elliott, 2014) Government report supports this notion, but as yet academia offers little solution as to how we plug this knowledge gap with supply chain professionals in protecting food supply chains from the outsider threat. Likewise, it certainly hasn't considered consumer and activist concerns or needs, that companies may struggle or be unable to deliver, for example, achieving assurance that there is total supply chain security against fraud / adulteration.

The areas of inventory, procurement and risk management practices which are identified and observed in current SCRM research - and supported by globally leading professional bodies (CIPS & CILT) - are at this time limited within the FSCRM literature. These variables are necessary to mitigate supply chain risks and build resilience, within food supply chains and hence require further targeted research. It has been muted by Governments and Intelligence agencies that criminals see the food supply chain as an easy target (Economist, 2014), and it is incumbent on academics and practitioners to step forward collaboratively, deploying allied research in the identified areas (inventory, procurement and risk) to combat this external threat to food supply chain integrity and bridge an apparent gap between research and practice. Lack of Trust and an Increase in Opportunistic behavior in the upstream food supply chain are two variables that require further research. This should also be studied within the auspices of potential legislative tools, the use of new technological systems and a framework of the factors that increase Food Fraud/ Crime and those which can help reduce it (Fig.3).

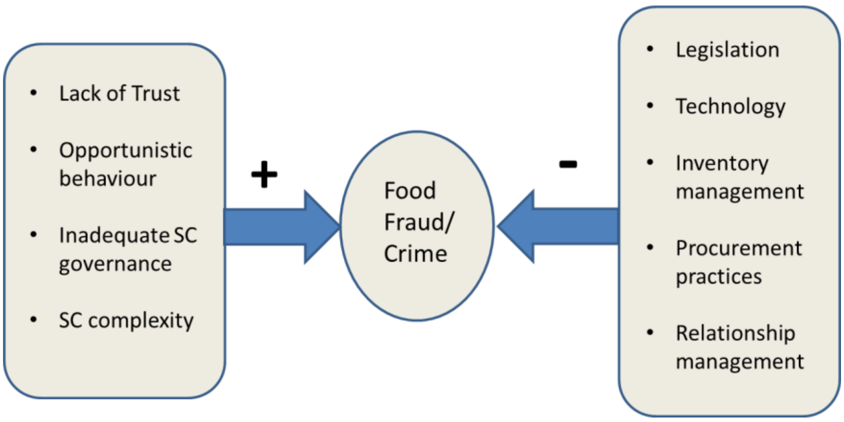

Figure 3: Factor relating to Supply chain crime

It is worth noting that a year on from the Elliot report little change is seen in the landscape of supply chain food crime (Noble, 2014) and we argue that much of this is attributed to the lack of understanding across tiered networks. It is also observed from the literature that the focus in the food crime and fraud research is more on security of supply rather than mitigation of risk and criminality. The drivers for change will be initiated through targeted research that will increase engagement and raise the profile of food supply chain risk mitigation strategies.

Finally, there is a further challenge in this area with confusion over terminology - as highlighted by the Elliot report (Elliott, 2013) - where US led systems prefer the use of 'fraud' and European based research adopts 'crime', which creates another divergence of topics within the research. The divergence of terminology use is creating confusion in the system and the authors support the need for academia and practitioners to utilise the term 'food crime' in order to build and strengthen a coherent body of knowledge.

In conclusion, much has been learnt over the years within traditional SCRM that can translate across many sectors including food however none of these seem to have been adopted by researchers charged with adapting tools and techniques. The clear divergence between academic journals, practitioner and news articles in food crime and public interest requires further research to raise awareness and delivery of a body of knowledge in FSCRM.

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PRICE SETTING STRATEGIES OF SMALL-SCALE TRADER FOR PERISHABLE PRODUCT

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ABSTRACT
This paper concerns with price strategies of Small-scale trader for perishable products under price control of Large-scale trader. If Small-scale trader follows Large-scale trader's lower price strategy, total sales will decrease. On the other hand, if Small-scale trader chooses high price strategy against Large-scale trader, most consumers will show unfavourable and unacceptable attitudes. Customer who buys the higher price product will help such Small-scale trader when shipped inventory is limited little. In this paper, we present the price setting problem of Small-scale trader and present mathematical model to analyse the problem. In the model, we assume that upper limit purchase price which corresponds to customer's behaviour is random variable according to probabilistic distribution. We present some numerical experiment representing potential consumer's behaviour.
Keywords: Fresh Foods, Inventory Theory, Stochastic Model

INTRODUCTION

Recently, Farmer's Market has obtained much attention in Japan, where fresh agricultural products are traded between farmers and consumers. Products traded in the market have advantages in freshness and safety because production process is unambiguous. At the market, decision making on management, e.g. production, sales and inventory, is primarily responsible of farmers. However, these have been executed according to their experience and leaders opinion without theoretical background.

Takeno et al. (2013b) carried out a questionnaire investigation and showed some analysis on farmers' decision making process. Through the investigation, they have clarified that farmers can be categorized into three groups according to their production size. Price setting of Medium-scale farmers is almost same with average price outside the market. Those of Large-scale farmers and Small-scale farmers are lower than average and higher than average respectively. The reason is explained as Large-scale farmers prevent themselves from holding dead stock of perishable products.

We have focused on the strategy of Small-scale farmers in which Large-scale farmer inflicts lower price on Small-scale farmers. As number of their products on hand is limited little, they have to set higher unit price to achieve higher income. On the other hand, expensive unit price is unfavourable and unacceptable by consumers. Therefore, it is important to seek highest unit price favoured and accepted by consumers as the market strategy for Small-scale farmers.

The problem is apparently same with Newsvendor problem; see Hiller and Lieberman (2010) for example. However, Newsvendor problem model cannot directly apply to the problem because expected demand distribution is different. In general, random variable of demand distribution is described as number of demand where price becomes the random variable in the problem. Therefore, Newsvendor problem cannot be applied to the problem.

This paper is a companion of Takeno et al (2014), where price setting problem model is extended. The purpose is to present rationality of small-size farmer's decision and strategies. First of all, we rebuild a mathematical model characterized with introducing stochastic process in consumers purchasing price. We present some numerical examples representing potential consumers and numerical experiment on a certain consumer-product matching process. Secondary, we present a numerical experiment based on proposed model to see potential effect of proposed model in Small-scale trader's strategy.

PRICE SETTING PROBLEM ON SMALL-SCALE TRADER FOR PERISHABLE PRODUCTS

Suppose that a market consists of two traders, one is Large-scale and the other is Small-scale, and lots of customers. Traders sell almost similar selection of perishable products such as green vegetables. Each trader decides price of their products. Here, we assume that selling volume of the Large-scale trader is ten to hundred times greater than that of the Small-scale trader. We also assume that total demand of the customers is much larger than total shipping volume of the Small-scale trader.

Consider three alternatives strategies of Small-scale trader's: lower price strategy, middle price strategy and higher price strategy. Middle price corresponds to average price of the product outside the market. As the products expected to be deteriorated in the certain term, Large-scale trader is going to sell out of his inventory even if price gets lower. Therefore, the price of Large-scale trader has a tendency to be lower particularly when inventory level is larger. If Small-scale trader followed Large-scale trader's lower price strategy, total sales would decrease compared with middle price strategy. On the other hand, if Small-scale trader chose higher price strategy against Large-scale farmer, consumers would show unfavourable and unacceptable attitudes.

In the model, we assume that acceptable price of each customer can be regarded as random variables, and that the acceptable price varies according to certain random distribution. A few customers may buy the products at high price. If number of the customers is larger than the inventory, the Small-scale trader obtains profit. To establish the Small-trader's strategy, it is useful that relation among number of the customers, set price and the profit.

EXTENDED SINGLE PERIOD MODEL FOR PERISHABLE PRODUCTS

The problem seems to be a newsvendor problem (Hiller and Lieberman 2010). Generally, newsvendor problem is conducted under assumption of price is constant. Suppose a random variable X corresponding to sales amount, namely amount of consumer's demand of the product. Let $g(x)$ be a probability density function where $X < x$. Figure 1 shows the probability density function $g(x)$. Shape of $g(x)$ is expected to be unimodal.

Takeno et al (2014) proposed a mathematical model for price setting problem at farmer's market, where sales amount is assumed to be constant. In fact, delivered products to the market is limited to certain amount. Suppose a random variable Y corresponding to sales price. According to the price which is determined by owner sales tendency will changes. Outcome is evaluated with the probability of sold out. Let $h(y)$ be a probability density function where $Y < y$. Figure 2 shows the probability density function $h(y)$.

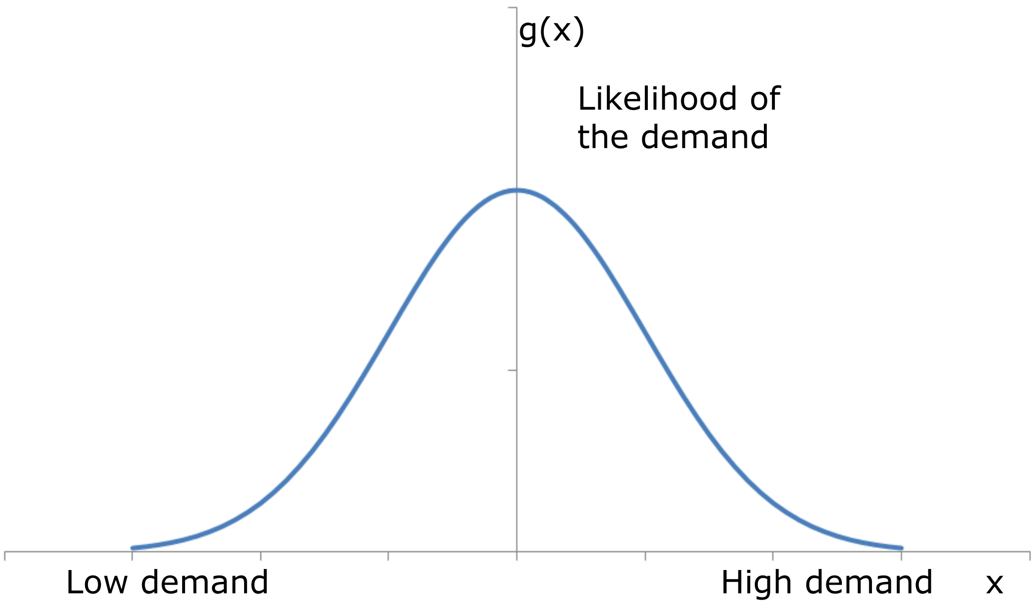

Figure 1 Probability density function of general newsvendor problem

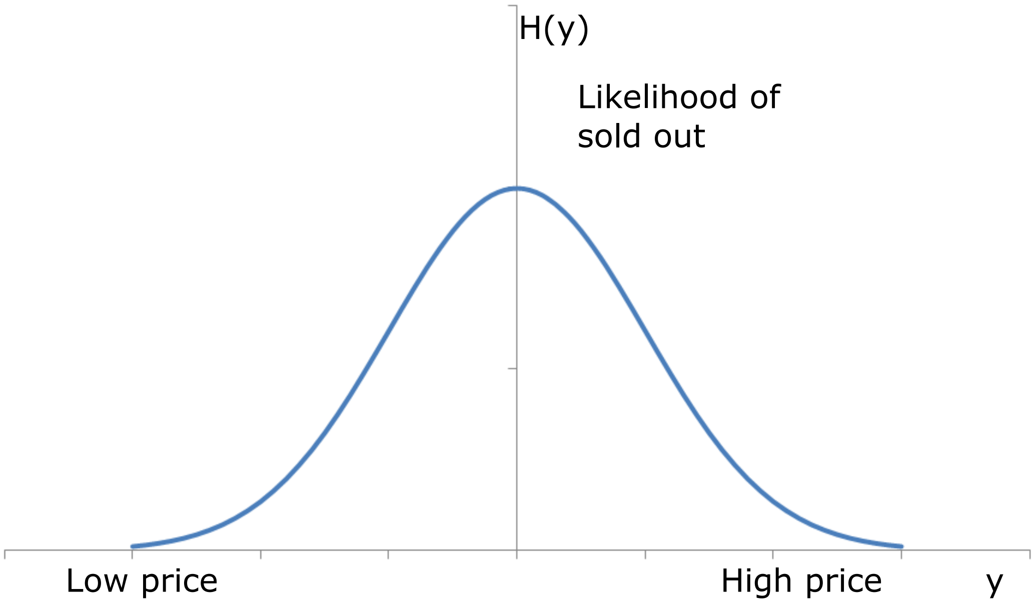

Figure 2 Probability density function of price setting problem of Takeno et al. (2014)

According to Price Elasticity, demand is expected to be larger if sales price gets lower. Therefore, monotonically decrease function will be suitable for shape of h(y). On the other hand, sold product is not always lower price product through the observation of consumer's behaviour in the market. One reason for this is that product identity is not always applicable. Fresh vegetables differ on each piece because their production process is much depended on nature. Lower price products have often some problems in their quality such as damaged surface. Namely, price of the product is roughly determined outside of the market and consumer's behaviour in the market is much depends on small difference among products. Therefore, shape of h(y) is also expected to be unimodal function.

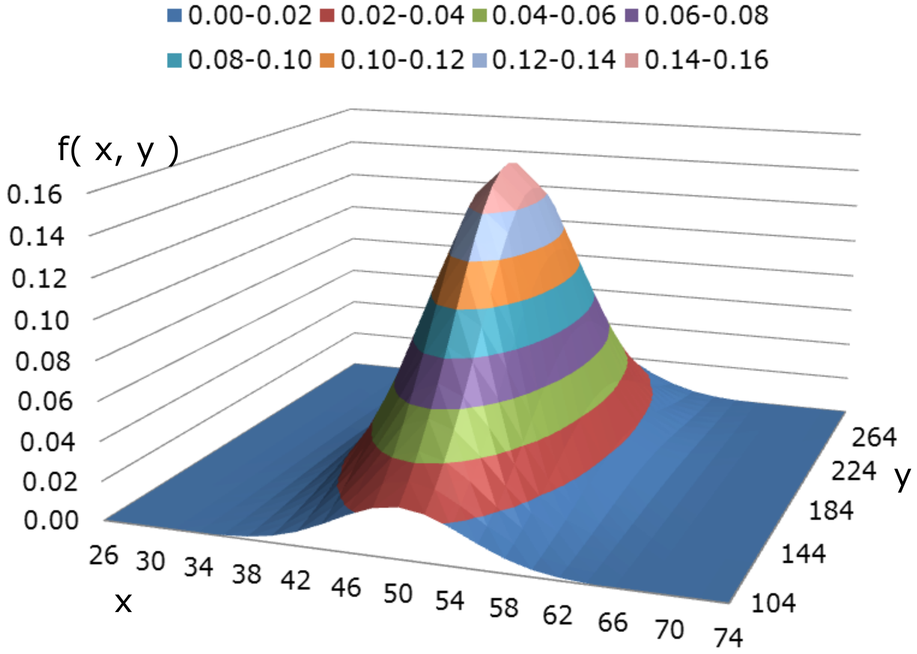

Figure 3 Example of joint probability density function of extended single period model for perishable product (μ_X=50, σ_X=5, μ_Y=200, and σ_Y=50)

Above two models are in relation of that constraints and random variables are exchanged. And two random variables are determined independently. Here, suppose a joint probability distribution f(x, y) as X < x and Y < y, where random variables are X: demand and Y: price respectively. Figure 3 shows an example of this relationship, where μ_X=50, σ_X=5, μ_Y=200, and σ_Y=50. We have g(x) and h(y) from f(x, y) whether X or Y is sets to be constant.

Figure 4 shows two examples of bird's-eye view of f(x, y) characterized with relationship between demand and price. For descriptive reason, we define Type A and Type B respectively. Type A corresponds to a market with products characterized that lower price product obtains larger demand. This characteristic can be seen with mature market such as commodities. On the other hand, type B

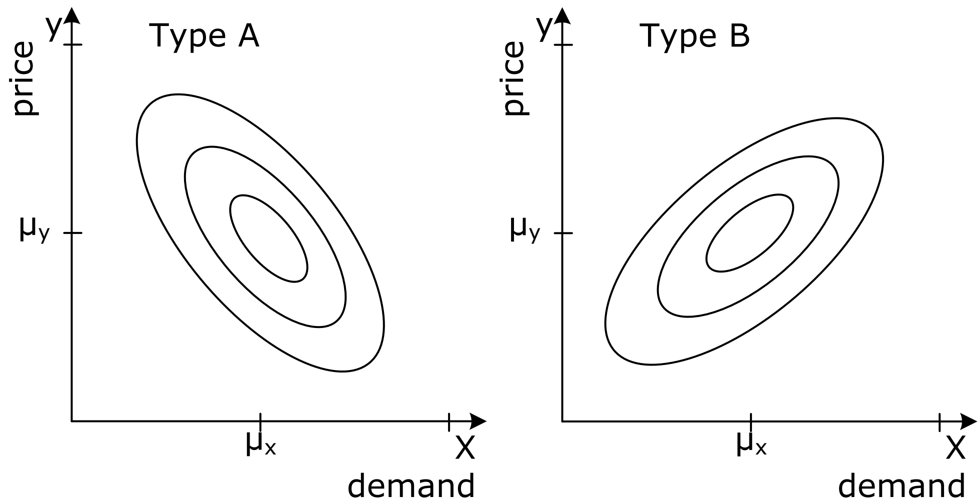

Figure 4 Examples of joint probability density function f(x, y)

corresponds to a market of a product characterized with that attractiveness of the product is higher than its price. This tendency can be seen in stage of growth especially in high technology product. With the proposed model, we can unify newsvendor problem and price setting problem in farmer's market. The model has potential to explain characteristics of products with parameters in joint probability distribution.

NUMERICAL EXPERIMENT

Suppose that a farmers' market in which customers buy product A. There are two farmers belong to the market. One farmer is Farmer F_1 who is a Large-scale farmer. And the other is Farmer F_2 who is a small scale farmer. Consumer C_i, i = 1, 2,…, n, has upper limit U_i on the price to buy product A. U_i is a random variables and has normal distribution with parameter μ_C and σ_C. Let P_1 and P_2 be a price of A produced by large scale famer F_1 and F_2 respectively. According to Takeno et al. (2013b), Large-scale farmer has tendency to set price lower than the other. Therefore we have $P_1 \leq \mu_C < P_2$. Let S_1 and S_2 be shipping volume of product by farmers F_1 and F_2 respectively. From the definition, S_2 is much smaller than S_1, $S_2 \ll S_1$. Let ρ be a ratio of production amount of S_2 to that of S_1, $\rho = S_2/S_1$. We have $0 < \rho < 1$. In actual farmers' market, ρ is expected to about 0.01.

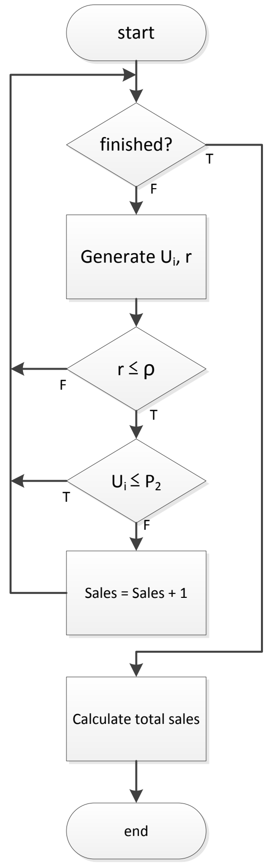

Figure 5 Overall process of calculation in Numerical Experiment

We have carried out a numerical experiment for the model with the situation that number of consumers and inventory at the market is identical. In other words, $n = (S_1+S_2) = 10000$. We also have assumed that $P_1 = \mu_C = 1000$. Figure 5 shows overall process of the numerical experiment. First, we have prepared 10000 consumers with upper limit price U_i. Here, each U_i is generated with Box-Muller methods. Second, we have also prepared 10000 products of which prices are randomly selected from P_1 or P_2 according to ρ. Consumer's behaviour is represented as that 1st consumer matches 1st product. If the price of the product is lower than the upper limit U_1, then the product is sold. Continue the process until all consumers are matched with relative products.

Table 1 shows the experimental environment. We have varied several combinations of ρ and σ_C. Calculation time for the combinations is smaller than 1 min.

CPU	intel Core i7-3930K	Operating System	Windows 7 Ent
Memory	16.0GB	Coding language	Visual Basic 2012
calculation time	< 1min		

Table 1 Experimental Environment

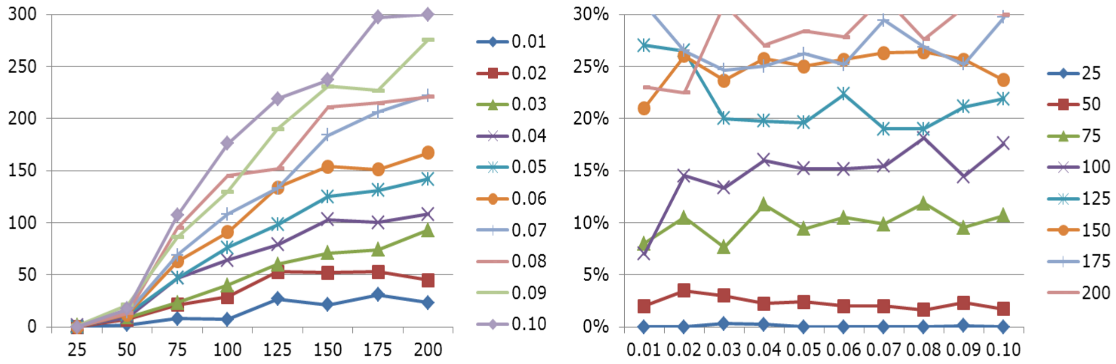

Figure 6 Effects of ρ and σ_C in Sales of Small-scale Trader (Price 1100)

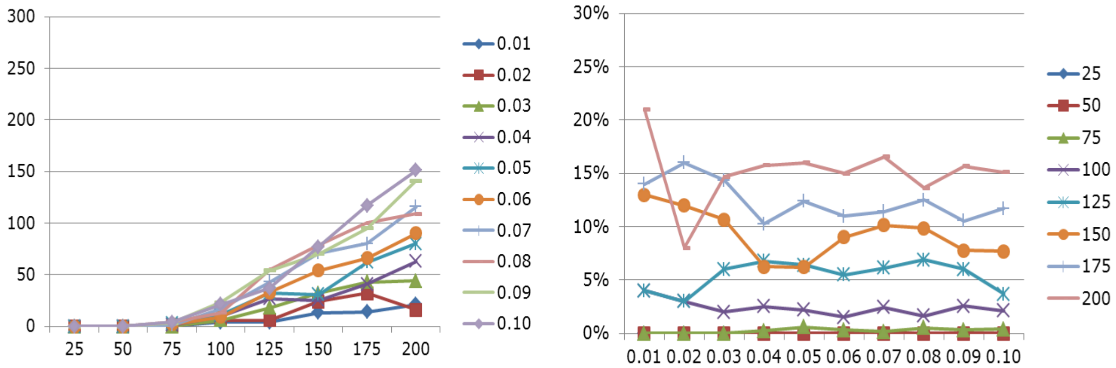

Figure 7 Effects of ρ and σ_C in Sales of Small-scale Trader (Price 1200)

Figure 6 shows effects of ρ and σ_C in sales of Small-scale trader where sold price is 1100. Vertical axis of left figure shows number of sold products. As σ_C gets larger, number of sales becomes larger. This tendency is obvious if ρ becomes larger. Vertical axis of right figure is percentages of amount of sold product in holding inventory. The figure shows that effect of ρ is rather smaller than it of σ_C. For small-scale trader, σ_C will be important parameter of customer behaviour to achieve high sales.

Figure 7 shows the effects in case of sold price is 1200. Tendency of figure is almost same with that of figure 6 except for number of sales is rather small. As μ_C is 1000, sales is not expected where $\sigma_C < 100$. High price strategy of small-scale trader is suitable only if customer's behaviour is rich in variety. In general, customer's behaviour will be given condition. Therefore, Small-scale trader should set their price to ($\mu_C + \sigma_C$) at most.

CONCLUSION

In this paper, we have focused on the price setting problem of Small-scale trader. We have proposed a mathematical model in which the upper limit price of each consumer is random variables. The model is characterized with integration of traditional newsvendor problem and price setting problem of Takeno et al (2013b), where a joint probability distribution is used to explain. The model will be useful to explain relationship between customer's demand and sold price.

We have also carried out a numerical experiment. Through the experiment, we have showed that the possibility of sold out about inventory of Small-scale trader is much depended on consumer's behaviour. A percentage of the sold out is independent from value of ρ.

Our future work is establish a mathematical model to calculate the most profitable price setting for Small-scale farmer under condition of given customer's behaviour represented in σ_C. For numerical experiment, matching process should be improved and varied. We have to consider further situation and matching process between consumer and products. Furthermore, the price setting methodologies treating in this paper can be utilized on price setting problem another niche product. Investigation about such product is also our future work.

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FACTORS AFFECTING VEHICLE UTILISATION: AN ANALYSIS OF THE RECENT DEVELOPMENT IN THE UK FMCG DISTRIBUTION NETWORKS

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Purpose: Maintaining a high level of vehicle utilisation is vital to a cost and carbon efficient transport operation. Recent statistics show that 28.6% of truck kms in the UK are run empty, with the reminder loaded to, on average, only 63% of their maximum weight capacity (Department for Transport, 2015). This paper investigates recent developments in the distribution networks of nine large companies from the UK fast moving consumer goods (FMCG) sector. We aim to identify factors that may be affecting utilisation of transport resources.

Research Approach: The analysis was completed using two comprehensive UK transport data sets for a single month in 2010 and 2013 provided by the participating FMCG manufacturing and retail companies. The data comprised of volumes of inbound, inter-depot and outbound freight flows, origins, destinations, depot location and vehicle type used. The changes in the number and locations of depots, volume of freight moved and delivery patterns over the three year period were then analysed. Finally, main causes underlying the recent developments were explored in a series of follow-up interviews with participating organisations.

Findings and Originality: Between 2010 and 2013, the amount of goods (measured as a number of pallets equivalent) delivered to customers increased by 8% and number of movements increased by 5%. The analysis indicates an increase in the frequency of deliveries, and a drop in the average order size in secondary distribution, indicating a strong Just-in-time (JIT) pressure in the sector. A number of companies in the sample restructured their logistics networks during the period; overall, fewer depots operated in 2013 compared to 2010.

Research Impact: This paper provides an insight into the latest developments in the FMCG distribution networks, and their impact on transport fleets utilisation. The key contributing factors are identified and suggestions for future research provided.

Practical Impact: The findings will support managers in the development of strategies aiming to increase operational and environmental efficiency of logistics activities in the FMCG sector.

INTRODUCTION:

As the UK economy recovers, the freight transport sector is undergoing profound changes. According to McKinnon and Ge (2006), the efficiency of transport operations can be judged by the degree to which a vehicle is utilised for inbound and outbound movements. This can be measured by calculating carrying capacity by weight/volume, loading factor and vehicle-kilometres run empty (McKinnon and Edwards, 2010). Recent statistics show that 28.6% of vehicle-kilometers are run empty and, on average, vehicles are loaded only to 63% of weight capacity (DfT, 2015). This paper aims to identify the factors that may be affecting utilisation of transport resources.

In order to identify these factors, an analytical framework (Piecyk and McKinnon, 2010) is adapted to understand the complex relationships between individual factors and their cumulative effects on the vehicle utilisation (Figure 1). The vehicle utilisation for road freight transport can be differentiated at six levels of logistics decision making within a company influenced by the following determinants (Piecyk and McKinnon, 2010):

1. *Structural factors*: number of locations, capacity of factories, warehouses and terminals.
2. *Commercial factors*: commercial decisions on sourcing, sub-contracting and distribution.
3. *Functional factors*: management of transport resources.
4. *Operational factors*: affecting the scheduling of product flow.
5. *External factors:* government regulations and tax policy, wider macro-economic trends, market dynamics and advances in technology.
6. *Product-related factors:* factors influencing nature of transport operations.

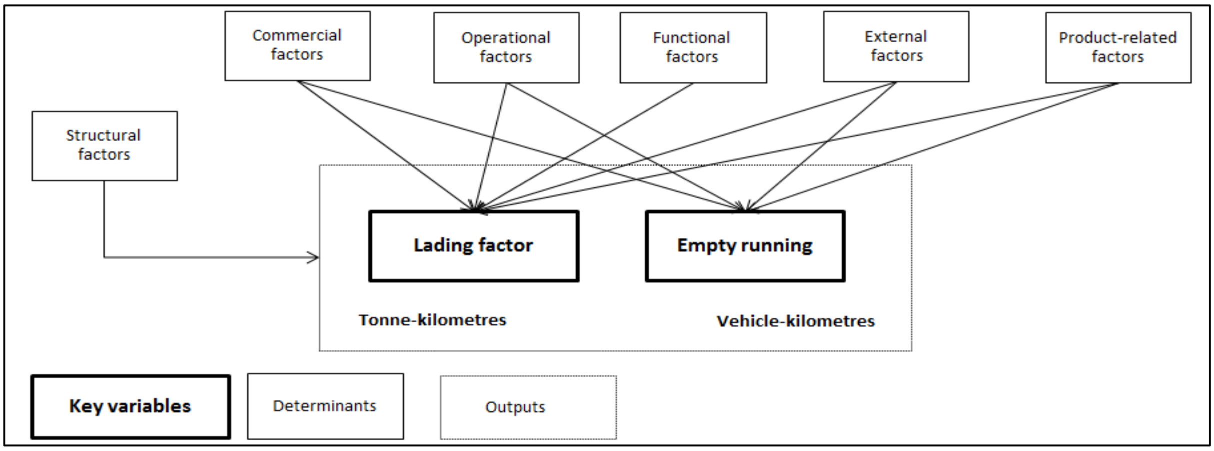

Figure 1: Relationship between key variables, outputs and the determinants of road freight transport. Source: Adapted from (Piecyk and McKinnon, 2010)

Figure 1 shows that determinants, such as structural factors, commercial factors, operational factors, functional factors, external factors and product-related factors have a direct relationship with the key variables lading factor and empty running. These variables are dependent on determinants that influence vehicle utilisation outputs such as vehicle-kms and tonne-kms. For example, restructuring of distribution networks includes centralisation of warehouses. In this case, vehicle-kms increases as they cover longer distances than they would do if the distribution networks were decentralised.

This paper focuses on the factors influencing utilisation of transport resources of the fast moving consumer goods (FMCG) industry in the UK. The paper is organised as follows: firstly existing literature is reviewed based on the determinants identified in the analytical framework (Figure 1) to understand recent trends in the FMCG supply chain (SC) and their consequences on vehicle utilisation. Following the literature review, research approach and methodology is defined to provide a platform for the data analysis and findings from the 9 FMCG companies. Finally, a case study of 9 FMCG companies is analysed using the analytical framework (Figure 1) and supported by follow up qualitative semi-structured interviews with the companies. The paper concludes with remarks for future research.

LITERATURE REVIEW

Structural factors:

Centralisation of warehouses has been a dominant trend in logistics over past few decades (McKinnon, 2009). Manufacturers and retailers are adopting centralisation in order to better utilise their resources and achieve further cost savings in their SC. As a result, there has been a shift from warehousing at supplier and customer sites and an increase in fewer, large-scale National Distribution Centres (NDC) and Regional Distribution Centres (RDC), which serve a wider geographical area. This approach benefits companies by using the 'square root law' of stockholding and economies of scale which results in the need to hold less inventory within the SC (McKinnon, 2009). According to Piecyk and McKinnon (2010), warehouse and inventory centralisation is a trend likely to grow by 2020. Whiteoak (1999) states centralisation of inventory support companies in driving up vehicle utilisation by maintaning full truck load (FTL). However, operating fewer, larger DC may increase transport costs and, to some extent, offset some cost savings resulting from the centralisation of inventory (McKinnon 2009).

Decentralisation strategy enables companies to relocate warehouses closer to customers in order to increase the response time of deliveries (Kohn and Brodin, 2008). In the UK, companies have been using this strategy to reduce order lead times and deliver to an increasing number of smaller convenience-type stores as opposed to larger hypermarket format stores (BBC, 2014). Schmitt et al., (2015) suggest that distributing inventory across multiple sites is a better option when demand uncertainty and disruptions are both present. Pedersen et al., (2012) argues that Small Medium Enterprises (SMEs) are more likely to go for a decentralisation strategy since they have limited management resources and may receive fewer advantages from economies of scale in a centralised environment. Decentralised strategies also benefit companies by reducing delivery costs as a result of less vehicle-kms to deliver to customers. However, vehicle fill is compromised sometimes due to frequent deliveries and short time available for planning FTL (Dekker et al., 2012).

Commercial factors:
The competition between major retailers is continually growing increasing the volume of product flows, the customer base and expansion into new market areas (Butler, 2015). It exerts pressure on suppliers to keep up with the changing demand and at the same time improve vehicle utilization. This encourages them to collaborate with third party logistics firms (3PL) who can optimise their distribution networks, allowing business to focus on core competencies (Selviaridis and Spring, 2007).

Indeed, a large proportion of distribution networks are managed by 3PL's for UK FMCG retailers, a trend which is growing in this sector (Rodrigues and Potter, 2013). The growing demand for rapid transport and guaranteed delivery times means that companies have to operate their fleet on fixed timetables, effectively creating a disconnect between transport volumes and transport demand (Dekker *et al.* 2012). Companies have overcome the situation by outsourcing non-strategic activities, such as secondary distribution, to 3PL's in order to improve their customer service, reduce inventory levels, lead times and order cycle times (Daughtery et al., 2006).

Operational factors:
In order to improve the efficiency of their distribution network, retailers maintain less inventory at stores by ordering smaller quantities to avoid over-stocks and obsolescences due to demand fluctuation (Fernie, 2006). This trend is quite visible in UK FMCG SC over the last decade and influences can be seen in various suppliers distribution strategy. The aim to cut inventory levels and reduce order lead times has forced retailers to order goods more frequently and in smaller consignments from suppliers to their Distribution Centers (DCs) and from DCs to their stores. Frequent lower volume orders makes the task of running full truck loads and reducing the number of empty running trucks very difficult for the suppliers (Blank et al., 2006). McKinnon and Edwards (2010) state that operating multi-drop from distribution to convenience stores can reduce empty running since there are less empty legs involved.

Research by McKinnon and Ge (2006) on the UK grocery SC indicated that worsening of traffic congestion, backdoor congestion at distribution centres and strict delivery time windows are some of the trends that make finding back loads difficult. Similarly, Rodrigues et al. (2013) indicated factors like delivery curfews, tight delivery windows and limited storage space at customer facilities imposed constraint for deliveries. In order to improve/maintain vehicle fill during a period of tightening JIT pressures, companies are channeling more consignments through consolidation centres where their products are combined with those of other suppliers for delivery in a fully loaded vehicle.

This has led to the adoption of Factory Gate Pricing (FGP) that attempts to optimize their distribution network by standardizing their contracts and collecting deliveries from suppliers with the help of vertical collaboration (Blanc et al., 2006).

Functional factors:
Many companies are implementing computerised vehicle routing and scheduling (CVRS) system to optimise vehicle utilisation in road freight transport operations (CVRS, 2007). Several researchers have outlined that collaboration as a functional factor has a big potential to improve vehicle utilization (McKinnon and Ge, 2006; Potter et al., 2007; Hingley et al., 2011). Potter et al., (2007) classifies collaboration into two types: vertical and horizontal. Vertical collaboration refers to an alliance between trading partners at different levels within a single SC (Wolf and Seuring 2010). According to Woensel et al., (2011), improved synchronisation of the production and distribution process have the capability to ensure full truck loads (FTL) and lower costs in secondary distribution of goods.

In horizontal collaboration, companies with similar SC processes work in co-operation in an attempt to share risks and rewards in order to achieve their business targets (Kanda and Deshmukh, 2012). A collaboration can occur between non-competing as well as competing companies. The companies in horizontal collaboration may choose to share warehousing facilities or join together to consolidate part truck loads (PTL) into FTL. This trend is emerging in the UK FMCG sector, for example, The Institute of Grocery Distribution and Efficient Consumer Response (ECR) in the UK have issued numerous guides, case studies and best practices to support road freight collaboration (IGD, 2015). However, in theory many companies follow transaction cost economics that acts as barrier to collaborate with their competitors (Grover and Malhotra, 2003).

External factors:
Economic fluctuation and changing consumer demand patterns have been a fundamental component of recent developments in distribution networks across the UK. As the economy grows, demand for movement of goods is likely to increase (McKinnon, 2004), exerting pressure on already congested UK road network.

The freight demand increase is subject to geographical and operational imbalances that will impact vehicle utilisation (McKinnon and Edwards, 2010). This triggers a growth in freight tonne-kms, leading to an increase in the demand of vehicles. Many transport operators lack the load information to improve vehicle loading on both outbound and return journeys (McKinnon and Ge, 2006). At a policy level, Quak and Koster (2007) argues that regulation for narrow delivery time windows will result in extra vehicles to deliver all the stores in a roundtrip. This will decrease the efficiency of vehicle utilisation and also increase delivery costs to the suppliers. Currently, trials of high capacity vehicles (HCVs) have been commissioned by the Department for Transport. The commissioning of these vehicles can provide opportunities for transporting of full loads of low density goods in roll cages or in a palletised form (Leach and Savage, 2012).

Product-related factors:
The FMCG sector consists of products that are heterogeneous in shape and sizes. Consignments of food products tend to be space-constrained rather than weight-constrained. Therefore, optimising vehicle fill becomes challenging – there is no financial benefit from transporting the empty space that happens naturally when loading irregular shaped products. Also, refrigerated commodities need strict control of temperature to ensure safety and quality of these food products (Kuo and Chen, 2010). This requires additional investment in refrigerated trucks and refrigerated depots for multi-temperature distribution capability. McKinnon and Ge (2006) states that specialised products and vehicles with specific handling characteristics imposes a constraint on backloading and consolidation opportunities. Furthermore, variable pallet size and handling equipment adds to the irregularity and further hardens the constraints.

METHODOLOGY:

A comprehensive literature review was undertaken on the distribution networks of FMCG companies in the UK. The keywords used in literature for the search were 'vehicle utilization', 'distribution networks', 'FMCG supply chain', 'road freight transport', and 'delivery patterns in FMCG companies'. The analysis was completed using two comprehensive UK transport data sets for a single month in 2010 and 2013 provided by the participating FMCG companies. The 2010 data was collected from 27 companies during Project Starfish (Palmer and McKinnon, 2011). In the second phase of the project, a data collection proforma was sent to a similar group of companies. Responses were received from 10 companies comprising of 7 manufacturers and 3 retailers. The data was analysed for all the companies who participated in the project for both 2010 and 2013. One of the manufacturers was not part of the 2010 analysis, therefore their data was excluded from the 2013 analysis. The data supplied by the companies was collected over the period of May or June in 2013 to maintain consistency in the analysis.

The data provided over a single month by the companies included all origins and destinations of suppliers and customers in the form of postcodes, quantity delivered (pallets, roll cages, stacks) for inbound and outbound deliveries, inter depot movements, and the type of vehicles used. For the purpose of the analysis, where the delivery volumes were given in roll cages, stacks or cases, these were converted into a standardised unit of pallet equivalents. Some of the companies provided data for all European operations, however, in order to maintain consistency, only data from mainland UK was used.

The data was analysed using a *network design model* and *descriptive statistics*. The network design model is a hybrid tool based on linear programming and a pseudo routing concept (Palmer and McKinnon, 2011). Descriptive statistics were used to summarize and describe data. In order to validate the analysis, individual company results and analysis were presented to the respective companies to improve and validate accuracy. This was followed by semi-structured qualitative interviews, which explore in more depth the factors behind changes to the distribution networks. The following questions were asked to all companies:

- What are the reasons behind changes in the number of customers?
- Why is there a drop in the average delivery size of pallets?
- Why there is a change in the delivery areas served by the depots?

The questions below were asked to the companies who experienced a reduction in number of depots and increase in the number of deliveries in excess of 26 pallets.

- Why there is a reduction in the number of depots operated by your company?
- Why is there an increase in the number of deliveries in excess of 26 pallets?

Responses from the companies were analysed using qualitative content analysis. A case study of all 9 FMCG was formed and presented in the next section.

FINDINGS AND ANALYSIS

Figure 2 presents a summary of percentage increase in all secondary movements (i.e. the movement from depot to customer) covering mainland UK in a period of a single month in 2013 relative to 2010. The analysis shows that the vehicle-kilometres by all companies had an overall increase of 33%. The quantity moved in pallets or pallet equivalents increased by 8%, and 7% more vehicles were used to deliver those quantities. The number of flows are deliveries between each origin (depot) and each destination (customer) location unique to the company. This has increased by 7%. The number of movements is effectively number of deliveries made from depot to customers which increased by 5% in 2013 relative to 2010.

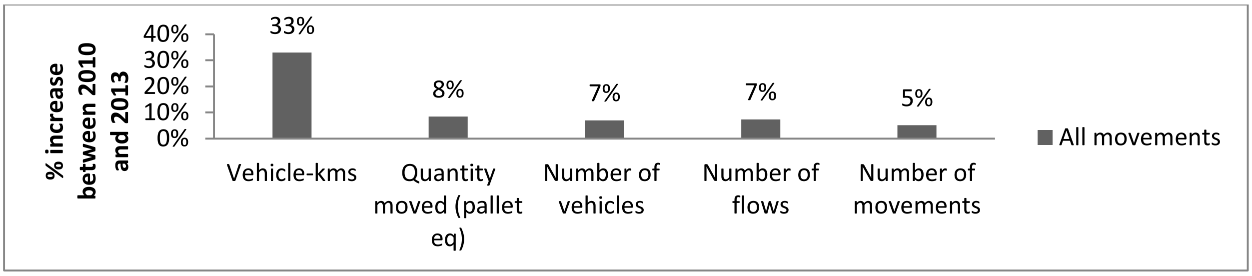

Figure 2: % increase in all company movements in 2013 than 2010

Figure 3 demonstrates the percentage increase in secondary movements by retailers and manufacturers for a single month in 2013 relative to 2010. The analysis shows that for retailers, vehicle-kms have increased by 36%, the number of flows by 14% and number of movements by 4%. However, less number of vehicles (5%) were used to move more pallets (7%), which indicates increased efficiency in their road freight operations. Whereas, manufacturers vehicle-kms increased by 23%, the number of flows decreased by 3% and number of movements increased by 10%. This analysis shows that manufacturers used more vehicles (23%) to deliver less pallets (17%), which presents a case of underutilisation of transport resources.

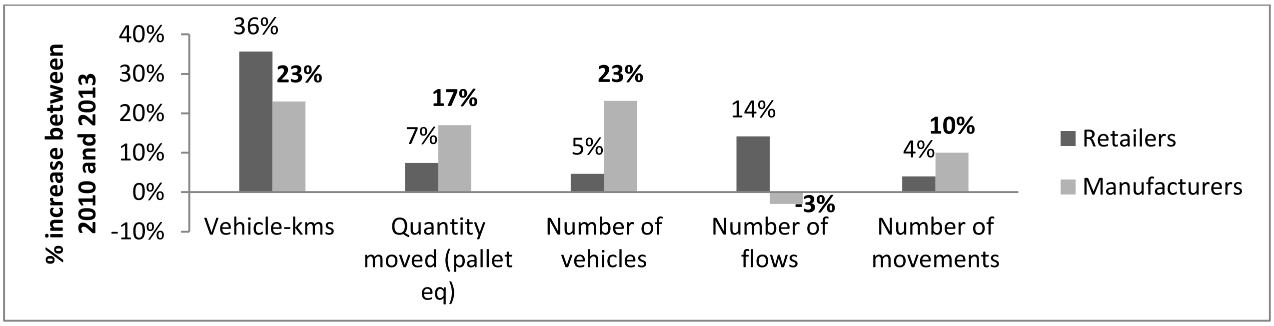

Figure 3: % increase in movements by retailers and manufacturers in 2013 than 2010

The factors identified within the analytical framework (Figure 1) will be used to identify the factors that may be affecting vehicle utilisation. The other factors influencing vehicle utilisation: product-related, functional and external will be analysed in the future work.

Commercial factors - Increase in freight volumes:
Figure 2 presents a summary of all secondary movements covering mainland UK in a period of a single month in 2010 and 2013. The analysis shows that the number of flows have increased by 7.4%, the number of movements have increased by 5.1% and the quantity moved have increased by 8.4%.

When the companies were asked about the reasons behind the increase in number of flows, movements and quantities the majority responded that they have increased their business both in volumes and number of customers i.e. postcode of destinations. A number of the manufacturers have increased their inter-depot movements to consolidate loads and make a FTL. New customers were added to the 2013 data, which has increased the number of flows. There was growth in 6% customers overall, one of the main reasons for the growth in number of movements was due to the opening of new convenience stores. The retailers were pushing manufacturers for more frequent deliveries of smaller quantities to keep inventory lower at the stores. Also, some manufacturers mentioned in the interviews that retailers were placing orders for next day delivery, but now they are pushing some suppliers for same day delivery. These frequent orders by retailers makes utilisation of vehicles tough for the manufacturers.

Operational factors - Delivery size profiles of companies:

Figure 4 shows the comparison of average delivery sizes in 2010 and 2013 that includes retailers and manufacturers. The y-axis represents number of depot-customers flows i.e. origin to destination movements, including both single and multiple depot-customer flows. The X-axis represents the average delivery size, i.e. average size of pallets in a delivery ranging from 1 to 52 pallets. Across all companies, the average delivery size remained relatively stable with 11.8 pallets in 2010 and 12 pallets in 2013. More customers received smaller deliveries (i.e. 1-6 pallets) in 2013 than in 2010 and the frequency of those deliveries increased in 2013 that shows a clear JIT pressure. A peak on average delivery size of 5 pallets in 2013 reflects the growing number of convenience stores in the retail sector. Retailers mentioned in the interview that there were opportunities for improvement in the vehicle utilisation for these deliveries on muti-drops. Analysis in figure 4 also shows that there is a drop in the delivery in full vehicle loads i.e. 24 to 26 pallets whereas the number of customer receiving deliveries in excess of 26 pallets has increased in 2013. This reflects an increase in the use of double decks by some companies. Many of the companies outsource their distribution to 3PL's and they will also consolidate smaller loads to make FTL. However, the analysis indicates that there may be more opportunities for increased efficiency by consolidating smaller deliveries between the manufacturers. There may also be opportunities to backhaul deliveries between the manufacturers for those full load deliveries over 20 pallets average delivery size.

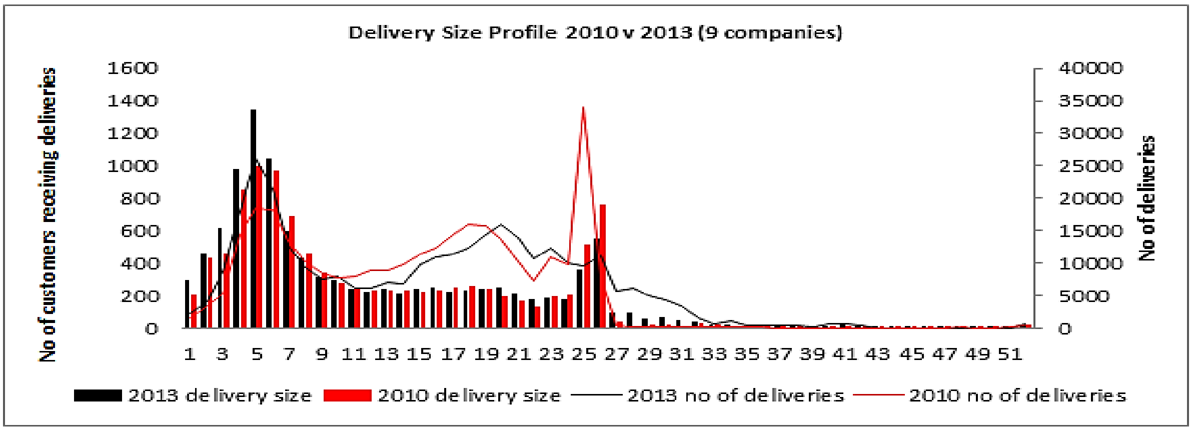

Figure 4: Average Delivery size profile for all companies 2010 v 2013

Structural factors – Changes in depot numbers:

The data collected for depots included national distribution centres, regional distribution centres, local warehouses, cross docks and other facility depots. Most of the manufacturer's depot locations in 2013 were relatively unchanged from locations listed in 2010. However, there was a 6% reduction in the number of operating depots.

Higher operating costs and growing demand from convenience stores in the south of the UK have changed the strategies of retailers regarding how depots serve customers, especially in the South-East and Greater London area. Retailers made strategic decisions to upgrade and make use of higher capacity warehouses based outside London to serve their convenience stores. This allowed closure of low capacity depots and increase in multi-drop deliveries. In addition, FGP by retailers has allowed manufacturers to optimise their distribution network by operating fewer warehouses. This increased retailers vehicle-kms and less vehicles were used to deliver pallets that shows an increase in load factor (Figure 3). However, reduction in warehouses and increase in convenience stores are some of the factors that increased vehicle-kms for manufacturers. More number of vehicles were used for multi-drops from manufacturers DC to deliver convenience stores due to constrained delivery time windows.

The manufacturers who operate a cluster of depots in the same region were able to channel deliveries into a single depot to reduce the response time to customers. Some of the depots were closed due to reduction in sales and strategic closure of their product lines. The closure or consolidation of depots enabled companies to minimise total distribution cost, maximise customer services through increased throughput and improve response time to customers. However, manufacturers mentioned in the interviews that they were seeking opportunities to reduce empty running in the backhaul movements specially from south-centric deliveries.

CONCLUSION

This paper shows the recent trends affecting utilisation of vehicles in FMCG distribution networks in the UK. Commercial, operational and functional factors were identified, and their impact on vehicle utilisation analysed. This analysis was supported by follow-up interviews, which showed an increase in convenience stores; freight was moved in smaller, more frequent frequent deliveries as a result of JIT pressure on manufacturers by retailers. In order to deliver to more geographically wide spread convenience stores, there were more multi-drops from manufacturers, and retailers DC. The retailer distribution network has become more efficient due to increases in multi-drops, whereas increase in vehicle-kms as a result of the reduced number of warehouses, manufacturers were using more vehicles to deliver stores with sensitive time windows. The analysis in this paper has demonstrated that there are opportunities available to better utilise transport resources and hence create more cost effective, efficient networks. The analysis also suggests that opportunities exist for consolidation of load in forward movements and reduction of empty running by backhauling. However, consolidation of load might not be the best option for companies with sensitive delivery-time windows.

The next steps of this research will be to identify these opportunities on how to reduce empty running and other factors – external, functional and product-related – will be discussed as a part of future work.

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THE PROMISE OF SUPPLY CHAIN COLLABORATION: A MYTH OR REALITY? AN EMPIRICAL ANALYSIS OF FRUIT PRODUCERS' PERCEPTIONS

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Abstract

Purpose of this paper:
In the last few years it has been observed that there is a change in the relationships among supply chain partners from arms-length transactions to collaborative relationships. Supply chain partners started to realise that working in a collaborative way can offer them substantial gains. Literature suggests that there are many benefits for supply chain partners achieving supply chain collaboration. However, achieving supply chain collaboration with partners does not always have the expected benefits. There are a number of challenges mentioned in the literature as the drawbacks of collaboration. Also, enhancing collaboration levels in agricultural supply chains is seen as a source of competitiveness. This research aims to evaluate the impact of collaboration on the business performance of the fruit producers.

Design/methodology/approach:
The research is based on the analysis of key literature in order to explore the concept of supply chain collaboration in the area of agricultural supply chain management. Additionally, a structured questionnaire was developed to measure supply chain collaboration and its impact on producers' business performance.

Findings:
The data is being analysed and some of the findings will be discussed in this paper. The 220 responses collected are analyzed using structural equation modelling techniques. The findings of this study will show whether collaborative relationships of fruit producers help them to achieve better business performance or not. Also, the analysis of the results will suggest whether other organisational characteristics have an impact on collaborative relationships in the agricultural sector.

Value:
This research is expected to provide new insights into how collaboration impacts business performance in the agricultural sector. Through this research the collaborative practices that lead to successful or not business performance will be ascertained. The findings of this study will be useful for agricultural producers, but also for SMEs operating in the agricultural and food sector.

Research limitations & future research:

This research provides an analysis of supply chain collaboration and business performance from the producers' perspective. Future research should evaluate supply chain collaboration from other supply chain actors' point of view. Also, another suggestion for future research is to identify the environmental factors that might impact a collaborative relationship.

1. INTRODUCTION

Relationships among supply chain partners evolved over the years with a tendency to closer collaborative relationships. Literature suggests that there are many benefits for supply chain partners achieving supply chain collaboration. However, achieving supply chain collaboration with business partners does not always have the expected benefits. There are a number of challenges mentioned in the literature as the drawbacks of collaboration such as increased costs and reduced profits. Thus, the relationship between collaboration and enhanced business performance is questioned. Enhancing collaboration levels in agricultural supply chain (ASC) is seen as a source of competitiveness. The effect of collaborative relationships with business partners on business performance has not been yet established. Most of the research in ASC is focused on the firms unit of analysis and not the producers. Thus, it has not been ascertained whether collaboration actually exists from the producers' perspective in the context of ASC; whether collaboration is myth or reality for ASC producers. This research aims to evaluate the relationship of collaboration and business performance of the fruit producers.

2. LITERATURE REVIEW

It has been observed that there is a change in the relationships among supply chain partners from arms-length transactions to collaborative relationships (Daugherty, 2011). Arms-length transactions involve basic communication and information transfer among supply chain partners only for transaction purposes (Lozano, 2007). While, collaboration encompasses partners sharing the responsibility of exchanging common planning, management, execution and performance measurement information (Anthony, 2000).

A range of conceptual definitions have been used to define collaboration among chain members or else supply chain collaboration (SCC). SCC is defined as "two or more chain members working together to create a competitive advantage through sharing information, making joint decisions, and sharing benefits which result from greater profitability of satisfying end customer needs than acting alone" (Simatupang et al., 2002, p.13). Humphries et al (2004) defined SCC as "working jointly to bring resources into a required relationship to achieve effective operations in harmony with the strategies and objectives of the parties involved, thus resulting in mutual benefit". The above definitions highlight the need for resource sharing and process sharing for higher profits and better satisfaction of customers' needs. Collaboration is not only about exchanging information and products, but also exchange of people and resources (Ziggers et al., 1999). Mentzer et al. (2000) argued that enablers of collaboration are not related to technology, but to people and personal interaction among business partners. Thus, collaboration is about effective and efficient interactions among business partners.

Supply chain partners realise that working in a collaborative way can offer them substantial gains. There are many benefits for supply chain partners achieving collaboration, some of which are the following: information exchange, improved planning and support, joint problem solving, gain of competitive advantage, reduced costs and reduction of negative bullwhip effect (Daugherty, 2011; Singh et al., 2009). Closer collaboration can reduce business uncertainty, give access to resources and increase business productivity (Dyer et al., 1998). Firms enter in a relationship to extend their resources and acquire skills from partners (Sambasivan et al., 2012). However, there are many cases where firms struggled or failed to achieve collaboration and get its expected benefits (Kampstra et al., 2006; Fawcett et al., 2010). There are a number of challenges mentioned in the literature as impediments in achieving collaboration. The main barriers associated with SCC are the following: difficulties in implementation, over-reliance on technological solutions for collaboration, failure to differentiate with whom to collaborate with, and lack of trust between trading partners (Barratt, 2004; Ramesh et al., 2008).

The Resource-Based View (RBV) of the firm suggests that organisations enter a collaborative relationship to access and acquire resources, skills and knowledge from other organisations (Sambasivan et al., 2012). The RBV argues that resources and capabilities provide firms with a competitive advantage that allows them to take advantage of opportunities (Wernerfelt, 1984). Resources are all assets, capabilities, organisational processes, knowledge and capabilities controlled by an organisation that enable the organisation to implement strategies that improve its efficiency and effectiveness (Barney, 1991, p.101). Agricultural supply chain (ASC) entities seek to collaborate with their partners as they realise that working together can get them substantial gains which cannot be achieved by operating alone (Matopoulos et al., 2007). Enhancing collaboration levels in ASC's has been seen as a source of competitiveness (Reynolds et al., 2009). Barratt (2004) stated that in order to define collaboration it needs to be put in a specific context. Specific contextual factors can influence the choice of collaboration levels (Danese, 2011). The intensity of collaboration in the ASC can be influenced negatively or positively by the nature of products, sector's structure, business environment (Ziggers et al., 1999; Fischer et al., 2010). Technological, regulatory and financial reasons in the ASC are shifting organisations towards greater collaboration (Hobbs et al., 2000). Matopoulos et al. (2007) found that industry's structure and product's characteristics in the ASC hinder collaboration, while industry's structure and product characteristics lower the intensity of SCC.

Different studies examined the impact of collaboration on business performance (Hyvonen et al., 2007; Vachon et al., 2008). The positive effect of supply chain collaboration on business performance outcomes has been confirmed by many research studies (Hyvonen et al., 2007; Zacharia et al., 2009; Rosenzweig, 2009). Hyvonen et al. (2007) examined the collaboration – business performance relationship in the grocery goods sector from the manufacturers, wholesalers and retailers perspective; the positive relationship between collaboration and business performance was confirmed. Singh et al. (2005) proved the existence of bidirectional relationships between inter-firm collaboration and business sales. However, William et al. (2009) examined the effect of internal and external collaboration practices of firms on their performance and proved that there is no significant association between collaboration and performance. Also, Stank et al. (2001) concluded that the relationship between collaboration with business partners and logistical service performance is not significant. Weak empirical support was found by Vereecke et al. (2006) for the hypothesized positive relationships between supplier or customer collaboration and business performance improvement.

All aforementioned studies examined the collaboration - business performance relationship from the firms, manufacturers and retailers perspective. There is a lack of research from the producers' point of view and the specific context (i.e. agricultural supply chain). There is no research indicating the positive or negative effect of collaboration on agricultural producers' business performance. Thus, using the RBV theory this research aims to fill this research gap by empirically testing the possible positive relationship between the levels of collaboration and business performance from the producers' perspective. Therefore, the hypothesis of this study is:

Hypothesis 1 (H1). Increased levels of collaboration will lead to better business performance.

3. METHODOLOGY

For the purposes of this study 220 questionnaires have been deployed to peach producers in Greece. The sample of this study is representative of the studied population of peach producers in Greece as the majority of peach production in Greece is based on Central Macedonia, Thessaly and Western Macedonia (Hellenic Statistical Authority, 2011). Since the exact number of peach producers is not available, the sampling frame was established based on the majority of peach trees per geographical location.

The questionnaires were administered in-person and the producers that sell their produce to at least one cooperative or producer organisation participated. The producers were asked to fill-in the questionnaire thinking about the collaborative relationship that they have with the cooperative or producer organisation that they sell their produce to.

Regarding the measurement of this study's variables, the collaboration measures of Cao et al. (2010) were adapted for this study and unit of analysis. The business performance of the peach producers was measured through the business sales that the producers had. The sales level measurement is commonly used by business managers as key performance metric, as higher sales might increase profitability (Weiss, 1971). Also, high sales performance is usually more valuable for companies independent of profitability (Singh et al., 2005). Seven-point Likert scale was used for the measurement of collaboration levels, while the sales performance was measured in tonnes of sold peaches. The two different types of peaches (i.e. table and processing peaches) were used as control variables. More specifically, table peaches refer to the peaches that are being sold for human consumption, while processing peaches are the peaches that are sold for producing other products (e.g. marmalades, canned fruit). The aforementioned two control variables were measured as dummy variables. The data collected was analyzed using structural equation modelling techniques.

4. RESULTS AND DISCUSSION

As seen in Table 1 the majority of the respondents (75%) sold their production to cooperatives, while the minority of the respondents (25%) sold their produce to producer organizations. Most of the respondents found to have peach production between 9 to 100 tonnes. The 82.27% of the respondents were from Central Macedonia, while only 9.09% and 8.64% were from Western Macedonia and Thessaly respectively. All the respondents had long-term relationships more than eight years, more precisely 15% <8 years, 11.4% 8-15 years, 0.9% 16-23 years, 13.2% 24-31 years, 20.9% 32-39 years, 12.7% 40-47 years, and 25.9% >48 years.

Relevant Dimension	Profile
Type of Collaborator	75% Cooperatives 25% Producer organisations
Geographical Location	82.27% Central Macedonia 9.09% Western Macedonia 8.64% Thessaly
Years in Collaboration	15% <8 years 11.4% 8-15 years 0.9% 16-23 years 13.2% 24-31 20.9% 32-39 years 12.7% 40-47 years 25.9% >48 years

Table 1. Sample descriptives

The data was analyzed and found to fall within acceptable levels of normality, skewness and kurtosis. The reliability and validity of the measures were also assessed. Using the LISREL 8.5 software (Joreskog et al., 2004) and the Maximum Likelihood estimation method the full measurement model was run (Hair et al., 2006). The hypothesis accounts for the possible direct positive effect of the collaboration level construct on business performance. In this context the independent variable is the collaboration level and the dependent is the business performance. Also, the two control variables of the type of peaches (i.e. table and processing peaches) were tested as independent variables to business performance.

The results of the structural model of the collaboration, business performance, type of peaches model indicate a good fit to the data with $\chi2= 12.064$, df= 8, p-value= 0.148, $\chi2/df= 1.508$, RMSEA= 0.048, CFI= 0.998, NNFI = 0.988, GFI = 0.991. The collaboration level construct in the model explains the 51.6% of variance of the business performance construct. As seen in Figure 1, the results of testing H1 show that there is significant relationship between collaboration level and business performance ($\gamma= 0.040$, $t= 1.660$, $p < 0.15$). Thus, H1 is supported. This indicates that increased levels of collaboration have a positive impact on business performance. The control variables which are the table and the processing type of peaches both have significant effect on business performance. More precisely, the table type of peaches has a positive relationship with business performance (γ= 0.155, t= 1.478, $p < 0.10$). While, the processing type of peaches has a very strong negative relationship with business performance (γ= -2.891, t= -2.438, $p < 0.01$).

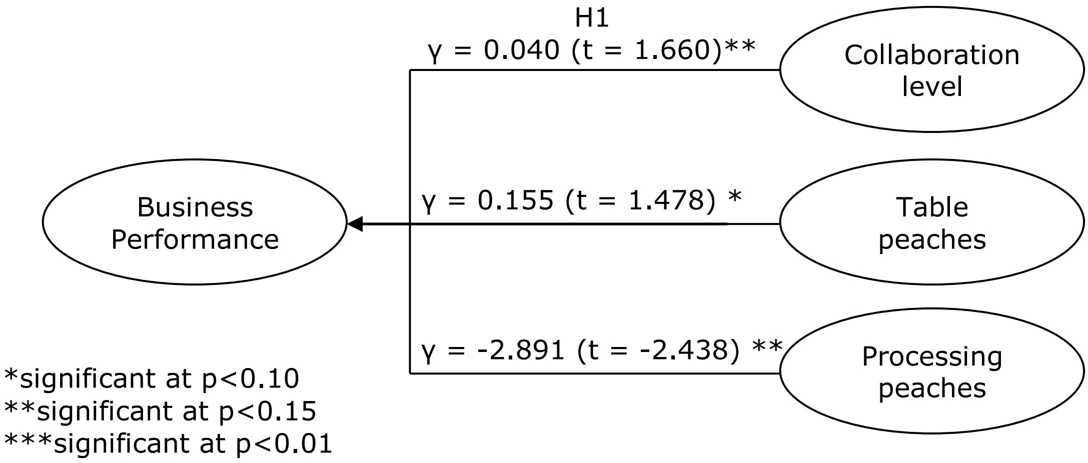

Figure 1. Structural model of this study's hypothesis testing

The findings of this study showed that more collaborative relationships of fruit producers help them to achieve better business performance. This is the status of the current research which is still in progress and aims to understand the different factors required for effective collaboration in the ASC in order to enhance producers' business performance. Collaborative relationships create new opportunities through the combination of skills, resources, knowledge and assets. Producers should try to engage in more beneficial for them business relationships in order to capitalize new collaborative opportunities. Cooperatives and producer organizations should also make sure that they have a fair relationship with the producers that they collaborate. This way, not only producers business performance will be improved, but the whole performance of the Greek ASC could be substantially improved.

Moreover, and as mentioned earlier, the type of peaches plays a significant role in the positive or negative business performance. The positive impact of the table peaches on producers' business performance could be justified due to the fact that the table peaches have higher profit margins for producers. This means that the table peaches are sold in much higher prices than the processing peaches. In addition, the negative impact the processing type of peaches found to have on producers business performance is mainly because the food processing companies take advantage of producers and they buy the specific type of peaches in the lowest price possible. The producers who grow processing type of peaches have very low profit margins and thus decreased business performance.

Based on the analysis of this study's data, it could be concluded that supply chain collaboration is not a myth in the context of ASC. Existing collaborative practices between producers and cooperatives or producer organisations in the ASC found to increase producers business performance. Thus, collaboration from the producers' point of view indeed takes place and it is beneficial for them.

5. CONCLUSION

This research provided an empirical analysis of the collaboration levels and business performance relationship from the agricultural producers' perspective. Drawing on RBV theory the relationship between collaboration level and business performance was explained. The hypothesis was tested using the SEM technique. The relationship between collaboration and business performance found to be significant. The type of the peaches found to have a significant impact on producers business performance too. Therefore, collaboration is existent in the ASC from the producers' perspective and helps increasing their business performance. Also, the type of the product seems to be an important factor that determines business outcomes.

The main limitation of this study is that only producers from one country (i.e. Greece) and only peach producers were included. However, the aforementioned limitation is overcome by the nature of this research as collaboration should be examined in a specific context and product to get generalizable results. Future research should evaluate the collaboration – business performance relationship in the ASC from other supply chain actors' point of view. The performance of the ASC producers should also be measured in other ways (i.e. not only using the sales measure). Also, another suggestion for future research is to identify the different environmental factors that might impact a collaborative relationship or other organizational factors.

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RESPONDING TO FOOD SCARES: USING SCENARIOS TO UNCOVER DECISION-MAKING IN THE EYE OF THE STORM[1]

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Abstract

Food scares and crises have both immediate and more long-term impacts on consumer perceptions and behaviour. Various studies of food scares highlight the positive impact of quick and transparent reaction by regulatory and other authorities. However, decision-making processes that guide communication during a scare have received little attention. Thus we have a particular interest in: (i) the impact of various media on the approaches taken to communications during food scares and, (ii) from a methodological perspective, the potential use of scenarios to uncover the factors influencing decision-making by a variety of key influencers as the scare unfolds.

Introduction

Most studies to-date have primarily reviewed communication strategies post-scare and while real-time analysis of communications can be conducted, it is rather difficult to gain access to key influencers during a scare to investigate factors impacting on decision-making. With this context, we consider some of the causes and consequences of food scares. Evidence to date suggests that transparent responsive communications from 'trusted' sources can minimise 'unjustified' responses and knee-jerk reactions. Thus both the nature of trust in evolving food systems and the influence of communication channels in building, maintaining and, where necessary, rebuilding such trust require consideration. In particular the decision-making practices operationalised during a crisis event interested parties as well as highlight can shed light on how each stakeholder considers the crisis. This can focus attention on misperceptions of the needs and responses of other good practices.

Prevalence of food scares/crises

Food and eating represent an integral part of the everyday lives of all citizens. The habitual character of their food behaviours generally results in little thought being given to safety when acquiring, preparing and consuming food. However, when the media draw attention to violations of good practice within the supply chain, citizens reflect on these practices and question what they assume (believe) about the safety/authenticity of the foods they consume. Furthermore they reflect on the trust that they have placed in the food supply system, the motivations of food industry stakeholders, including government and government agencies, and the consequences of the violation on, for example, their and others' health and wellbeing. This can result in short term, and sometimes dramatic, changes in behaviour and can also affect a more permanent turn in

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how certain foods, brands, food companies, governments and government agencies are perceived. For example, good becomes judged as bad, honest as deceitful, reliable as unreliable and those viewed as protecting the interest of society may be seen as protecting the interest of business. Importantly, failures within the supply chain can cause, what could be described as, unreasonable responses from a public health risk perspective (Regan *et al*., 2015). Furthermore, while consumption may recover the memory trace of a crisis can manifest as a more cynical distrusting consumer. Consequently with each successive crisis consumer confidence is undermined and trust diminishes. Thus it is not surprising that substantial effort is made to minimise citizen exposure to real or perceived food risks.

Risk management and good standards of practice can minimise the number of food safety incidents, indeed such practices prompted Bánáti (2013:1941) to suggest that the European food chain "*is one of the safest in the world*". However, with the ever increasing complexity of the food supply chain, food incidents now occur with some degree of regularity (See Table 1). These events can be inadvertent or intentional in nature with a number of recent cases of both food fraud and food scares. Within the fraud domain the Chinese melamine milk (2007/2008) and EU Horsemeat scandals (2013) represent two significant cases that garnered global media attention. The 2011 contaminations of fenegreek sprouts with *Escherichia coli 0104:H4 (*resulting in 54 deaths across Germany) and cantaloupes with *Listeria monocytogenes* (resulting in 43 deaths across the US) (Matthews, 2014) focused much public attention on both processing practices and supply chain complexity. Therefore, notwithstanding the need for robust food systems that build and maintain trust and are preventive in nature, it is now recognised that food crisis events are inevitable and there is a need to strengthen the capability to react to these in the short term (Reilly, 2013).

Year	Source country	Product	Contaminant	Cause
1988	UK	Eggs	Salmonella	Poor Practice
1996	UK	Beef	*BSE*	Poor practice[2]
1996	USA	Canteen Food	Shigella dysenteria	Sabotage
2002	China	Breakfast foods	Rat poison	Sabotage
2003	USA	Minced beef	Insecticide	Sabotage
2005	UK (upstream supplier)	Spices	Sudan 1	Fraud
2007	China	Baby Formula	Melamine	Fraud
2008	British Company	Ready-made baby milk	Curdled	Poor Practice
2008	Ireland	Pork	Dioxins	Poor Practice
2011	Bangladesh and India	Paan leaf	*Salmonella*	Poor Practice
2011	Egypt	Fenugreek seeds	*E-coli O104*	Poor Practice
2013	UK	Pastries	Peanuts in nut-free foods	Sabotage
2013	Europe	Processed Beef products	Horsemeat	Fraud

Table 1: Examples of food incidences

[2] Ruminant derived meat and bone meal in animal feed is hypothesised to be the cause of BSE. Risks (of transmission, recycling and amplification of pathogens) associated with use of rendered meat and bone meal in animal feed were known to both policy makers and industry.

Trust and Communication

Given the afore mentioned context it is not surprising that food risk has been fore-fronted in the consumer's mind and consequently trust in the food system has been eroded. Trust can be viewed as a dynamic, complex concept which involves rational and emotional dimensions and is guided by past experience (Daiparan & Hogart-Scott, 2003; Aung & Chang, 2014). Zucker's (1998) typology of trust provides a useful starting point to appreciate the complexity of this construct by distinguishing the bases on which it is formed. Zucker suggests that, from an organisational perspective, trust is created through a range of mechanisms: process-based (associated with past or expected exchange and represents a social system of shared commitment between the trustor and trustee), institution-based (linking to formal societal structures involving individual or organisation-specific attributes or intermediary systems) and characteristic-based (based on personal and social characteristics). In addition to the mechanisms identified by Zucker (1998), Johnson *et al*. (2000) make reference to 'personal-based' trust in the context of service relationships. In recent years increased consumers disconnection from food supply (both geographical and psychological distance) and associated lack of knowledge of the food supply chain has shifted the bases upon which trust is given (Henderson, *et al*., 2011). Indeed, if we consider this disconnect through the definitional lens of trust forwarded by Offe (1999:47), *"the belief that others, through their action or inaction, will contribute to my/our well-being and refrain from inflicting damage upon me/us*", it comes as no surprise that trust in food supply chain actors is typically low, with 35% and 38% of EU citizens expressing trust in food retailers and manufacturers, respectively (Eurobarometer and EFSA 2010). In contrast EU citizens express relatively high levels of trust (64%) in national and European food safety agencies (Eurobarometer and EFSA 2010) this suggests that personal knowledge-based trust is being replaced by 'institutional' trust.

Clearly trust has been earned (or lost) as a result of reactions to various breaches of good practice by food supply chain actors. This draws our attention to the characteristics of the trustee in determining levels of trust. Knight and Chervany's (2001) review of trust literature highlighted that while there are multiple disciplinary perspectives through which trust is viewed, there is recurrent reference to the trustee characteristics of competence, benevolence (caring), integrity and predictability. These characteristics are, at least in part, judged on the basis of past behaviours; for example, various studies have highlighted the positive impact of quick and transparent reaction by regulatory and other authorities. Mollering (2005) considers the notion of competence trust where the trustor and trustee have compatible interests. In this context trust is seen as a communicative process through which the managing of vulnerability and uncertainty enables action, where this would otherwise be unlikely.

Thus trust building, maintenance and repair models need to respond to the fundamental types of trust and its psychological and social characteristics.

In the main consumers rely on the media to provide them with relevant information on an unfolding food crisis thus making them an important conduit of information between stakeholders and consumers (Ward *et al*., 2011). The media ultimately guide the agenda of concern amongst the public; i.e. they set the agenda on what we, the public, think about (McCombs and Shaw, 1972). Greater emphasis on particular crisis and dimensions of a crisis adds saliency to these for the public. How a crisis is translated into a story by a journalist, the frames they use, can result in an overemphasis on specific aspects of the crisis and a side-lining of others. This framing is also based on how the journalist makes sense of the world. Unsurprisingly, therefore, the media have a critical role in how a crisis is understood by the public (Hornig, 1993). Inevitably the construction of the story and the emphasis of the narrative bears on who is implicated, held accountable and trusted. That said, the public are not empty vessels or puppets of the media and while their reaction to newsworthy stories varies according to the information provided, and the character of the issue, it is also shaped by cultural and individual characteristics (including existing knowledge and trust levels) (Greehy *et al*., 2014; de Vocht *et al*., 2015).

However 'who' communicates 'what' and 'when' to the media remains central. Wilson *et al*. (2014) suggest that professionals should proactively approach the media to help influence the agenda that is set and ensure a balanced focus on salient attributes. This speaks to the idea that in the absence of germane information, for crises that may be considered newsworthy, the media will create a story based on what is available and thus may focus on sensational elements that increase public concern. A proactive approach may reduce the likelihood of making enemies with the media (Löfstedt, 2003) and helps rebuild trust when it has been eroded (Löfstedt, 2005). To support a more proactive dynamic engagement Löfstedt, (2010) put forward risk communication guidelines that he suggests could steer the media, industry and regulators away from risk sensationalisation, erosion of trust and knee-jerk reactions which could ultimately lead to regulators establishing poor policies (Löfstedt, 2011). Löfstedt's (2010) communication guidelines provide a useful platform for considering the likely public responses given certain conditions. These guidelines take account of the characteristics of the hazard (e.g. natural or manmade, voluntary or involuntary, stigmatised/feared or not), those most affected (e.g. vulnerable groups), the communicator (trusted or not) and the population (high trust or low trust environment) and likely response of the media based on these characteristics.

At another level, organisations must consider who makes, what decisions, for whom during a crisis. Hale *et al.* (2006) draw attention to need to investigate internal decision-making processes deployed by crisis management teams and acknowledges the manner by which decision-making during a crisis differs from other organisational decision-making contexts. Therefore studies investigating decision-making during a crisis need to take account of both internal processes and external engagement.

All of these observations suggest good standard operating practices for dealing with a food scare/crisis exist and offer a foundation to ensure high standards of crisis management and communication. However, risk communication recommendations offered to date are based on retrospective evaluations of crisis through assessing media and public responses and collecting accounts from decision-makers in various stakeholder organisation. As explanations and rationales for approaches and actions taken at the time are prone to 'sanitisation', studies that stimulate such event may provide particularly useful insights into crisis management decision-making.

Prompted by the recent work of Wilson *et al*. (2013) we look to the use of vignettes to create hypothetical scenarios that provide the conditions necessary to explore decision-making as a scare unfolds.

Investigating stakeholder decision-making during a food crisis

Researchers that seek to provide a deep account of individuals' experiences (be it in their personal or professional roles) of events/happenings or on the common shared experiences of an event often look to a range of qualitative methods. Within this context, traditional data collection methods such as focus groups, in-depth interviews and observations have been widely applied. Each of these approaches has inherent strengths and weaknesses, thus their relevance varies depending on the core research question. For example, weaknesses associated with focus groups include the impact of 'groupthink' and the views of peers on recall and responses. In-depth interviews are susceptible to inherent biases due to retrospective descriptions increasing the possibility of error or 'deceit' (Giorgi & Giorgi, 2008). Observations, that require the systematic recording of behaviours and decisions, are by their very nature time consuming and the quality of the output is dependent on being able to observe all aspects of the event as it unfolds. Furthermore this approach requires openness to scientific observation which may not be forthcoming in the context of certain events such as crisis management. In response to the inherent weaknesses in these methods researchers have adapted such approaches to create conditions more congruent with respondents' realities in given contexts. This is particularly evident in citizen focused research in the field of risk communication where research on hypothetical scenarios, in various guises, has been conducted for some years. These approaches are normally applied to explore issues such as decision processes, group and individual judgments and evaluations based on 'hot political topics' and attitude formation. Citizens Juries, one such approach, have the capacity to help guide policy makers decision-making and support a more participatory regulatory system (Wakeford, 2002: pp 1). DEliberate Meetings Of CitizenS (Democs) (NEF, 2005, 2006; Bruce, 2007, 2010) uses conversation-based card (on stories, factual information and issues) games to present information in an iterative manner thus enabling a group to understand and discuss an issue. The deliberative discourse (Greehy et al. 2013) involves a one to one interaction between an expert and lay citizen where information on the issue under investigation is revealed in stages. Presenting information in an iterative manner, as evident in these approaches, offers an interesting middle ground between observational and retrospective studies. This work and that of Wilson et al. (2013) has prompted us to look to the use of vignettes to create hypothetical scenarios that provide the conditions necessary to explore decision-making as a scare unfolds.

A scenario describes (textually or graphically) a set of hypothetical sequences of events that might reasonably take place (Kahn and Wiener, 1968). Bradbury-Jones et al. (2015) find the terms scenarios and vignettes used interchangeably, indeed Schoenberg and Ravdal (2000) describe vignettes as being 'hypothetical scenarios' that can simulate a real-life situation and elicit rich but focused responses from informants. Notwithstanding increasing use of vignettes as a research methodology, there are few methodological papers that share experience in the field and offer guidance. Bradbury-Jones et al. (2015) seek to address this and based on their own experience and the limited published work in this area (Richman and Mercer, 2002; Hughes and Huby 2002; 2004; Paddam et al. 2010) they put forward four considerations that should inform vignette development: data sources, vignette format, capturing reality and vignette/participant congruence. Data sources may include literature, previous research findings and real life events. In many cases vignettes are informed by both existing literature and actual case studies as authenticity comes from real-life scenarios (Hughes and Huby 2002; Bradbury-Jones et al., 2015). The format follows a story telling approach. The hypothetical scenario is typically brief and followed up with questions on decision-making (Schoenberg and Ravdal, 2000). Notwithstanding some debate on the use of hypothetical or 'real' scenarios, the key condition is that the vignette represents a plausible scenario that captures the real-life dynamic of decision-making (Hughes and Huby 2002; Bradbury-Jones et al., 2015). Thus in addition to a judicious mix of relevant sources vignettes should be vetted by an expert(s) and pretested to ensure that they represent situations relevant to the study participants (Flaskerund, 1979; Gould, 1996). Finally the terminology used should be readily understood by participants and reflect the vernacular, this support vignette/participant congruence.

Our research will employ vignettes to investigate decision-making during 'crisis response' (i.e. coping strategies deployed to minimise the damage caused by a crisis that has occurred, and if possible neutralise it). Risk management, including response to crises, has received increasing attention in the supply chain management literature. However, these studies tend to focus on organisational/supply chain recovery capability timelines (i.e. resilience) rather than response to external influencers such as the media.

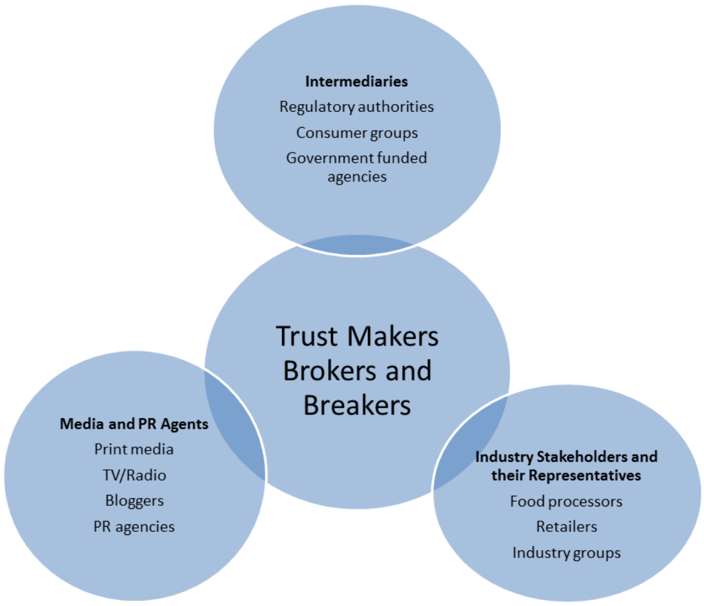

Figure 1 Trust Influencers

Figure 1 schematically presents the various trust influencer groups that need to be considered when deploying a vignette methodology to understand the challenges faced during a food crisis event. This approach could inform good management practices, including robust and omni-channel risk communication plans. Within the context of industry and intermediary stakeholder groups' interaction with the media (and vice versa), this study proposes to follow a layered approach to scenario building. This should elucidate key factors influencing decisions and associated processes and protocols adopted. In particular, this layered approach can unpack agenda setting at various stages and investigate the interplay between various key influencer groups. With respect to the media group, in recent years the role of social media has greatly increased thus inclusion of these media in the study is critical as communication strategies must explicitly address the need for multiagency integrated crisis management.

Conclusion

Most studies to-date have primarily reviewed communication strategies post-scare and while real-time analysis of communications can be conducted, it is rather difficult to gain access to key influencers during a food crisis to investigate factors influencing decision-making. This paper considers the food scare environment and proposes an unfolding scenario based methodology to probe decision-making process and protocols. Thus the proposed approach takes account of both the internal and external influences that shape decision making processes when endeavouring to rebuild and maintain trust during a crisis.

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Section 11: Supply chain performance management

CHALLENGE FACING THE LOGISTICS INDUSTRY WITH INCREASING DEMAND FOR 'SAME DAY' DELIVERY

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Abstract

Purpose of this paper
The paper will report on new research into the challenges faced by the logistics industry arising from increasing demand for 'same day' parcel services, and, on the measures being taken to tackle them.

Design/methodology/approach
The key players are identified as a triad of *shipper, carrier* (LSP) and *customer*. Since the literature is limited and 'same day' practices are changing fast, expert-oriented qualitative research has been chosen, to allow an in-depth understanding of the field. Following Fontana and Frey (2005), it is hoped that experts will be able to explain processes and customer requirements, since they are privy to the ongoing market requirements. A stratified random sampling approach (Bryman and Bell, 2003) was employed to select shippers and carriers for interview. A separate interview was conducted with one Technology Service Provider (TSP), as TSPs are less numerous. The interview questions were driven by both academic literature and general and logistics press; to capture real world developments.

Findings
The findings reveal collaboration to be an effective approach for the logistics industry, with impacts on delivery speed and efficiency (Wang et al, 2007). Insights into the role that ELMs are obtained, particularly in relation to freight consolidation, and how innovative collaboration can facilitate an effective 'same day' delivery platform. The research also reveals the influence of firm size on strategy, with larger more vertically integrated players being less dependent on collaboration.

Research limitations/implications
Qualitative research involving nine interviewees has enabled the researchers to gain a preliminary understanding of the issues. A survey will be employed to achieve a larger sample, and these findings will be used to inform the questionnaire design.

Practical implications (if applicable)
The research findings will help to inform LSPs of the choices available to them as they respond to increased demand for 'same day'.

What is original/value of paper
The paper will contribute to academic knowledge of the express parcel industry and the increasing role of collaborative approaches and technology.

Keywords
'Same day', logistics

INTRODUCTION

A series of studies concerning recent trends in the logistics services market, retail competition and internet usage suggests growth in demand for ''same day'' courier services (Lim and Shiode 2011). The same study also indicates that increasingly unstable requests by customers require firms to proactively and innovatively 'respond to the demand volatility'. Reasons include: shortening product and technology lifecycles, competitive pressures forcing more frequent product changes and consumers demanding greater product variety (Singh 2011). Statistics from the Centre for Retail Research (2014) reveals e-commerce as the fastest growing retail market in Europe, with sales in the UK, Germany, France, Sweden, Netherland, Italy, Poland and Spain expected to reach a combined total of £111.2 bn in 2014 (€155.3 bn or $212.8 bn) and for the US to reach $306.0 bn (€224.0 bn) in 2014. With rise in the e-tailing business, 30% of its delivery is dependent on the express delivery (Oxford Economic Forecasting and Mott Macdonald, 2006), contributing to 579,000 European jobs and €23.4 bn of GDP, as the industry serves the increasing need for rapid and guaranteed delivery. Amazon CEO Christopher North also analysed how parcel delivery has transformed from one week to next day, and predicts that over the next five to ten years, 'same day' delivery will become a norm and that is Amazon's target (Fletcher, 2015).

The paper will report on new research into the challenges faced by the logistics industry arising from increasing demand for 'same day' courier services, and, on the measures being taken to tackle them.

SELECTED LITERATURE REVIEW

Academic coverage of ''same day'' delivery is very limited, although there has been some coverage of high technology solutions, see for example Murray and Chu's (2015) article covering efforts by Logistics Service Providers (LSPs) and large retailers to use Unmanned Aerial Vehicles (UAV)/drones and Mobile Depots (MD) for speedy parcel delivery. The literature review has therefore largely focused on factors supporting effective logistics/courier services, as "same day" may be seen as the next step for the express parcels industry.

One research strand to emerge from this backdrop has been a study by Wang et al. (2007 and 2011) into the role of Electronic Logistics Marketplaces (ELMs). These are seen as a collaboration/consolidation platform for shippers and carriers, enabling enhanced access to the logistics resources necessary to respond to market trends, to facilitate more complex and enhanced communication capability, and to improve freight capacity utilisation. Wiengarten et al. (2013), in similar research, discovered and proposed technology for effective information exchange and inter-organisational collaboration to aid logistics operations.

Soosay et al. (2008) have revealed the ways that collaboration can lead to innovative ideas where firms integrated to link operations for increased effectiveness in areas of service delivery, process improvement, capacity planning and technology transfer. Audy et al. (2012) regard collaboration as a tool to gain unrestricted access to new markets, while Mahour and Spillan (2014) outlined its role in gaining competitive edge through the development of "IT-enabled supply chain capabilities that are firm specific and hard-to-copy across organizations".

RESEARCH QUESTIONS

The literature has revealed technology and collaboration as the most viable tools for carriers and shippers to improve their overall performance. The authors have, following a more extensive review of academic literature and the professional/trade press, identified the following research questions:

In what capacity can the technology platform influence collaboration?

Can collaboration enable 'same day' parcel delivery to become commonplace?

METHODOLOGY

The key players are identified as a triad of *shipper, carrier* or LSP and *customer*, with their inter-relationships facilitated by a Technology Service Provider (TSP), as shown in Figure 1.

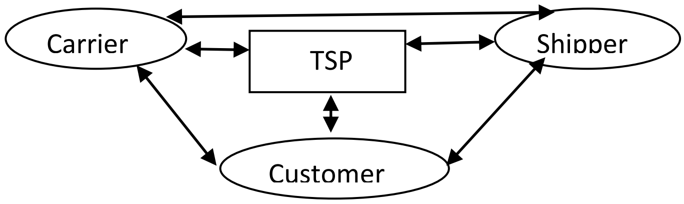

Fig 1: The logistics collaborative triad

Expert-oriented exploratory qualitative research with narrative analysis (Fontana and Frey, 2005) was chosen, to allow an in-depth understanding of the field. According to Wiles et al. (2005), narrative analysis helps with strategies to organise, conduct, interpret and present interviews, thereby enabling researchers to take cognizance of the respondent's own evaluation. A stratified random sampling approach (Bryman and Bell, 2003) was employed to select shippers, carriers and a TSP for interview. The interview questions were driven by both academic literature and general press, to allow up-to-date coverage of real world developments.

Four interview sessions were conducted with carriers, two large scale and two medium scale. Similarly, four shippers (a mix of large and medium scale) were interviewed, but due to the similarity in their responses, a summary of their views has been presented. TSPs are less numerous, and only one TSP has therefore been interviewed.

This research focuses on goods and the retail industry, but e-groceries were excluded. Unfortunately, due to time and space constraints, the views of customers are not represented in this paper.

FINDINGS

The main characteristics of the interviewee organisations are shown in Tables 1 and 2.

Carrier				
Carrier Code	Category	Services	Turnover	Vertical Integration Level
Carrier 1	Large Carrier	Transport and Warehousing	£9,456m (2014)	High
Carrier 2	Large Carrier	Transport and Warehouse	£112.7m (2013)	High
Carrier 3	Medium	Transport	£2.5-10m(2013)	Medium
Carrier 4	Medium	Transport	£6.5m(2014)	Low

Table 1: Characteristics of carrier organisations

Shippers			
Shipper Code	Category	Sector	Turnover
Shipper 1	Large	Retail and E-tail	£9,000m (2014)
Shipper 2	Large	Retail	£2,300m (2014)
Shipper 3	Medium	Retail and E-tail	Unknown
Shipper 4	Medium	Retail and E-tail	Unknown

Table 2: Characteristics of shipper organisations

Summary of Interview with Carrier 1

Carrier 1 attributed the 'same day' courier quest to competitive strategy between retailers, most especially the giant e-tailers such as Amazon and eBay. An example is the recent partnership between Amazon and Smith News to nationally deliver parcels on the 'same day'. He explained that ever since e-tailing became a norm, courier requirements have been changing. He cited an example that in e-tail systems, product price, delivery cost and speed are now germane to customers' decision making. It is based on this, that to remain relevant and competitive, small and medium e-tailers plan to either enrol to Amazon e-marketplace to benefit from the newly launched 'same day' courier service, or, partner with a 'same day' courier service provider. If a high success rate is recorded in the partnership, Carrier 1 believes this will put the demand for 'same day' courier service 'on the rise', and it could become a criterion for carrier selection by retailers, and could make the service commonplace.

Impact on the business

Carrier 1 explained that their major clients being large shippers, two of which are Amazon and eBay, often give carriers new specifications to align with, thereby putting carriers under pressure to innovate. Carrier 1 further explained that the service is already being offered to Amazon by Smith News, which now stands as a major competitor. They made it clear that their slow response to the 'same day' market demand is not because they cannot render the service, but because the market is being carefully studied for continuity and high volume demand.

Plans for the ''same day'' Service

Carrier 1 believes the market is new and 'there is still a lot to benefit from it'. They however acknowledge that a series of obstacles are to be overcome before the service can be offered. It will require a huge investment in the IT infrastructure, equipment, distribution centres and manpower. Carrier 1 has therefore embarked on series of research projects to investigate how the service can be achieved efficiently and cost-effectively. They acknowledged collaboration with other carriers as being a good approach towards achieving 'same day' parcel delivery, but said that they can afford the required infrastructure and manpower, and that collaboration with third party carriers would not be needed. They said that the company wants to be in charge and never to feel obliged. They further explained that collaboration with third parties would not allow total control and, as a result, won't be embraced. It was further explained that their distribution channels are highly technologically inclined for the services they render (one of which is next day delivery), and despite that, another quotation for IT improvement with the inclusion of 'same day' delivery plan, is in the pipeline.

It was explained that since the current 'same day' service offered by Amazon, through partnership with Smith News, doesn't capture door-to-door delivery, they believe that they could use their manpower strength and national postcode coverage as a competitive advantage.

Summary of Interview with Carrier 2

Carrier 2 emphasized the company's specialism in 'same day' delivery, but mostly for time critical parcels and not yet designed as mass service. He explained that, in order to adapt to market requirements including 'same day', the company had embarked on vertical integration through acquisition or merger with smaller local carriers that specialise in speed or 'same day' delivery, mostly where its own 'last mile' delivery infrastructure is not strong. He said that this approach had started to yield results. He added that vertical integration had helped to achieve economies of scale and had boosted the company's operations and competitive stance in the parcel delivery industry. He corroborated his point with the ongoing plan to partner with national rail service providers, to strengthen the infrastructure for speedy delivery. Carrier 2 is also making arrangements to increase the number of distribution centres across the country, and is planning to finalise all projects and partnership deals at the earliest possible time, to help them roll out improved services alongside an affordable national 'same day' delivery service. The company's plan is broad and the improvement strategy is not tailored to only satisfy giant e-tailers, but also to leverage its 'same day' delivery capability across the retail market, irrespective of business size. He explained that the current challenge in the integration process is attributable to IT platform incompatibility. The lack of seamless communication can lead to failures in real-time information sharing. The company has ongoing plans to transform its information systems from standard to intelligent infrastructure, and to increase the number of national distribution centres. These developments will help with information sharing, parcel consolidation, tracking from pick-up to delivery, and other intelligent/innovative features.

Summary of Interview with Carrier 3

The Carrier 3 representative made it clear that they have observed that 'same day' delivery requests increase where the service is rendered, which suggests that customers only demand these services when they become available. Since 'same day' is still a growing business idea, Carrier 3 only offers 'same day' within major UK cities. Due to infrastructure deficiencies, Carrier 3 does not offer 'same day' on an inter-city basis. Their initial market survey reveals that customers would want the service if it existed and was relatively cheap and affordable, with a good level of professionalism. It is on this basis that the company partners with e-tailers and works with individual customers through their website for 'same day' delivery in major cities. Parcels are picked up and delivered through an inter-modal and multi-modal freight system. The service is strictly internet reliant, with a delivery timeframe and real-time tracking.

Carrier 3 identified partnerships with a few large carriers and reiterated their willingness to further collaborate with other large carriers, for parcel collection and last mile delivery. The company is studying Smith News and hopes to partner with them in future for last mile delivery.

Summary of Interview with Carrier 4

The Carrier 4 representative outlined some similarities with Carrier 3 in terms of coverage and mode of operation. He lamented the fact that the company had started its 'same day' delivery business in London, but that, in recent times, there had been new entrants to the market, growing competition and reduced profitability. Another major problem faced in recent times was the spread of the click-and–collect system, resorted to by carriers to reduce/eradicate the first time failed delivery attempt. He also mentioned IT compatibility problems and lack of backhaul, leading to empty trucks.

Carrier 4 wants to remain strong in the market, and has embarked on the design of an intelligent interactive platform, where customers can reschedule delivery time or delivery address, leading to a new estimated delivery time. Carrier 4 does not possess the infrastructural capability for inter-city networking, and has partnered with few other large carriers, both national and international, to handle collection and last mile delivery.

Summary of Interviews with Shippers

'Same day' parcel delivery has been an established courier practise for time critical parcels at local, national or international level, but, at a costly rate. In this case, it is not the cost of freight or the product that is expensive to the customer, but the cost of not having the parcel. However, in recent times, the market is changing, as it has now become an evolving B2C business competitive strategy amongst large e-tailers. They explained that a series of attempts had been employed by large e-tailers to establish 'same day' parcel delivery. Some examples are the widely reported drone test by Amazon in Cambridge, eBay's collaboration with Uber in the United States, and the recently reported partnership between Amazon and Smith News in the United Kingdom.

They also acknowledged that although a few large carriers offer 'same day' services, they are mostly offered by medium-size carriers who specialise in local 'same day' deliveries within major cities or inter-city. These carriers collaborate with shippers and use their online platform to service individual customers e.g. Shutl, the 'same day' courier in Manchester and Bristol, and Crisis Courier Solutions in Northampton. Since these ideas work locally, large e-tailers have decided to move a step further by 'nationalising' the idea, the result of which we are seeing today.

Challenges

Shippers strongly believe that there would be high patronage if 'same day' parcel delivery is affordably available to customers, but they do not possess such logistics capability. They explained that outside the Amazon and Smith News partnership, no carrier has come out to advertise or market inter-city 'same day' national parcel delivery, except the ones still in the trial stages e.g. Google Express in the United States, and eBay Now, which is still a local service in major cities of the United States. Shippers further revealed that there is no desperation for 'same day' delivery until it becomes commonplace, and, moreover that most of their carriers render effective 'next day' delivery services. There is no known pressure from customers for a 'same day' delivery service, and neither has there been any patronage reduction due to unfulfilled 'same day' delivery requests. This suggests that 'same day' delivery is currently not seen as a threat to their business. The giant e-tailers want to use it as a competitive strategy, and any SME that wants to benefit from the package can subscribe to their e-marketplace platform.

Interview with a Technology Service Provider

Findings from interviews with shippers and carriers, and the recurring themes of collaboration and information sharing, prompted the need for an interview session with a TSP. The interview with a TSP director confirmed the development of several features to drive innovative and intelligent carrier-shipper collaboration in iCargo and intelliTrans projects. He emphasised the need for innovative collaboration as very important for today's market requirements, and that these requirements have driven the projects. He also argued that integration of these projects can help facilitate a vertical integration process whilst operating within an ELM.

The project supports freight and logistics operations for multiple players through various modes, while adapting to changing freight conditions and dynamic route planning of intelligent cargo, vehicle and an infrastructure system that possesses a databank for real time services, resource and information sharing from and between different stakeholders. The project supports multi-modal freight, parcel consolidation, carrier collaboration, end-to-end real time tracking, dynamic and intelligent transport re-planning arising from real-time tracking information, and low cost transportation.

DISCUSSION

Technological developments are transforming the courier industry, leading to rapid evolution of the business models employed and, ultimately, to changes to structural change in the industry. A series of events have unfolded, both empirically and theoretically, from standard delivery to next day delivery, and from traditional time critical parcel delivery, to the possibility that 'same day' delivery may soon become commonplace. These results have started to surface, as forecasted in the literature.

Interviews with carriers and shippers revealed recurring themes concerning the need for improved collaboration by the both the shippers and carriers, and, the need for reliable real-time communication and information sharing. These identified needs suggest that 'same day' delivery capability, beyond the immediate locale, would require:

1. an intelligent collaboration platform;
2. a platform for seamless communication and information sharing.

Shippers

Shippers have not started to feel the impact on their business, neither are they under any pressure to get involved, nor has there been a decline in sales/patronage level. However, because of the evolving market some of them currently partner with local/domestic ‘same day’ carriers, and they are of the opinion that when the service gains popularity they will review their partnership terms with the national carriers that render the service. The above data also revealed that in their attempts to remain competitive, the majority of shippers are accustomed to the habit of partnering with more than one carrier, in order to provide the best deals to their customers.

Carriers

Even though large carriers have the resources to adjust to changing specifications by major e-tailers/retailers, the medium scale carriers do not, and this necessitates the need to leverage their position in the market. Even though one of the major carriers interviewed rejected collaboration as an option for its business, the other players indicated that collaboration will be essential to leveraging their position in the ‘same day’ delivery market.

CONCLUSION

This study reveals that firm size influences business strategies due to their infrastructural capabilities. Analysing the existing approach by different carriers to meet the market requirements revealed that, in general, large carriers stand a better chance to adapt through vertical integration.

The findings also suggest that large carriers should drive an innovative/intelligent collaborative platform to integrate small and medium carriers, for wider network coverage and enhanced speedy and cost effective ‘same day’ delivery. ELM is an example of suitable technology, through its effective consolidation, collaborative and integrating features

In order to benefit from the evolving ‘same day’ parcel delivery trend, small and medium carriers must be open to merger or integration with large carriers, and with an intelligent /collaborative technology platform, such as an ELM.

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THE ROLE OF SUPPLIER ASSESSMENT IN BUILDING RELATIONSHIP BETWEEN THE ENTERPRISES IN THE POLISH MARKET

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ABSTRACT

Purpose of this paper: The main aim of this paper is to present the role of selection and evaluation of suppliers in building partnerships between the enterprises which are operating in the Polish market. This evaluation allows buyers to significantly limit the level of risk especially in the case of new suppliers. Through a preliminary evaluation of the suppliers, the buyer gathers evidence of the suppliers' ability to achieve the expected level of product quality through a trial purchase, the quality of processes through an audit or the economic situation of suppliers through due diligence. Many international companies help local suppliers to meet the requirements by offering them support in the form of consulting and training through the special development programs.

Design/methodology/approach: The article describes the results of empirical studies carried out in 182 enterprises operating in the Polish market. The aim of the survey was to identify the criteria and forms of selection and evaluation of suppliers. The selection of companies was focused on producers and service providers in the B2B market, who have implemented management systems in accordance with the international standard ISO 9001.

Findings: The results of empirical study indicate that companies operating in Poland, in order to build the partner relationships with suppliers carrying out an evaluation of suppliers are focusing mainly on technical quality of the products, delivery and favorable price conditions, flexibility, effective evaluation of communication processes, product safety, terms of this guarantee. The results of this study indicate that companies concentrate on the evaluation criteria such as technical quality suppliers of products (no defective products), favorable price conditions, on time delivery, ensuring continuity of supply, the reaction time for orders and to complaints, warranty obligations, vendor flexibility (the ability to changes in the contract), and the willingness of the supplier to reduce costs.

Value: It should be observed that the Polish companies are adapting to global trends currently associated with the evaluation and selection of suppliers. These trends are focused on taking into account the criteria related to the implementation of social responsibility elements in the evaluation of suppliers.

Keywords: evaluation of suppliers, building relationship in supply chain, supplier development programs

INTRODUCTION

Analyzing the current market trends one could observe that more and more companies, especially multinational corporations selecting local sources were not guided by the bid submitted by the supplier. These companies are trying to gather much evidence which conform the ability of suppliers to achieve the expected level of product quality (through a test purchase or trial free use), processes (through audits), or financial conditions (through due diligence), and self-assessment questionnaires. Increasingly, as the criteria for assessment of the supplier, are taken into account also such elements like communication with customers, research and development activities (introduction of new technologies, and new products), the human resources development (the level of qualification of personnel), financial results, introduction of QHSE (Quality-Heath-Safety-Environment management systems to ensure the desired level of safety of the product and processes for the users and environment. Such criteria are used especially by international companies [Ekici 2013].

BUILDING PARTNERSHIPS WITH SUPPLIERS

Building partnerships with suppliers ensures effective communication, which should provide a rapid exchange of information [Zhao & al. 2013]. Currently, communication between companies most often takes the form of exchange of information, utilizing electronic media [Fleiss & al. 2006, Sanders 2007]. Many suppliers are placed on the websites offering (in the form of catalogs, multimedia presentations) product certificates which ensure that the products are confirming the safety standards. Increasingly, service orders and after sales service are carried out on-line. The process of building relationships with suppliers can be summarized in ten phases. These are:
-Setting the expectations and requirements for suppliers in terms of technical quality and service (before and after sale, frequency of orders, organizational systems (implementation of QHSE management standards, technical and technological capabilities as well as financial conditions;
-Identification of potential suppliers;
-Assessment of potential suppliers (through self-assessment questionnaires, analysis of submitted bids, auditing factories owned by providers);
-Supplier classifications;
-Negotiating the terms of deliveries with supplier;
-Choice of supplier;
-Contract agreement;
-The ordering (establish order, handling order);
-Performance of the contract realization (including the transmission of orders, deliveries and monitor purchasing process documentation);
-Evaluation of co-operation and development of partnerships, including periodic rating of suppliers (through the scoring or indicators), assessing the impact of cooperation with the supplier to improve the efficiency of processes in the supply chain (design, purchasing, warehousing, manufacturing, maintenance, environmental and safety management, compliance with best practices in the field of ethical conduct). A partnership comprises a process in which the customer and the supplier gradually build strong and extensive social, economic and technical relationships. Creating partnerships usually results from some kind of evolution beginning with repeated transactions based on loyalty to the source of purchase and on confidence related to the positive image of a particular partner. Repeated transactions often transform into long-term connections in which relations are regulated by agreements. If the parties are happy with keeping to the arrangements set out in the agreements, their cooperation may transform into a close partnership [Wagner 2011]. This may generate lots of benefits for the partners and these are: improved quality of products and services, prompter carrying out of orders, preferential prices, improved communication between the supplier and the recipient (quicker and more complete exchange of information), joint research and development [Beverland & Lindgreen 2005]. The benefits enhance the positive images of the partners. In some cases, a partnership between the supplier and the customer may transform into a strategic alliance which is based on joint achievement of specific long-term goals.

SUPPLIER STATUS

Increasingly, companies, hoping to reduce the risk associated with the purchase, use periodic evaluation systems suppliers. This evaluation is particularly important for building long-term relationships with suppliers. The result of this evaluation is recorded on the supplier scorecard. The basic criteria for the evaluation focus mainly on three most important parameters, referred by the acronym QCD (Quality, Cost Delivery) [Thanaraksakul & Phruksaphanrat 2009]. In practice, one could specify the following types of supplier status:
-Preferred suppliers, characterized by a stable financial position and leadership in the field of technical solutions, quality and timely delivery and competitive price;

-Active suppliers that meet the requirements (with the prospect to be the preferred supplier);
-Restricted suppliers on hold, having problems with maintaining the technical quality and timely deliveries, which gradually reduces the size of the transaction of purchase and does not turn them into new projects;
-Disqualified suppliers who do not meet a minimum set requirements [Ulaga & Eggert 2013].
Companies that have implemented and certified quality management systems attach importance to the periodic assessment of suppliers. In accordance with the requirements of ISO 9001, these companies are obliged to carry out a preliminary and periodic assessment of suppliers and determine their status. This assessment relates primarily to suppliers of basic products (the main raw materials, semi-finished goods, assembled parts, machinery and equipment), as well as logistics and maintenance and IT services. The frequency of supplier assessment is dependent on the intensity of purchasing processes. Many companies that have made orders relatively often, carry out an assessment once a month or quarterly. Other entities make such assessment every six months or at least once a year. In the case of the acquisition of infrastructure, customers assess individual deliveries. Periodic assessment of provider infrastructure relates primarily to the fulfilling of their warranty obligations and services after sale, like technical support.

THE MAIN CRITERIA FOR PERIODIC EVALUATION OF SUPPLIERS.
Technical quality has particular importance as a criterion for periodic evaluation of suppliers, most often measured by the level of defective supplies. This level defines the percentage ratio of the number of defective pieces in supplied products to the total number of delivered products. In the case of bulk products, the level is measured by the rate of Defective Parts Per Million [Öztop & al. 2013, Singh 2014]. The price conditions are often assessed not only in relation to the cost of the purchase, but also to other costs incurred by the buyer in the transaction (such as shipping, insurance), costs associated with the operation of the product (usage, maintenance), the cost of withdrawal of the product from the use (disposal costs). Timeliness of delivery is an important criterion for periodic evaluation of suppliers for companies operating in the Just in Time. An important criterion is also the flexibility of suppliers relating to the possibility of changes in the contract about the timing, quantity, sequencing, or the type of goods purchased. Many companies, especially multinationals, wanting to reduce the risks associated with contacts with suppliers also focus on criteria such as ethics behavior of providers, as well as environmental activities [Deshmukh & Vasudevan 2014]. For this reason, the supplier must comply with strict rules contained in codes of conduct and directives such as:
-RoHS (Restriction of Hazardous Substances) Directive EU 2003/95/EC,
-WEEE (Waste Electrical and Electronic Equipment) Directive 2001/96/EC,
-EuP (Eco-design for Energy using Products) Directive 2009/125/EC,
-Battery and Accumulator Directive 2006/66/EC,
-Packaging Directives 94/62/EC, 2004/12/EC, COM Decision 97/129/EC,
-REACH (Registration Evaluation Authorization and Restriction of Chemicals) Regulation 1907/2006/EC.
A criterion for assessing suppliers taken often into account is the speed and effectiveness of communication that enables and ensures a rapid response to an inquiry made by a client request or complaint, and the problem with the use / operation of the product. Many companies notice efforts made by suppliers regarding building partnership marketing and their offering on-line technical advice, training, and/or team-building meetings. They also often take advantage of the opportunity to place orders on-line. An increasing number of companies improve relations with suppliers by means of joint research and development of new products and offering training to suppliers. International companies pay more attention to the ability of suppliers to conduct joint research and development of new products. To encourage them to cooperate in the design of new products and the development of existing products many OEMs offer their suppliers special support by development programs which are based on the principle of win-win [Chavhan & al. 2012, Omurca 2013].

SUPPLIER DEVELOPMENT PROGRAMS

Supplier development programs are implemented through joint projects aimed at introducing new, or improving existing products. The successful implementation of these programs sometimes requires companies who are clients of investment to equip partners with the necessary infrastructure and technology [Arroyo-López & al. 2012, Ahmed & Hendry 2012]. In practice, one can notice that supplier development programs can be of short and medium term (reactive, focusing largely on eliminating the current problems) or long term (strategic, based on a strong integration partner). They can focus on activities aimed at ensuring and improving the quality of products or the provision and improvement of the process quality. These programs can also be aimed at providing basic or specialized support activities to improve products and processes (Song & Benedetto, 2008; Mishra & Patel, 2010). The successful implementation of these programs allows both suppliers and customers to improve the quality of products (lower the level of non-compliance, introduce product innovations, increase reliability and security), shorten cycle processes and to reduce their costs (in particular with regard to operational processes such as design, customer service before and after the sale, production/services, transportation and maintenance of infrastructure) and improve mutual communication (Bai & Sarkis 2011, Fu & al. 2012]. Actions aimed at developing suppliers undoubtedly contribute to a reduction in transaction costs related to the exploration of new supply capacity, conducting audits and other forms of assessment, verification and qualification of the sources of purchase [Nagati & Rebolledo 2013]. In order to ensure the effectiveness of supplier development program is necessary to produce a climate of cooperation based on mutual commitment, trust and open information exchange especially in the area of performance quality (level of compliance with the requirements for the provision and improvement of products and processes) and cost (access to financial data relating to joint ventures). Effectively implemented, the development programs of suppliers undoubtedly contribute to building the intellectual capital of the partners [Krause, & al. 2007].

Results of empirical study

Identification of criteria for assessing suppliers were the subject of empirical study which was carried out from September to December 2013 through the use of the postal survey. Questionnaires were sent to 3857 companies operating in Poland. 182 questionnaires were returned (response rate at 4.7%). Companies were selected from a database of ISO Guide 2012. The selection of companies was focused on producers and service providers in the B2B market, who have implemented management systems in accordance with the international standard ISO 9001.The results of empirical study indicate that companies operating in Poland, in order to build the partner relationships with suppliers, when carrying out an evaluation of suppliers focus mainly on technical quality of the products, delivery and favorable price conditions, flexibility, effective evaluation of communication processes, product safety, terms of this guarantee. The results of this study indicate that companies concentrate on the evaluation criteria such as technical quality suppliers of products (no defective products), favorable price conditions, on time delivery, ensuring continuity of supply, the reaction time for orders and to complaints, warranty obligations, vendor flexibility (the ability to changes in the contract), and the willingness of the supplier to reduce costs. Detailed results are presented in the following tables 1-3. Analyzing the detailed results and the differences between the segments could one notice that the manufacturers of much more attention than service providers are paying on time deliveries, ensure continuity of supply, warranty obligations, responsiveness to inquiries, quality of services before sale, as well as environmental friendliness of the products. Supplier flexibility(the ability to change the order) is highly important for service providers.

Tab. 1 Criteria for assessing the suppliers indicated by the surveyed companies (general results and a comparison between the segments depending on the sector, a percentage of responses)

Criteria	General N=182	Sector	
		Producers N=112	Service providers N=70
Technical quality of the product	4.76	4.78	4.73
The favorable price conditions	4.60	4.59	4.61
On time delivery	4.50	4.55	4.40
Ensuring continuity of supply	4.33	4.38	4.22
Response time on request	4.26	4.33	4.10
response time to complaints	4.15	4.17	4.11
The discharge of the guarantee obligations	4.11	4.20	3.93
The flexibility of the supplier	4.08	3.97	4.34
The ability of the supplier to cut costs	4.02	4.06	3.93
Response time to inquiries	3.92	4.00	3.72
quality after-sales service	3.91	3.93	3.85
quality before-sales service	3.62	3.70	3.42
Product innovation	3.59	3.62	3.52
Environmental friendliness of the products	3.29	3.51	2.61

Source: author's research

For companies with foreign capital much more important than for domestic companies are the technical quality of the products, response time to complaints, response time to inquiries, quality after-sales service, as well as innovative product solutions offered by suppliers. In contrast, the capital companies with domestic capital pay more attention to favorable pricing conditions and flexibility of the supplier (the ability to change the order).

Tab. 2 Criteria for assessing the suppliers indicated by the surveyed companies (general results and a comparison between the segments depending on the capital, a percentage of responses))

Criteria	Capital	
	Foreign N=41	Polish N=141
Technical quality of the product	4.92	4.72
The favorable price conditions	4.51	4.62
On time delivery	4.70	4.44
Ensuring continuity of supply	4.39	4.31
Response time on request	4.32	4.25
response time to complaints	4.28	4.11
The discharge of the guarantee obligations	4.14	4.10
The flexibility of the supplier	3.97	4.11
The ability of the supplier to cut costs	4.06	4.01
Response time to inquiries	4.22	3.83
quality after-sales service	4.15	3.84
quality before-sales service	3.67	3.60
Product innovation	3.73	3.55
Environmental friendliness of the products	3.21	3.30

Source: author's research

Table 3 Criteria for assessing the suppliers indicated by the surveyed companies (general results and a comparison between the segments depending on the number of employees, a percentage of responses)

Criteria	Number of employees		
	- 50 N=45	51-250 N=89	251- N=48
Technical quality of the product (no defect)	4.74	4.78	4.77
The favorable price conditions	4.51	4.65	4.59
On time delivery	4.46	4.46	4.62
Ensuring continuity of supply	4.44	4.29	4.31
Response time on request	4.32	4.24	4.27
response time to complaints	4.13	4.20	4.08
The discharge of the guarantee obligations	3.90	4.23	4.09
The flexibility of the supplier	3.94	3.79	4.78
The ability of the supplier to cut costs	3.80	4.03	4.22
Response time to inquiries	3.72	4.00	3.95
quality after-sales service	3.81	3.91	4.00
quality before-sales service	3.23	3.75	3.73
Product innovation	3.33	3.64	3.74
Environmental friendliness of the products	3.08	3.33	3.36

Source: own research

Large companies that employ more than 250 employees favor on time delivery, flexibility suppliers (the ability to change the contract), the ability of the supplier to cut costs, quality after-sales service and product innovation. On the other hand, small businesses are focused on ensuring continuity of supply. It is significant that one of the criteria for periodic evaluation of suppliers, which began to be noticeable in companies operating on the Polish market is the environmental friendliness of the products. It is also recognized for companies operating in Poland to inform by the suppliers about the risks associated with the products and their impact on the environment. This is due to the guidelines contained in the directives and regulations of the European Union for the protection of the environment. The requirements of these directives apply also often non-EU companies, especially large multinationals producing high-tech products (mainly from the United States and Japan), such as Dell, HP, IBM, Motorola, Fujitsu, NEC, Panasonic, Sony, and Toshiba [Sanders 2007, Igarashi & al. 2013].

THE TRENDS IN BUILDING RELATIONSHIPS IN THE SUPPLY CHAIN

Observing world trends, one may easily notice that recently suppliers have been monitored from the point of view of meeting the sustainable development requirements following economic aspects (demanding high technical quality, delivery reliability, price competitiveness, technical support), and often also environmental and social aspects (principles based on the concept of the Global Compact). Furthermore, supplier Conduct Principles are defined. Regarding environment protection requirements, special emphasis is put on suppliers by Japanese firms which laid down detailed guidelines for suppliers. Many international companies more frequently require from their suppliers detailed evidence defining environmental goals, documentation, activities aimed at limiting resource consumption, employee training, reducing factors harmful to environment (resulting from processes e.g. gas emission, noise, vibration, waste), and disseminating information on performance connected with environmental protection [Hoejmose & Adrien-Kirby 2012, Tate & al. 2012]. When signing contracts with suppliers, a lot of international companies also make them sign statements according to which they will be obliged to adopt principles included in clauses of so-called business practices (Statements on Business Practices). The enterprises often issue special behavior and ethical rules for the suppliers (Supplier Conduct Principles, Principles and Standards of Ethical Supply Management Conduct) as well as guidelines in respect of their implementation (Supply Chain CSR Deployment Guidebook. Purchasing Way), organize programs (Supply Chain Social

Responsibility Programs), introduce projects (Supplier Responsibility Projects) and draft control lists (Supply Chain CSR Checklist). Statements on Business Practices are connected with avoiding corruption practices, avoiding employee discrimination, protection of human rights and responsibility for the environment. It is worth noting that these requirements are not imposed on one party only (by means of forcing suppliers to meet them). More and more companies want to shape their image as a reliable partner (customer) and therefore draw up purchasing codes of ethics [Foerstl & al. 2010; Goebel & al. 2012].

CONCLUSIONS

To recapitulate the considerations presented in the article, it should be noted that the assessment of suppliers is an important part of building partnerships with them. These partnerships will ensure the required technical quality of purchased products, ensure continuity, timeliness and flexibility of supply and provide the opportunity to improve operational processes, which helps to reduce costs in the supply chain.

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TEMPORAL RELATIONSHIPS BETWEEN COAL PRICES AND BALTIC DRY INDEX

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ABSTRACT
To understand the long-run and short-run interactions between coal prices and Baltic Dry Index (BDI), this study investigated the Australian coal price (AUC), the U.S. coal price (USC), and the BDI using time series approach. Quandt-Andrews test was conducted first to investigate whether there are structural changes in our collected data. Then we applied the approaches of unit root test, Granger causality test, Vector autoregressive model, Johansen's co-integration test, and vector error correction model to examine the long run and short run relationships between the coal prices and BDI. Findings of this study indicate the existence of a structural breakpoint for all data series in 2008, the year of global financial and economic crisis. In addition, there are bidirectional Granger causalities between AUC-BDI and USC-BDI. From the cointegration test, we also proved that there was a long-run interaction relationship between the USC-BDI.

INTRODUCTION
Coal is one of the primarily seaborne trade commodities in dry bulk cargo transportation, which is the most important of the so-called main bulk goods as well as grain and iron ore (Lundgren, 1996). The important role of coal has been emphasized by many works, particularly, after the experience of oil crisis, coal has been seen as the main alternative energy to oil and gas and become increasingly momentous (Lin and Liu, 2010). It can be seen from the consumption volume of coal in recent decades. The consumption of coal in 2009 grew to 40% over the past 10 years (BP, 2010). To have an extended observation of the coal consumption which is shown as Figure 1, we can find that the demand of coal kept going up since 1965. The average growth rate of coal consumption was stable by 0.40% per annum from 1965 to 1972.

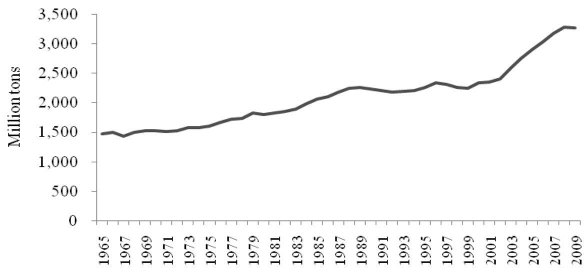

Figure 1: Coal consumption during 1965-2009

Most coal is transported by dry bulk vessel. Based on the geographic proximity, there are two main regional coal markets: a Pacific market and an Atlantic market. According to the freight costs, the coal exporters will find their suitable markets. The widely distribution of coal reserves in over almost 50 coal producing countries which avoid any cartel mechanism, so that the coal prices vary mainly according to quality and transport costs. In addition, because the seaborne coal trade accounted for 93% of total hard coal trade in 2002, the ocean freight rates are an important factor affecting the coal price (Ekawan and Duchêne, 2006). Bachmeier and Griffin (2006) confirmed the close relationship between transportation cost and coal price and illustrated that on average about 35% of the coal price accounted as transportation costs in the US coal market. Although previous studies have shown the relationships between coal prices and freight rate, there is relatively little research on the temporal relationships between coal prices and bulk cargo freight rates. Consequently, the aim of this study is to investigate the long run and short run interactions of coal prices and Baltic Dry Index (BDI), which is the best known freight index. Such interaction information is especially helpful to the dry bulk shipping industry because it provides detailed understanding of the long-term and short-run dynamics that are important for the development of reliable forecasting models.

DATA COLLECTION AND METHODOLOGY

In order to evidence the long run and short run interaction relationships between the prices of coal and BDI, the Australian coal price (AUC), the US coal price (USC), and the BDI are included in this study. The Australian quarterly coal data is based on Free On Board (FOB) and is selected over the period from 2000Q1 to 2008Q4 from the IMF's INTLINE International Macroeconomic Statistical Databank. The US coal data is based on FOB as well and is composed of monthly spot prices over the period from January 2000 to March 2009 from the Global Financial Database. And the data of BDI is collected from the Baltic Exchange database and transferred into monthly time series data over the period from January 2000 to March 2009.

Once we collected the data, Quandt-Andrews test was conducted first to investigate whether there are structural changes in our collected data. After determined a proper duration of data, to avoid the possibility of spurious regression, unit root test was applied to check the stationary properties among these series data through the method of Augmented Dickey-Fuller (ADF). The test of the ADF approach is based on the estimates of the following regression.

$$\Delta y_t = \mathbf{\Theta D}_t + \phi\, y_{t-1} + \sum_{k=1}^{p} \psi_k \Delta y_{t-k} + \varepsilon_t \ , \tag{1}$$

where y_t is the price or freight variable at time t, $\Delta y_t = y_t - y_{t-1}$, $\mathbf{D}_t$ is a vector of deterministic terms with coefficient vector Θ, p is the number of lags, ε_t is the error term, and ϕ and ψ_k are the coefficients.

Then, we investigated the causality relationships among the variables of AUC, USC, and BDI, all transformed series data are taken into account by pair. Pairwise Granger causality tests are used for bivariate regressions which shown as Equation (2) and Equation (3). The Granger causality relationship is detected through Wald F-test.

$$X_t = \sum_{i=1}^{m} a_i X_{t-i} + \sum_{i=1}^{m} b_i Y_{t-i} + \varepsilon_i \ , \tag{2}$$

$$Y_t = \sum_{i=1}^{m} c_i X_{t-i} + \sum_{i=1}^{m} d_i Y_{t-i} + \eta_i \ , \tag{3}$$

where m is lag length, ε_i and η_i are two independent white noise series.

The next procedure was to establish models for understanding the relationships among our observations. Vector autoregressive (VAR) model was established as a basic model for Johansen's co-integration test. Let $\mathbf{Y}_t = (y_t, y'_t)$ denote a 2×1 vector with the BDI (y_t) and the coal price (y'_t) at time t. Series y_t and y'_t are non-stationary with same I(d) in the same region. Consider the basic form of the p-lag (VAR(p)) model without exogenous variables.

$$\mathbf{Y}_t = \mathbf{\Theta D}_t + \sum_{k=1}^{p} \mathbf{\Pi}_k \mathbf{Y}_{t-k} + \boldsymbol{\varepsilon}_t \ , \tag{4}$$

where $\mathbf{D}_t$ is a vector of deterministic terms, $\mathbf{\Pi}_k$ are 2×2 coefficient matrices, p is the lag length, and $\boldsymbol{\varepsilon}_t$ is a 2×1 zero mean white noise residual vector.

For those non-stationary time series variables having the same integration order, a cointegration test was used to check the long run relationships between AUC, USC, and BDI. By applying the Johansen's methodology for modeling cointegration (Johansen, 1988), paremeters with the same I(d) were analyzed pairwise to test their cointegration relationships. Finally, the vector error correction model (VECM) was applied for the short-term dynamic analysis (Engle and Granger, 1987).

$$\Delta \mathbf{Y}_t = \mathbf{\Theta D}_t + \mathbf{\Pi Y}_{t-1} + \sum_{k=1}^{p-1} \mathbf{\Gamma}_k \Delta \mathbf{Y}_{t-k} + \boldsymbol{\varepsilon}_t \ , \qquad (5)$$

where $\mathbf{\Pi} = \mathbf{\Pi}_1 + \mathbf{\Pi}_2 + \cdots + \mathbf{\Pi}_p - \mathbf{I}_n$, $\mathbf{\Gamma}_k = -(\mathbf{\Pi}_{k+1} + \mathbf{\Pi}_{k+2} + \cdots + \mathbf{\Pi}_p)$ for k=1,…, p-1, and the vector $\mathbf{\Gamma}_k$ is called the short run impact matrix. The Granger causality test was employed again to observe the long run and short run relationships between coal prices and BDI in VAR and VECM respectively. The Wald $\chi^2(n)$ test is used to detect the Granger causal relations in the long run and short run between variables.

FINDINGS

Quandt-Andrews test is conducted to test for an unknown structural break point among all the original regressors with 5% trimming. The results are shown in Figure 2, in which describes the F-statistic for the average of AUC, USC, and BDI. The existences of the structural break were obviously trending patterns in the plot during the year of 2008. The structural changes of AUC, USC, and BDI were happened on January, August, and May 2008 respectively. To taking account of the equal lengths of all series sampled in this study, a revised observation range is unified from 2000 to 2007.

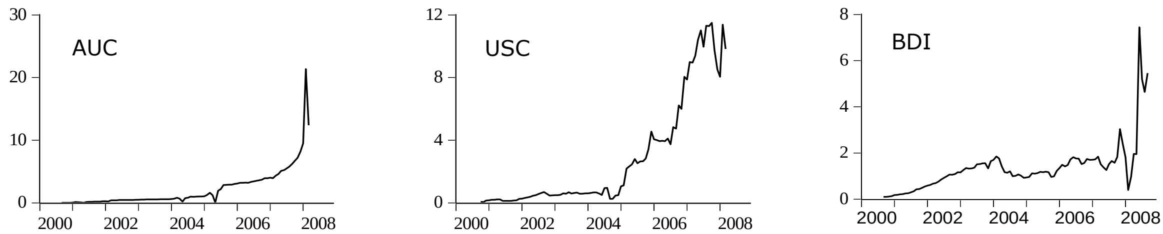

Figure 2: The results of Quandt-Andrews breakpoint test

The next pre-test step is to check the stationary properties among the time series data. The results of unit root test are summarized in Table 1. Because the null hypothesis of a unit root cannot be rejected for the level of all variables, all variables are non-stationary. For those non-stationary variables whose differences were applied 1 time to make the processes stationary. The result is shown that the null hypothesis of a unit root can be rejected for their first difference series at the 1% significance level. It can be concluded that AUC, USC, and BDI can be integrated in order 1. Then the time series of the coal price and BDI with the same integration orders were paired to analyze their dynamic relationships. Accordingly, the AUC-BDI and USC-BDI are the 2 pairs of analysis data.

Variables	Level series		First difference series	
	With intercept and trend	Lag length	None	Lag length
AUC	-2.1949	7	-3.0666^{***}	3
USC	-1.7978	1	-5.5200^{***}	0
BDI	-1.8919	1	-6.0626^{***}	0

Notes: a. *** indicates rejection of the unit root hypothesis at 1% level.
b. The selection of the lags is based on the smallest Akaike's information criterion (AIC).

Table 1: ADF unit root tests (2000M01-2007M12)

We first applied the Granger causality test in advance for the confirmation of causality between AUC-BDI and USC-BDI. This procedure can prevent the meaningless analysis for the following interaction investigations. From Table 2 the F-test shows that, strong causations are found between AUC-BDI and USC-BDI which reached at least 5% critical value. Because the null hypotheses of non-Granger causality from AUC to BDI, from BDI to AUC, from USC to BDI, and from BDI to USC cannot be rejected, there are bidirectional Granger causalities between AUC-BDI and USC-BDI.

H_0	Lag	F-statistics	P-valu
AUC does not Granger Cause BDI	1	6.1332	0.0149**
BDI does not Granger Cause AUC		6.3587	0.0132**
USC does not Granger Cause BDI	1	6.1674	0.0147**
BDI does not Granger Cause USC		25.0267	0.0000***

** and *** denote significance at 5% and 1% levels respectively.

Table 2: Granger causality results

The short run dynamic interaction relationship for USC-BDI in VECM is shown in Table 3. The Wald $\chi^2(16)$ statistic for the null hypothesis of no Granger causality from USC to BDI does not reach the confidence level, thus USC does not Granger causes BDI in the short run. Conversely, the Wald $\chi^2(16)$ statistic for the null hypothesis of no Granger causality from BDI to USC is rejected and suggesting that BDI Granger causes USC in the short run. In addition, the short run Granger causality running from BDI to USC indicates short run dynamics of BDI on USC. The coefficients of the lagged terms of BDI are negative and statistically significant achieve at least 5% confidence level. The short run elasticity of USC with respect to BDI show that the short run effect of BDI on USC has maintained from two to fourteen months.

Dependent variable	Lag	Variable	Coefficient	Std. error	*t*-value	Granger causality
$\Delta(BDI)_t$	16	ECT	-0.2218	0.1730	-1.2821	
		$\Delta(USC)_{t-6}$	-57.1374	27.8884	-2.0488**	
		$\Delta(USC)_{t-10}$	-65.5986	31.7900	-2.0635**	$\chi^2(16)$=17.8583
$\Delta(USC)_t$	16	ECT	0.0031	0.0009	3.3636***	
		$\Delta(BDI)_{t-2}$	-0.0032	0.0011	-2.8818***	
		$\Delta(BDI)_{t-5}$	-0.0026	0.0012	-2.2908**	
		$\Delta(BDI)_{t-7}$	-0.0035	0.0013	-2.7600***	
		$\Delta(BDI)_{t-14}$	-0.0028	0.0012	-2.2333**	$\chi^2(16)$=30.9541**

Table 3: VECM for USC-BDI

CONCLUSIONS

The coal prices have become a matter of current economic, market conditions, and related to the prices of other fossil fuels. With the closed relationship between coal prices and freight rates, this study investigates the long run and short run interactions of coal prices and bulk cargo freight rates. Our findings indicate that all variables are non-stationary. While we established the VAR model, the pair of AUC-BDI does not satisfy the condition of the white noise process. Therefore, the interaction analysis is focused between the USC and BDI. The BDI could be a good indicator for the USC but not such suitable for the AUC. In addition, the granger causality test is performed in VAR model, CE, and VECM to diagnose the causal relation among variables, long run and short run lagged terms. Once we verified the causal relation from BDI to USC, the long-term and short-term interactions between them are analyzed in the CE and VECM. In the long run, BDI does positively affect the USC. However, in the short run, the BDI has a negative dynamic effect on USC.

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LOGISTICAL BEST PRACTICES: ASSESSING THEIR IMPACT ON CORPORATE PERFORMANCE

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1. BACKGROUND

Most managers would like to make a benchmarking to the world class logistical models to compare them against their own operational practices to determine whether or not a change in the status quo is in place. Organizations not following logistical practices will not be able to adopt a substantial number of them at once due to time, financial and/or technology constraints. Hence, it results practical to identify which of these practices are significant to a firm's overall performance, as well as to assess the potential benefits of intensively focusing on individual practices (Fugate et.al, 2010). The ultimate purpose of logistical practices is to provide the Supply Chain with long-term benefits for all stakeholders through collaboration, coordination, and resource sharing (Saber et al., 2014)

This research aims at evaluating, through the use of statistics, the impact of a set of pre-selected logistical practices on corporate performance, as well as to assess the relationship between performance and level of emphasis as it relates to the use of such logistical practices.

1.1 Research Hypotheses

The first and second hypotheses formulated in this study have to do with Customer Relations logistical practices. The first hypothesis deals with the identification of Customer Relations practices that are relevant to a firm's performance. The second one validates the assumption that when intensively implemented, these practices lead to superior performances.

H1.a: A customer-relations focus, characterized by a deep customer interaction in operations, information systems, collaborative design, forecasting, and strategic planning has a significant impact on a firm's performance.

H1.b: Companies that strongly develop a customer-relations focus will exhibit enhanced performance compared to those that do not.

The third and fourth hypotheses deal with Supplier Relations logistical practices. The third hypothesis looks at significant Supplier Relations practices that impact firm's performance. The fourth one relates to Supplier Relations practices that, when intensively used, result in superior performances.

H2.a: A supplier-involvement focus, characterized by a deep involvement of suppliers in operations, information systems, collaborative design, forecasting, and strategic planning has a significant impact on a firm's performance.

H2.b: Companies that strongly develop a supplier involvement focus will exhibit enhanced performance compared to those that do not.

The fifth and sixth hypotheses have to do with Environmental Awareness logistical practices. The fifth hypothesis looks at the significant Environmental Awareness practices that impact a firm's performance. The fourth one looks at practices that, in case of being intensively used, will lead to superior performances.

H3.a: An environmental-awareness focus, marked by a strong environmental responsibility, having defined processes for the recovery and afterwards recycling, re-manufacturing or final disposition of products, and the design of products with a longer life cycle, has a significant impact on a firm's performance.

H3.b: Firms that strongly develop an environmental-awareness focus will exhibit enhanced performance compared to those that do not.

A questionnaire was developed, and items were grouped based on three categories: Customer Relations practices, Supplier Relations practices, and Environmental Awareness practices. A fourth section of the questionnaire consisted of performance measurement variables. The objective of the survey was to assess the relationship between a firm's logistical practices, and the chosen performance measures.

To test hypotheses H1.a, H2.a, and H3.a, a Factor Analysis was performed in order to group the variables of each of the three parts of the questionnaire that have to do with logistical practices. For each performance measure (i.e. thirteen total), a Multiple Linear Regression analysis was carried out to determine which factors (groups of variables) were relevant to the organization's performance.

In regard to hypotheses H1.b, H2.b, and H3.b, T-tests for analyzing significant differences in corporate performances were conducted. These involved contrasting firms with a high emphasis on logistics against those without it.

1.2 The Importance of Integration and Collaboration in Supply Chain Management

Executives are becoming aware of inter-network competition. They recognize that the successful integration and management of key business processes across members of the supply chain will determine the final success of single enterprises. Hence, the supply chain has to be considered as a network of multiple businesses and their relationships. The objective of Supply Chain Management can be understood as to maximize competitiveness and profitability for companies as well as the whole supply chain network including the end-customer (Lambert et al., 1998; Cooper et al., 1997; Croxton et al., 2001). The supply chain must then be managed as a system (McAdam, 2001).

Individual companies work together to form inter-enterprise networks in order to survive and achieve business success (Browne and Zhang, 1999). A considerable number of manufacturing and service businesses is moving to "network" models of organization. Several companies are establishing corporate logistics/supply-chain management centers to provide information, resources, and guidance to keep networks functioning on an optimal basis (Alsagheer and Ahli, 2011; Boyson et al., 1999).

Coordination among independent firms is the key to attaining the flexibility that is necessary to progressively improve logistics processes responding to rapidly changing market conditions. The main concern of supply chain management is to ensure independent companies working together as a whole under changing market conditions. (Simatupang et al., 2002)

Stank et al. (1999) believe that a strong cross-enterprise coordination in the supply chain would result in absolute performance improvements in the following areas: inventory levels, transportation costs, warehousing costs, ordering costs, stock-outs, order cycle variance, on- time deliveries, unacceptable deliveries, product availability, customer satisfaction, transaction processes, order cycle time, flexibility, and the assessment of customer needs. Bowersox (1990) reports that logistics alliances offer opportunities to dramatically improve customer service and at the same time lower distribution and storage operating costs.

Coordination of sourcing, production, and logistical activities in a supply chain perspective permits a loosely linked group of businesses work as a synchronized enterprise, focused on efficiency improvement and increased competitiveness. Higher levels of coordination are expected to yield improved logistics cost and customer service performance. Many firms have discovered that an improved systems coordination and a streamlined information flow can be achieved by strengthening their relationships with product and service suppliers and customers rather than relying on short-term, single-transaction arrangements (Stank et al., 1999).

1.3 Environmental Awareness

Although the sustainability of economic development is a shared responsibility of businesses, governments, and consumers alike, the corporate role in slowing down the planet's environmental degradation is particularly relevant (Verma, 2014; De Burgos and Cespedes, 2001). Due to changing environmental requirements affecting manufacturing operations, increasing attention is given to developing environmental management strategies for the supply chain.

There has been increasing public attention placed on the overall condition of the natural environment. There is an overall awareness of the worsening state of the environment, as well as a desire to reverse that trend (Verma, 2014; Beamon, 1999). The fully integrated supply chain contains all the elements of the traditional supply chain, but additionally constructs a loop that includes product and packaging recycling, re-use, and/or remanufacturing operations (Barve and Muduli, 2013; Beamon, 1999).

De Burgos (2001) states that corporations can obtain several benefits associated with the reduction of the organization’s impact on the environment, which can help towards obtaining a competitive advantage. Among these benefits are: reduced operation costs, an early adoption of new regulations, an improved company image, better access to new markets, improved customer loyalty, and improved stakeholder communication and feedback.

Croxton et al. (2001) consider that the effective management of product returns is a critical part of Supply Chain Management. While many firms neglect the importance of understanding the dynamics involved in the process of handling returns, doing so enables the achieving of a sustainable competitive advantage. Effective management of the return process leads to productivity improvement opportunities and breakthrough projects.

2. Methodology

In this research, a survey in the form of a questionnaire was applied to medium and large scale organizations. Multivariate analysis was then conducted on the collected data to provide empirical evidence that customer-relations, supplier-relations, and environmental-awareness practices have a significant impact on a perceived firm's performance. Moreover, the study focused on providing evidence that firms which aggressively develop customer relations, supplier relations, and environmental awareness, exhibit superior performance compared to those that do not. The survey, and subsequent analysis, was applied to medium (i.e. between 100 and 500 employees) and large-size corporations (i.e. more than 500 employees).

2.1 Questionnaire

A questionnaire consisting of four sections was developed based on the published literature: one section for measuring Customer Relations , another for Supplier Relations, other one for measuring Environmental Awareness, and the fourth one for measuring Firm Performance.

The Customer-Relations rubrics consist of 17 questions or items on customers' involvement in manufacturing and production plans, product and process design, planning and forecasting, logistics, agility and flexibility, and order fulfillment.

The Supplier-Relations section consists of 15 questions on suppliers' involvement in manufacturing and production plans, product and process design, planning and forecasting, logistics, agility and flexibility, and order fulfillment. The Environmental Awareness part of the survey includes eight questions on environmental awareness and responsibility, reverse logistics, and environmental manufacturing practices such as re-manufacture, re-cycling, and re-use. The Performance Measurement questions are thirteen queries on customer service, cost management, quality, productivity, and asset management. For the three first questionnaire sections, respondents were asked to indicate their agreement with statements concerning how much their companies complied to the chosen logistical practices based on a 5-point Likert scale, where l = Totally Disagree and 5 = Totally Agree. For the series of questions on corporate performance, respondents were asked to indicate, using the same five point Likert scale, their perceptions on their company's shown performance relative to that of their major industry competitors.

No consensus exists as to a universal performance definition. Similarly, no agreement regarding what factors constitute the best measure of performance has been reached (Sellers-Rubio, 2010; Stank et al., 1999). Given the lack of consensus regarding a valid cross-industry measure of corporate performance, the performances of individual companies were rated in this study by managerial perceptions relative to their major competitors (Glavan, 2012). Although objective measures of firm performance are preferable to perceived measures, they are difficult to obtain, and previous studies in the field have demonstrated that perceived measures are legitimate representatives of objective data (Glavan, 2012; Tracey and Tan, 2001).

Personnel from a total of 186 companies were surveyed. 185 completed questionnaires were received. 61 questionnaires were eventually eliminated from the analysis due to different reasons. The remaining 124 surveys were utilized for a Multivariate Analysis using the SPSS statistical software.

2.2 Statistical Tools employed in the Study

For each of the first three groups of questions (independent variables), exploratory Factor Analysis was applied to identify the not directly observable factors based on the variables. The goal was to identify a smaller set of factors to represent the relationship among the variables parsimoniously. In this research, principal components analysis with eigenvalues greater than one was used to extract factors, and varimax rotation was used to facilitate interpretation of the factor matrix. The Bartlett Test of Sphericity (to test the null hypothesis that the correlation matrix is an identity matrix) and the Kaiser-Meyer-Olkin measure of sampling adequacy were used to validate the use of Factor Analysis. Consequently, the 17 Customer-Relations practices were reduced to four underlying factors, the 15 Supplier-Relations practices were reduced to three underlying factors, and the 8 Environmental-Concern practices were reduced to two underlying factors.

For the chosen thirteen performance measures, multiple linear regressions were carried out using the factors as independent variables (each factor was represented with the average of the variables that loaded higher in that factor). Durbin-Watson statistic and normal probability plots were used to verify that residuals were independent and normally distributed. All independent variables (factors) were entered simultaneously in the regression analyses. A backwards analysis was used in the SPSS to get to a model with only significant variables.

T-tests for analyzing significant differences in the performance means of firms that strongly develop a logistic focus and those that do not were also conducted in the study. The items of the questionnaire that weighed higher on each factor were averaged. These averages were used to group companies depending on how intensively they focused on those logistical practices. Clusters were achieved by splitting out respondents with overall scores of 4 or more into one group (indicating high levels of focus), and respondents with overall scores lower than 4 into a second group (indicating low levels of focus). T-test of significant differences in means was then conducted to test each of the pre-established hypotheses.

3. Results from the Research

3.1 Multiple Regression Analyses

For each of the thirteen performance measurement indicators, multiple linear regressions were carried out using the nine factors as independent variables. All thirteen regression models were statistically significant at confidence level of 0.95.

Regarding hypothesis H1.a, the statistical analysis showed that:

a) The Customer Involvement factor had a significant positive impact on Customer Satisfaction.
b) The Plans, Programs, and Information factor had a significant positive impact on Return on Assets, Delivery Speed, Responsiveness to Key Customers, Order Fill Capacity, Advanced Shipment Notification, and Inventory Turns.
c) The Focus on Customer factor has a significant positive impact on Informal System Support, and a significant adverse impact on Inventory Turns.
d) The Focus on Customer factor 2 had a significant positive impact on Product Flexibility.

With respect to hypothesis H2.a, the statistical analysis showed that:

a) The Supplier Involvement factor had a significant positive impact on Low Logistics Costs, Order Fill Capacity, Order Flexibility, and Delivery Time Flexibility.
b) The Supplier Involvement factor2 had a significant positive impact on Delivery Dependability, and Inventory Turns.

Finally, as it pertains to hypothesis H3.a, the statistical analysis showed that:

a) The Recovery, Recycling, and Remanufacturing factor had a significant adverse impact on Advanced Shipment Notification.
b) The Environmental Concern factor had a significant positive impact on Inventory Turns.

3.2 Testing for Significant Differences in Performance between Firms with a Strong Logistic Focus and Those without It

Using the means of the variables that weighted highly on each studied factor, two groups were developed: a group of enterprises that use logistical practices intensively, and another which do not. For each of these groups, an average in each of the performance measurements was calculated to determine if there is a significant difference in these means via a set of t-tests.

Regarding H1.b, our statistical analysis showed that:

a) The Customer Involvement factor was significant to Delivery Dependability, Responsiveness to Key Customers, Inventory Turns, Customer Satisfaction, and Informal Systems Support.
b) The Plans, Programs, Information factor was significant to Low Logistics Costs, Delivery Dependability, Responsiveness to Key Customers, Order Fill Capacity, Advanced Shipment Notification, Inventory Turns, Customer Satisfaction, and Informal Systems Support.
c) The Focus on Customer factor was significant to Product Flexibility, Low Logistics Costs, Responsiveness to Key Customers, Order Fill Capacity, Customer Satisfaction, and Informal Systems Support.
d) The Focus on Customer factor 2 was significant to Product Flexibility, Responsiveness to Key Customers, and Advanced Shipment Notification.

Regarding H2.b, our statistical analysis showed that:

a) The Supplier Involvement factor was significant to Delivery Dependability, Responsiveness to Key Customers, Order Fill Capacity, Order Flexibility, Delivery Time Flexibility, Advanced Shipment Notification, Inventory Turns, Customer Satisfaction, and Informal Systems Support.
b) The Supplier Involvement factor 2 was significant to Return on Assets, Product Flexibility, Delivery Dependability, Responsiveness to Key Customers, Order Fill Capacity, Order Flexibility, Delivery Time Flexibility, Inventory Turns, Customer Satisfaction, and Informal Systems Support.
c) The Information factor was significant to Delivery Time Flexibility, and Inventory Turns.

With respect to H3.b, our statistical analysis showed that:

a) The Recovery, Recycling, and Remanufacture factor was significant to Informal Systems Support.
b) The Environmental Awareness factor was significant to Inventory Turns.

4. Conclusions and Final Remarks

Through Multiple Regression analysis, it was shown that a focus on customer relations, supplier relations, and environmental awareness has a significant impact on a firm's performance. Additionally, performed T-tests validated the premise that firms that strongly develop a customer relations, supplier relations, and environmental awareness focus ultimately exhibit a superior performance as compared to those that do not.

Based on these findings and through the feedback attained from the responses to our questionnaire, the authors of this study make the following recommendations:

With regard to Customer Relations:

1. Integrate programs and activities with customers
2. Make sure that you have a friendly product (in transit) information system to customers
3. Exchange information with customers for planning
4. Involve important customers in strategic planning
5. Inform counterparts about events that could affect them
6. Inform customers about fluctuation in production
7. Involve customers in planning of logistics strategy
8. Involve customers un forecasting and plans
9. Involver customers in design

With regard to Supplier Relations:

1. Consider advantages given by suppliers in production planning
2. Integrate programs and activities with suppliers
3. Involve suppliers in design of products and processes
4. Establish long term agreements with suppliers
5. Make strategic plans with collaboration of important suppliers
6. Involve suppliers when elaborating forecasts and plans
7. Synchronize demand and material flow with your production plan
8. Involve suppliers in new product development and concurrent engineering
9. Involve suppliers in planning of logistics strategy
10. Exchange information with suppliers for planning
11. Use internet and electronic data in your suppliers' delivery process
12. Elaborate programs with suppliers to support special requests by customers
13. Elaborate contingency plans to react quickly to sudden changes in demand

Finally, the authors of this study are aware of the shortcomings of this research. The surveys included a limited number of respondents, not enough to draw conclusions by industry, only by size. The survey was also restricted to medium and large scale organizations. It is a well-known fact that most small firms do not have adequate managerial and organizational structures. It may be worth exploring the degree of logistical chaos that is present in small organizations.

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THE IMPACT OF ALTERNATIVE RACK LAYOUTS ON ECONOMIC AND ERGONOMIC PERFORMANCE MEASURES IN ORDER PICKING

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ABSTRACT
Manual order picking ranks among the most critical activities in warehouses, and it has frequently been studied in the past. Although humans play an important role in order picking, integrated planning models that consider both economic and ergonomic objectives in order picking design are still rare in academic research. This paper aims at closing this research gap by studying how the layout of racks and the way products are stored on racks impact economic and ergonomic performance measures in order picking.

INTRODUCTION AND LITERATURE REVIEW
Warehouses are important elements of supply chains. The management of warehouses has a large impact on performance figures such as product availability, delivery speed and customer satisfaction. Even though warehousing processes can be automated in general, most warehouses still heavily rely on manual material handling activities. This is due to the fact that employing human workers, instead of machines and automated systems, ensures a high level of flexibility with low investment cost (Richards 2011). One of the most important manual activities in warehouses is order picking, which is responsible for retrieving items from storage locations to fulfil customer orders (Frazelle 2002). Due to low degrees of automatization, order picking ranks among the most costly activities in warehouses accounting for about 50% of all operating costs (Tompkins et al. 2010). In manual order picking, human factors, such as cognitive and motor skills of the pickers, affect process efficiency and quality (Grosse et al. 2015). Repetitive handling of (possibly) heavy loads in awkward body postures, however, exposes order pickers to a high risk of developing health problems, such as musculoskeletal disorders (MSD) (Lavender et al. 2012). The risk for injuries and the required physical workload is mainly affected by the design of the order picking system (cf. Neumann and Village 2012). For example, the design of warehouse racks determines the energy expenditure that is needed for workers to extract items from storage positions, often requiring workers to twist, bend, kneel and stretch, which also affects workers' fatigue (Grosse et al. 2015). The fact that order picking creates a risk environment becomes obvious from occupational illness figures. In the European transport and storage sector, for example, MSD accounted for over 62% of all work-related health problems in 2007 (Eurostat 2009). The economic burden of MSD is up to 2% of the gross national product in the European Union (Schneider and Irastorza 2010).

Interestingly enough, management-oriented research has mainly focused on economic goals (such as reducing order picking time) and neglected human factors and ergonomic issues. For this reason, integrating human factors into order picking planning models offers interesting research opportunities (Grosse et al. 2015). Only a few works have studied human factors in order picking planning models so far (Grosse et al. 2015). These works focused on

- the effect of learning and individual worker skills on order picking performance (Grosse and Glock, in Press),
- the impact of paperless picking technologies on the occurrence of human errors (Battini et al. 2015),
- methods to evaluate simultaneously task times and related body postures of workers during picking activities (Battini et al. 2014a), and

- measures to avoid occupational accidents (De Koster et al. 2011).

We conclude that there exists a clear need to integrate ergonomic performance measures into order picking design to take into account the health risk that is inherent in order picking tasks, which has been confirmed in various ergonomic field studies (Lavender et al. 2012, St-Vincent et al. 2005). The paper at hand builds on this line of thought by developing a mathematical model that considers both order picking time and worker health risks by evaluating different storage rack layouts. The model helps to evaluate of how the layout of storage racks and the way products are stored on racks in the warehouse impact the economic (in terms of time) and ergonomic (in terms of energy expenditure) performance of the order picker. Due to the integrative character, the model can be used as a decision support tool to assess different alternatives for storing products on warehouse shelves, which can help to reduce operating time and costs as well as worker illness caused by poor ergonomic conditions.

The remainder of the paper is structured as follows. In the following section, the problem studied here is described in detail and a mathematical model is developed. The behaviour of the model is investigated in a numerical analysis and results are presented. The paper concludes by summarizing managerial insights and directions for future research.

PROBLEM DESCRIPTION

We study three alternative rack layouts: a) traditional pallet picking, b) half-pallet picking, and c) half-pallet picking with a pull-out system, which are described briefly in Table 1.

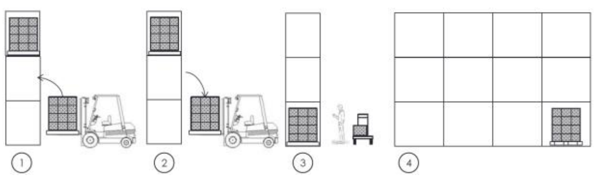
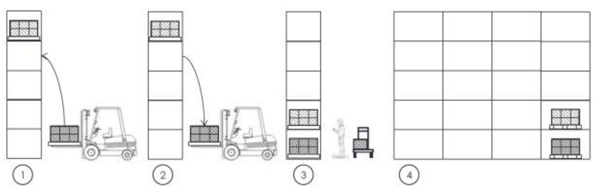
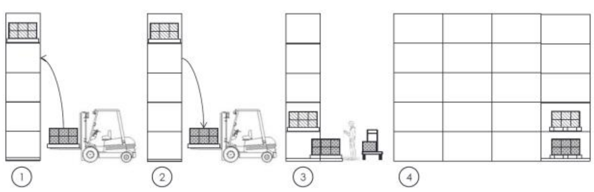
Rack layout	Description
a) Traditional pallet picking 	Pallets are stored in the reserve area (1) and stocked in the forward area (2) with the help of a forklift truck. In the forward area, workers pick full cartons from the pallet requiring a certain pick time as well as a certain energy expenditure (3). (4) shows the front view of the rack layout considered.
b) Half-pallet picking 	Half-pallets have lower dimensions and require less floor space; however, storing (1) and retrieving (2) activities increase as fewer cartons can be stored per pallet. Workers pick cartons from half-pallets in upper and lower rack locations (3).
c) Half-pallet picking with pull-out system 	This scenario considers half-pallet picking with the option to pull out pallets that are stored in the lower locations, as these pallets are located on a specific pull-out device that is common in industry. Pulling out pallets manually requires a certain amount of time and is connected with a certain level of energy expenditure (3).

Table 1: Alternative rack layouts studied in this paper

MODEL DEVELOPMENT

The model development for the three proposed systems is split up into two parts: a) economic models and b) energy expenditure models. Notations are shown in the Appendix.

a) Economic evaluation models

The economic analysis considers the unitary total cost expressed in € per picking line. This total cost is mainly composed of two cost components, derived from the time needed to perform the corresponding activities, namely "pallet handling cost" and "picking cost". The first term concerns the stocking activity (the pallet is stocked in the reserve area) and the refilling activity (the pallet is moved from the reserve area to the forward area, enabling the picking of products). The formula for this first term is the same for all considered warehouse solutions. The second term, instead, deals with the proper picking activity and considers the actual physical pick, the travel and all additional activities that are usually needed (i.e. product barcode scanning, product verification etc.). Hence, this term depends on the configuration of the racks: in case of picking from half-pallets and picking from half-pallets with a pull-out system, there are two terms for the picking activity (one for picking products located in the lower part of the rack and one for picking products located in the upper part). However, both storage positions are reached with the same travel distance, as there are two different products available for picking in the same horizontal space, instead of only one (compared to traditional pallet picking). For picking from racks with the pull-out system, we have to consider also the physical action of extracting the pallet located on the floor. Finally, the cost of the pull-out system C_3 has to be added to the "pallet handling cost" and the "picking cost". The cost of the pull-out system is divided by 2, since in the corresponding layout it is employed only for half of the stock locations.

Traditional pallet

$$C_p = \frac{\left(t_{ST} \cdot \frac{Q_i}{q_p} + t_{REF} \cdot \frac{Q_i}{q_p}\right) \cdot C_1 + \left(t_{P\,p} \cdot Q_i + t_{TRAV} \cdot Z_i + t_{FIX} \cdot Z_i\right) \cdot C_2}{Z_i}$$

Half-pallet

$$C_{hp} = \frac{\left(t_{ST} \cdot \frac{Q_i}{q_{hp}} + t_{REF} \cdot \frac{Q_i}{q_{hp}}\right) \cdot C_1 + \left(t'_{P\,hp} \cdot \frac{Q_i}{2} + t''_{P\,hp} \cdot \frac{Q_i}{2} + t_{TRAV} \cdot \frac{Z_i}{2} + t_{FIX} \cdot Z_i\right) \cdot C_2}{Z_i}$$

Half-pallet with pull-out system

$$C_{po} = \frac{\left(t_{ST} \cdot \frac{Q_i}{q_{po}} + t_{REF} \cdot \frac{Q_i}{q_{po}}\right) \cdot C_1 + \left(t'_{P\,po} \cdot \frac{Q_i}{2} + t''_{P\,po} \cdot \frac{Q_i}{2} + t_{PO} \cdot \frac{Z_i}{2} + t_{TRAV} \cdot \frac{Z_i}{2} + t_{FIX} \cdot Z_i\right) \cdot C_2 + \frac{C_3}{2}}{Z_i}$$

b) Ergonomics evaluation models

The proposed ergonomics analysis deals with the estimation of energy expenditure, limited to the picking activity. For each of the rack configurations, two different values of energy expenditure are needed, the first one expressed in kcal/min and the second one in kcal/line. The structure of the model is similar to the one proposed for the economic evaluation; the difference is the consideration of the unitary energy expenditure, corresponding to every single activity (physical picking, travelling, confirming).

Traditional pallet

$$\dot{E}_p = \frac{\dot{E}_{P\,p} \cdot t_{P\,p} \cdot Q_i + \dot{E}_{TRAV} \cdot t_{TRAV} \cdot Z_i + \dot{E}_{FIX} \cdot t_{FIX} \cdot Z_i}{t_{P\,p} \cdot Q_i + t_{TRAV} \cdot Z_i + t_{FIX} \cdot Z_i}$$

$$\dot{E}_{Z\,p} = \frac{\dot{E}_{P\,p} \cdot t_{P\,p} \cdot Q_i + \dot{E}_{TRAV} \cdot t_{TRAV} \cdot Z_i + \dot{E}_{FIX} \cdot t_{FIX} \cdot Z_i}{Z_i}$$

Half-pallet

$$\dot{E}_{hp} = \frac{\dot{E}'_{P\,hp} \cdot t'_{P\,hp} \cdot \frac{Q_i}{2} + \dot{E}''_{P\,hp} \cdot t''_{P\,hp} \cdot \frac{Q_i}{2} + \dot{E}_{TRAV} \cdot t_{TRAV} \cdot \frac{Z_i}{2} + \dot{E}_{FIX} \cdot t_{FIX} \cdot Z_i}{(t'_{P\,hp} + t''_{P\,hp}) \cdot \frac{Q_i}{2} + t_{TRAV} \cdot \frac{Z_i}{2} + t_{FIX} \cdot Z_i}$$

$$\dot{E}_{Z\,hp} = \frac{\dot{E}'_{P\,hp} \cdot t'_{P\,hp} \cdot \frac{Q_i}{2} + \dot{E}''_{P\,hp} \cdot t''_{P\,hp} \cdot \frac{Q_i}{2} + \dot{E}_{TRAV} \cdot t_{TRAV} \cdot \frac{Z_i}{2} + \dot{E}_{FIX} \cdot t_{FIX} \cdot Z_i}{Z_i}$$

Half-pallet with pull-out system

$$\dot{E}_{po} = \frac{\dot{E}'_{P\,po} \cdot t'_{P\,po} \cdot \frac{Q_i}{2} + \dot{E}''_{P\,po} \cdot t''_{P\,po} \cdot \frac{Q_i}{2} + \dot{E}_{PO} \cdot t_{PO} \cdot \frac{Z_i}{2} + \dot{E}_{TRAV} \cdot t_{TRAV} \cdot \frac{Z_i}{2} + \dot{E}_{FIX} \cdot t_{FIX} \cdot Z_i}{(t'_{P\,po} + t''_{P\,po}) \cdot \frac{Q_i}{2} + t_{PO} \cdot \frac{Z_i}{2} + t_{TRAV} \cdot \frac{Z_i}{2} + t_{FIX} \cdot Z_i}$$

$$\dot{E}_{Z\,po} = \frac{\dot{E}'_{P\,po} \cdot t'_{P\,po} \cdot \frac{Q_i}{2} + \dot{E}''_{P\,po} \cdot t''_{P\,po} \cdot \frac{Q_i}{2} + \dot{E}_{PO} \cdot t_{PO} \cdot \frac{Z_i}{2} + \dot{E}_{TRAV} \cdot t_{TRAV} \cdot \frac{Z_i}{2} + \dot{E}_{FIX} \cdot t_{FIX} \cdot Z_i}{Z_i}$$

PARAMETRICAL ANALYSIS

To gain insights into the behaviour of the models and the performance difference of the three rack systems, a parametrical analysis was performed. Such an analysis deals with several scenarios that consider different parameter combinations. The fixed parameters, which are the same for the considered scenarios, are:

- the pallet height, $H_p = 1.5\,m$ and the half-pallet height, $H_{hp} = H_{po} = 0.75\,m$
- the scenario-dependent picking times, $t_{P\,p} = 5.5\,s$, $t'_{P\,hp} = 6.5\,s$, $t''_{P\,hp} = 5\,s$, $t'_{P\,po} = 4\,s$, $t''_{P\,po} = 5\,s$
- the fixed time $t_{FIX} = 10\,s$ and the pallet pull-out time $t_{PO} = 4\,s$
- the operators costs, $C_1 = C_2 = 17$ €/h and the pull-out system cost $C_3 = 0.02$ €/h
- The energy expenditures $\dot{E}_{TRAV} = 2\,kcal/min$ and $\dot{E}_{PO} = 2\,kcal/min$, estimated based on the work of Garg et al. (1978), considering a male picker of 75 kg

On the other side, the six variable input parameters are:

- the carton weight W_c (0.5, 5, 10 kg) and volume V_c (0.008, 0.027, 0.064, 0.125 m^3), considering the relations $q_p = \left\lfloor \frac{V_p}{V_C} \right\rfloor$ and $q_{hp} = q_{po} = \frac{\lfloor V_p/V_C \rfloor}{2}$
- the picked cartons per hour Q_i (50, 100, 150, 200, 250 cartons/h) and the average number of picked cartons per line Q_i/Z_i (1, 1.5, 2, 2.5, 3, 3.5, 4 cartons/line); this range is considered reasonable based on the results of prior studies in the field (De Koster et al., 2007; Battini et al., 2014b)
- the pallet refill time t_{REF} (90, 120, 180 s), assumed to be equal to the pallet stocking time, and the travel time of the picker t_{TRAV} (20, 30, 40 s)

The energy expenditure parameters for the physical pick, expressed in kcal/min, have been calculated based on the study of Garg et al. (1978), considering the various actions and postures of the picker, for the three different carton weights (W_c=0.5, 5 and 10 kg). In particular, the corresponding results are:

- $\dot{E}_{P\,p}$= 4.6992, 5.8388 and 7.1051 for the pallet
- $\dot{E}'_{P\,hp}$ = 5.2921, 6.6492 and 8.1571 for the half-pallet and $\dot{E}'_{P\,po}$ = 5.9815, 7.5823, 9.3610 for the half-pallet with pull-out system
- $\dot{E}''_{P}$ = 3.9690, 5.0667, 6.2864 for both half-pallet configurations (the pick from the higher rack requires the same energy expenditure)

ANALYSIS OF RESULTS

The results of the parametrical analysis are summarized in Figure 1. For each of the variable input parameters, the three rack configurations were compared in terms of unitary total cost for the economic evaluation and unitary total energy expenditure for the ergonomics one, expressed both in kcal/min and in kcal/line.

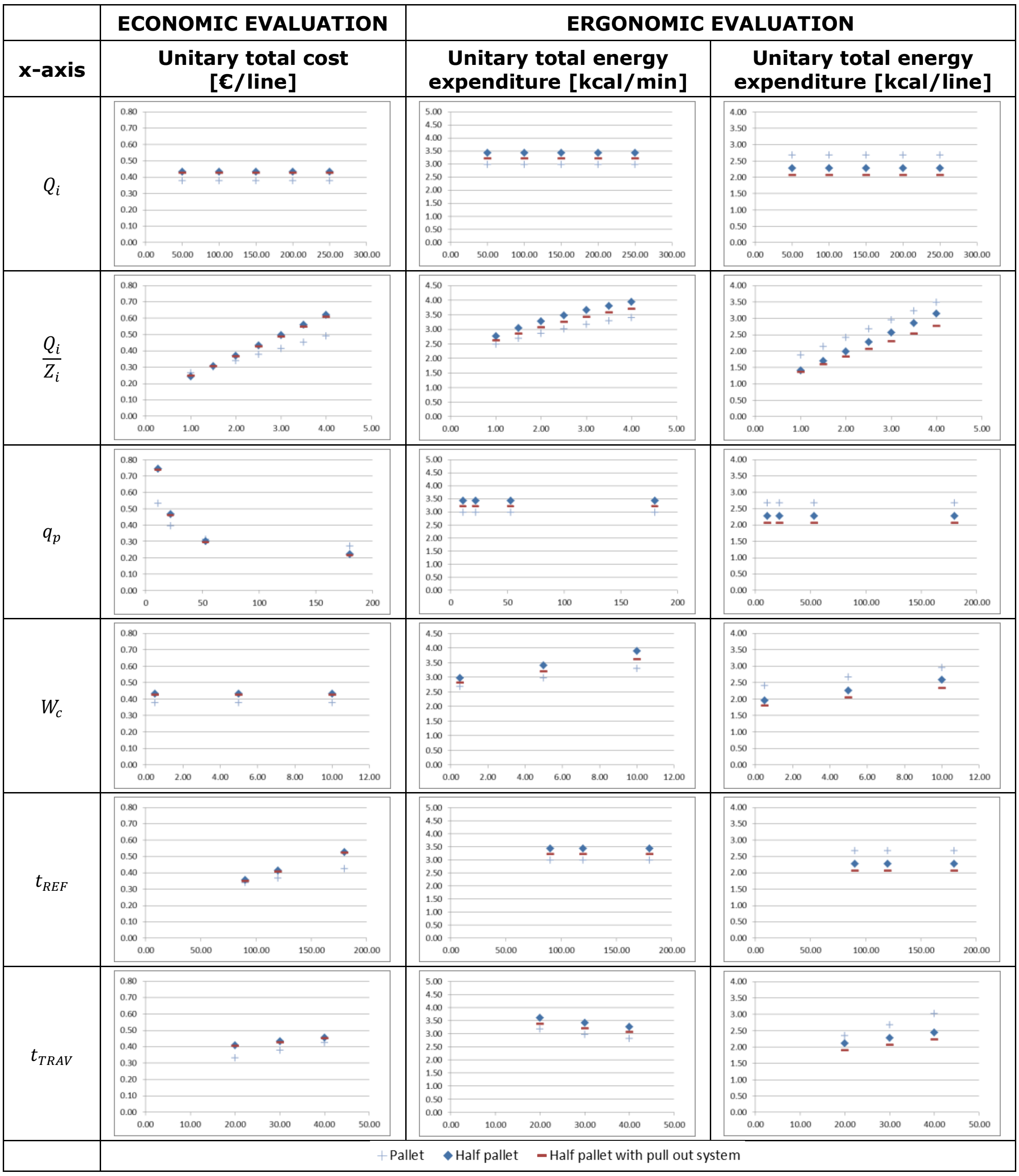


Figure 1: Economic and ergonomics evaluations results

With respect to the economic measures, it can be observed that the determination of the best rack configuration is mostly influenced by Q_i/Z_i and q_p, as the system appeared to be very sensitive in these parameters. In particular, the traditional pallet turns out to be better than the half-pallet configurations for high values of Q_i/Z_i and for large cartons (small values of q_p). Furthermore, the plots show that the half-pallet and the half-pallet with pull-out system perform identically from an economic point of view: the pull-out system additional cost is compensated by the lower picking time of this rack configuration.

Interesting are the results of the ergonomics evaluation, in particular with respect to the comparison of the energy expenditure $\dot{E}$ in [kcal/min] and $\dot{E}_Z$ in [kcal/line]. In fact, the results show that the traditional pallet is always the better solution in terms of $\dot{E}$, but not for $\dot{E}_Z$. This is due to the fact that in the case of $\dot{E}$, the results are influenced by the time needed to perform the pick; that is, if the pick takes more time (as in case of picking from the traditional pallet), the ergonomic impact is lower since the picker has also more time to recover. On the contrary, if the energy expenditure per picking line $\dot{E}_Z$ is considered, the best solution is always the one with the pull-out system, since in general it warrants better body postures, fewer movements and as much travelling as the half-pallet configuration. Indeed, considering the travelling time t_{TRAV}, it can be seen that it has a lower impact on the energy expenditure of the two half-pallet solutions, which are characterized by a halved travelling time. This is even more evident for higher values of t_{TRAV}. Finally, it is important to point out that for low numbers of picked cartons per line Q_i/Z_i, the two half-pallet configurations are almost equivalent, since the lower average picking time of the half-pallet with pull-out system (and, hence, the lower energy expenditure) is compensated by the additional action of pulling out the pallet. This effect has, in turn, a lower impact when the number of picked cartons per line is higher (the picker pulls out the pallet just once and picks several cartons, one after the other).

CONCLUSIONS AND SUGGESTIONS FOR FUTURE RESEARCH

This paper presented a new method for the evaluation of different rack layouts of an order picking warehouse. Options for storing products considered are the following: traditional pallet storage, half-pallet storage, and half-pallet storage with a pull-out system (for the pallets stored on the floor). After introducing the three different configurations, both economic and ergonomics models were presented together with a parametrical analysis, performed to evaluate the behaviour of the models. From an economic point of view, the analysis showed that the two half-pallet solutions are more convenient for picking small objects (corresponding to a high q_p) and slightly better when the number of picked cartons per line Q_i/Z_i is low; on the contrary, for higher values of these parameters, the traditional pallet is the best solution. From the ergonomics analysis, it turned out that the three solutions are not influenced by q_p, but instead by Q_i/Z_i. Moreover, as far as the energy expenditure per line $\dot{E}_Z$ is concerned, the results showed that the half-pallet with pull-out system is always the best, since it facilitates the picking actions. Finally, it is important to underline that the higher values of energy expenditure obtained for the half-pallet with pull-out system are due to the fact that picking is, on average, faster with such system.

The present work represents a first approach to an important issue concerning warehouse order picking: the evaluation and the possible improvement of ergonomics in warehouse picking systems (Grosse et al., 2015). Future research in this direction could study other possible rack layouts. In addition, the ergonomic evaluation in terms of energy expenditure could be enhanced by other, more recent and sophisticated evaluation methods. Finally, it could be interesting to develop a unique evaluation parameter that synthetizes the results of both the economic and ergonomics analyses. This paper can be seen as a first step into this direction.

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APPENDIX

1	2	3	4	Description
Q_i				Number of picked cartons per hour for item i
Z_i				Number of picking lines per hour for item i
V_c				Carton volume
W_c				Carton weight
	q_p	q_{hp}	$\boldsymbol{q_{po}}$	Number of cartons per pallet
	H_p	H_{hp}	$\boldsymbol{H_{po}}$	Height of a location
t_{ST}				Unitary pallet stocking time in the forward area
t_{REF}				Unitary time to move a pallet from the forward to the reserve area
t_{TRAV}				Single order line travelling time
t_{FIX}				Single order line fix time for complementary activities
	$t_{P\,p}$			Unitary average picking time for the traditional pallet
		$t'_{P\,hp}$	$\boldsymbol{t'_{P\,po}}$	Unitary average picking time for picking an item from the lower location
		$t''_{P\,hp}$	$\boldsymbol{t''_{P\,po}}$	Unitary average picking time for picking an item from the upper location
			$\boldsymbol{t_{PO}}$	Unitary average time spent for pulling out a pallet
C_1				Hourly cost of the stocking operator
C_2				Hourly cost of the picking operator
			$\boldsymbol{C_3}$	Hourly equivalent cost of the "pull-out location"
	C_p	C_{hp}	$\boldsymbol{C_{po}}$	Unitary total cost per line
	$\dot{E}_p$	$\dot{E}_{hp}$	$\boldsymbol{\dot{E}_{po}}$	Unitary total energy expenditure in kcal per min
	$\dot{E}_{Z\,p}$	$\dot{E}_{Z\,hp}$	$\boldsymbol{\dot{E}_{Z\,po}}$	Unitary total energy expenditure in kcal per line
	$\dot{E}_{P\,p}$			Unitary average energy expenditure for traditional pallet alternative in kcal per min
		$\dot{E}'_{P\,hp}$	$\boldsymbol{\dot{E}'_{P\,po}}$	Unitary average energy expenditure to pick an item from the lower location in kcal per min
		$\dot{E}''_{P\,hp}$	$\boldsymbol{\dot{E}''_{P\,po}}$	Unitary average energy expenditure to pick an item from the upper location in kcal per min
			$\boldsymbol{\dot{E}_{PO}}$	Unitary average energy expenditure to pull out a pallet in kcal per min
$\dot{E}_{TRAV}$				Single order line travelling energy expenditure in kcal per min

Table 2: Notations (1 = General, 2 = Traditional pallet, 3 = Half-pallet rack and 4 = Half-pallet rack with pull-out system)

MASS CUSTOMISATION AND FASHION LOGISTICS PERFORMANCE MEASURES OF COMPLETE GARMENT KNITTED FASHION PRODUCTS: SAMAND'OR – A CASE STUDY

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ABSTRACT
Samand' Or located in Takashimaya department store in Tokyo, a shop for on-demand production of customised knitted garments, uses complete garment knitting technology for customisation of knitted fashion. A photo is taken of the client who got the opportunity to see them dressed in different clothes, with option to change the design, colours, neck-shape and sleeve length by the simulation program in the computer. Here the client can be a co-designer and customise a garment in accordance with their personal taste. The method employed is a case study with and inductive approach which showed that the interaction process between the company and the customer was of the manual co-design type. The result in the study and the SWOT analysis shows a high sell-through factor, no stockpiled inventory of ready-made garments, few lost sales and a positive shopping experience for the customer.

INTRODUCTION
Supply chain management (SCM) is now seen as a broader concept of manufacturing and retailing than earlier views that limited it to individual companies. In a chain for textiles and apparel, all parts must be synchronised and able to adapt to demands on the market. This is especially crucial for the types of products that fashion represent (Bruce & Daly et al., 2004).

Nowadays, SCM focuses on relationships between those in the supply chain (Stuart, 1997). Retailers collect detailed point-of-sales information that reflects real-time demand for goods by consumers. Through computer systems, they then share this information with suppliers who, in turn, can ship orders within days to automated distribution centres. SCM takes a wide view of configurations, which Gattorna (2010) defines as "any combination of processes, functions, activities, relationships and pathways along which products, services, information and financial transactions move in and between enterprises, in both directions." Gattorna stresses the importance of having the definition embrace everyone in the company for SCM to work.

Complete garment technology (*seamless garment technology*) was introduced on flat knitting machines in 1995 and since then, the technology has been considered an innovative process and is steadily increasing in use around the world (Choi & Powell, 2005). In this type of production, the entire garment is ready-made directly in the flat knitting machine. The different parts of the garment are produced in the right shape and knitted together with the trimmings, pockets, and other accessories. This technology makes it possible to eliminate cutting and sewing operations and produce 'on-demand' knitting, which can shorten lead times considerably (Legner, 2003).

In 1987 Stan Davis, a visionary business thinker and consultant coined the term *mass customisation (MC)* for the first time. He described it as a system in which "the same large number of customers can be reached, as in mass markets of the industrial economy, but simultaneously can be treated individually, as in the era of customised markets in pre-industrial economies" (Davis, 1987). MC involves all aspects of development, manufacturing, sales, and delivery of the product (da Silveira, Borenstein & Fogliatto, 2001). It is a concept that comprises the whole chain from the designer's sketch to the final product received by the customer.

MC allows buyers to modify products according to their taste and requirements. It exists today in a variety of areas including automobiles, furniture, food, and clothing. One advantage for the retailer is that the product can typically be sold before the manufacturing takes place. Since the customer has already purchased the product, the risk for unsold goods is lower.

While MC may not replace mass production of clothing, it may be a solution for certain products and niche markets. Complete garment technology opens up new perspectives with its reduction of processes that allow a rapid response to customer demand, while the possibility of MC serves each customer individually. Fashion logistics, MC, and complete garment technology form an effective partnership. These three concepts are the focus of this paper. The principal objective of the present study is to examine how the supply chain of knitted fashion products can be changed. From a mass production perspective to a more on-demand strategy involving mass customisation.

This study poses the objective and the following research questions:

Research Question One (RQ1): *"What are the logistics effects of complete garment knitting and mass customisation applied in a retail store for customised garments?"*

Research Question Two (RQ2): *What are the effects on the fashion logistics measures, such as: sell-through factor, lost sales and stock turn by combining complete garment technology and MC?*

The answer is pursued by a case study of the fashion company Samand' OR.

METHODOLOGY

In order to show how complete garment knitting technology in can be used for the mass customisation of flat-knitted products, this study uses an inductive approach based on a case study involving both company visits, interviews of store personnel and customer observation during the customisation process. (Yin, 2009). Since it seeks to identify critical factors of success in fashion retailing, quantitative data as well as a Strengths-Weaknesses-Opportunities-Threats (SWOT) analysis is performed with qualitative data (Helms & Nixon, 2010).

SUCESS FACTORS IN THE SUPPLY CHAIN OF FASHION PRODUCTS

Logistics for fashion products are marked by a climate of uncertainty due to rapid changes in trends and fluctuating customer demand. For this reason, it can be an advantage to bring products to market as quickly as possible or retailers may be left holding unsaleable merchandise because items have gone out of fashion.

The rent for an upscale clothing store in a good location is very high, so it is essential to carry the correct level of inventory. Such a retail shop is too expensive to use as a warehouse; on the other hand, too little stock will result in customers not finding what they want. The ideal would be to have an efficient system that could restock garments in one or two days, or even in hours, as they are sold. Such logistics activities require different kinds of sourcing, production, and inventory management than are currently being used. A supply chain and logistics system must be integrated in order to reduce lead time. This imposes special requirements on the companies in the supply chain. It is an accepted fact in the industry that the demand for fashion products is difficult to forecast. Fashion markets have been characterised as open systems that are often chaotic (Christopher et al., 2004). For many years the trend in the textile and fashion business has been to source production in low-cost countries in order to maximise gross profit margins for the company. This philosophy can have a negative impact on revenue because of the lead times necessitated by long-range forecasts ahead of sales campaigns. The danger of sourcing to such countries months before the season is an excess of inventory, a greater number of products that must eventually be sold at discounted prices, the risk that customers cannot find what they want in the shop, and ultimately a loss of profit (Mattila, King & Ojala, 2002).

A supply chain needs to be time-based, customer-orientated, and responsive to rapid changes in demand (Hoover et al., 2001). Christopher and Peck (1997) list three dimensions of time-based consumption: *time to market*, or how long it takes a business to recognise a market opportunity, translate it into a product or service, and bring it to the market; *time to serve,* or how long it takes to secure a customer's order and deliver or install the product to the customer's satisfaction; and *time to react,* or how long it takes to adjust the output of the business in response to volatile demand, that is, how quickly the supply "tap" can be turned on and off.

In mass customisation, closing the sale with a customer becomes one of the initial steps in a retail transaction, rather than the final one. From that point, streamlining time-consuming manufacturing operations after the point-of-sale is the key to shortening delivery time. Situating the manufacturing process after the point-of sale eliminates or reduces a company's inventory of ready-made garments and may increase its stock-turn percentage.

At one of the Samand' OR stores in Wakayama, Japan, shown in Figure. 1, the co-design process can be observed as the kind of tailored customisation described by Lampel and Mintzberg (1996). Customers browse the store for a garment they like and it becomes the starting point of the product's design. The interaction between client and store personnel is crucial as the customer proceeds to customise an item.

Figure 1: Samand' OR store in Tokyo.

COMPLETE GARMENT KNITTING

In 1995, the Japanese manufacturer Shima Seiki introduced the first complete garment knitting machine capable of producing a ready-made flat-knitted garment on the machine, illustrated in Figure. 2. The company launched the complete garment concept under the name WholeGarment®. Complete garment technology will continue to evolve and create expanded market share for flat knitting machines. It is following the same trend as hosiery machines: the reduction of processes with a product that is almost completely finished as it comes off the machine. Historically, the main reason for long lead times has been the presence of several *non-value-adding* activities throughout the supply pipeline. These activities may now be reduced or eliminated entirely, especially in the manufacturing process, without diminishing the total value added to the product. This has been the proven way forward in manufacturing: minimising processes in order to make a product as efficiently and inexpensively as possible. The implementation of complete garment technology in combination with MC in a supply chain for fashion products may result in measurable benefits:

- Reduction in manufacturing lead times
- Garment custom-knitted close to point-of-sale
- Fast order fulfilment for the customer
- A positive customer shopping experience

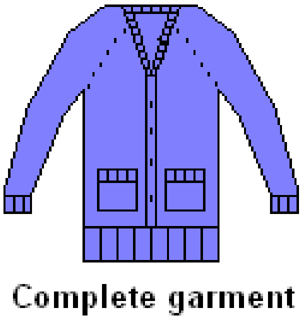

Figure 2: Complete garment production method.

If the production system and the supply chain are adapted to this new logistic concept, the time from yarn to finished garment will be greatly improved.

SAMAND' OR – A CASE STUDY

In 2012, the Samand' OR opened a retail shop Samand' OR with a business concept launched by Shima Seiki that combines knitting technology and mass customisation. The store is located at the fashionable department store Takashimaya located in the business district of Nihombashi in Tokyo. The shop welcomes a customer to enter the showroom, design and customise a flat-knitted garment. In the boutique, the client has the opportunity of examining fashion magazines, swatches of knitted fabric, colour charts and garment samples for ideas while designing their own custom garment.

A photograph is taken in a small photo studio and then the customer offers the opportunity to see her dressed in garment styles that can be customised in the store. In the computer it is also possible to change yarn colour, sleeve lengths, neck-style and background view. A selection of garments in various sizes may be tried on to assure a perfect fit. In creating a personal item, the client is guided through the customisation process by a shop assistant skilled in clothing design. The Samand' OR concept offers garments in fully-fashioned and complete garment manufacturing methods with different options in each technology.

Customisation may range from small changes or adjustments of a sample garment to a more complicated full design process incorporating personal choices from start to finish. The path from entering the retail shop until the custom designed garment is purchased, manufactured, and delivered is shown in Table 1.

The Samand' OR customisation concept
Customer enters the store
Browsing in the store
Design and customisation of the garment
Point of sale
Placing order and prepaying for purchase
Manufacturing of customised garment
Delivery of the garment by post

Table 1: The Samand' OR customisation concept.

An important part of the customisation process is the personal fit of the garment. For this reason, measurements are carefully taken by trained personnel. After the customisation has been completed, the customer is still free to decide whether or not to purchase the garment. If the answer is affirmative, an order is generated and sent to the shop's production unit in Wakayama near Osaka. The complete garment alternative of manufacturing results in a seamless product which has a more perfect fit and drape than is possible for sewn products.

CASE ASSESSMENT FOR SAMAND' OR

The quantitative data in this case study indicates that the important factors for success in Samand' OR are more significant than for traditional fashion retailing companies. The data presented in Table 3 shows that the sell-through factor is almost 90%–100%, compared to the average of 65%–70% in ordinary fashion retailing (Mattila et al., 2002).

Samand' OR needs to develop its co-design system to the point that customers do more of the customisation themselves. The current system, where one or two staff members devote their full attention to the customer during the co-design process, provides very good service for the customer. However, attending to one customer at a time is costly for the company.

Success factors	***Ordinary fashion retailing***	***Samand' OR***
Sell through factor	65% - 70%	90% - 100%
Lost sales	20%	Very few lost sales
Stock turn	2 – 5 times/year	Very high

Table 2: Critical factors for success.

For the SWOT analysis of Samand' OR:s customisation and production concept the shop in Takashimaya department store in Tokyo were visited and shop personnel were interviewed along with the representatives from Shima Seiki. The result of the SWOT analyses is shown in Table 3. The analysis suggested that internet sales may present an opportunity for the future. With an efficient co-design system on a company's web page, a vast number of customers could be reached at the same time.

At that point, the problem of getting accurate customer measurements will present itself. Samand' OR shares this dilemma with other companies who sell customised fashion garments over the internet today.

Strengths	Weaknesses
No inventory of ready-made garments No seasonal sales Positive shopping experience High sell-through factor Low lost sales No inventory of ready-made garments	Customers cannot take product home with them Risk of long queue of customers in the shop Limited retailing experience Time consuming co-design process Little re-use of customised information
Opportunities	***Threats***
To develop the co-design process Large potential markets Sell know-how to other retailers Internet sale	Customers must wait to receive garment purchased Time consuming co-design process Limited interest among customers

Table 3: SWOT analysis.

One solution may be to let the customer enter their own measurements directly into the co-design system as many companies already do. However, it may be difficult to do this correctly and some people may resist the process altogether.

Another advantage is the fact that nothing is produced that is not sold; only customers dissatisfied with their garments will lower the sell-through percentage. The percentage of lost sales will be low because garments may be customised, thereby, increasing a client's likelihood for satisfaction. A traditional retailing company that turns around stock about four times per year has a great deal of money tied up in inventory, negatively affecting its profitability. The stock turnaround for Samand' OR can be much higher because only such raw materials as yarn and attachments, but no ready-made garments, have to be kept in inventory. Complete garment technology, with its reduction of manufacturing time by simplifying the processes, makes it possible to produce a garment faster than by using conventional methods. Retailing companies may presently lack sales staff that lacks the experience and skills needed to help customers design their own garments. Mass customisation may be one solution to the widespread time-to-market problem, both for knitwear and for like fashion products that lend themselves to a technical solution.

CONCLUSION

The research questions addressed in this study were: *"What are the logistics effects of complete garment knitting and mass customisation applied in a retail store for customised garments?"* The SWOT analysis indicates strengths such as no inventory of ready-made garments, no seasonal sales and a possibility to have the decoupling point very close to the Point Of Sales, P.O.S.

The second research question: *"What are the effects on the retail performance, such as: sell-through factor, lost sales and stock turn by combining complete garment technology and MC?"* As presented the retail performance factors: sell-through, lost sales and stock turn-over is affected positively in the Samand' OR retail concept. This is because the product is sold before it is produced according to the mass customization idea. The complete garment knitting technology can in the future make the manufacturing time of the product very short, enabling a fast delivery to the customer, maybe in hours.

In the future, customisation may enable the industry to supply the latest designs while they are still current rather than produce merchandise that maybe already out of fashion when it reaches the shelf. Rapid production of customised garments fulfils the need to keep time-to-market very short. Short lead times in all processes from the first moment of identified customer demand all the way to a satisfied customer. Mass customisation may be one solution to the widespread time-to-market problem, both for knitwear and for like fashion products that lend themselves to a technical solution.

Complete garment technology, with its reduction of manufacturing time by reducing the processes, makes it possible to produce a garment faster than by using conventional methods. This makes it an important factor for the development of fashion products also in ordinary mass production concepts. In the future, the industry may enable to supply the latest designs while they are still current, rather than produce merchandise that are already out of fashion when it reaches the shelf in the shop.

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Section 12: Education and training

ENGAGING THE ACADEME WITH SUPPLY CHAIN INDUSTRY: THE EDUCATION INTEGRATOR ROLE

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ABSTRACT
This paper investigate the role of the education integrator as a catalyst for purposeful industry-academe engagement in an era of Web 2.0-enabled open learning. It addresses pedagogical issues within the supply chain discipline, the skills required by practitioners, and novel approaches to education provision and engagement. Focusing attention of supply chain decision makers onto a novel turnkey concept, conceived using a developmental research approach, avoided the generation of yet more lists of industry needs and helped to further refine the education integrator concept.

INTRODUCTION

The economic wellbeing of a resource-rich country like New Zealand (NZ) depends greatly on commodity exports that result from highly efficient and constantly evolving production systems. In addition, globalisation and free trade agreements call for realignment of logistics to match new patterns of freight distribution, and transformation of industries characterised by internal competition. By overcoming the challenges, new opportunities will accrue to port operators that extend governance beyond traditional port perimeters **(Notteboom and Rodrigue, 2005)**; to industries that reform around synergistic relationships; and, to exporters that differentiate their supply chain (SC) products and services **(Zineldin, 2004)**. However, acquiring the knowledge and skills required can be very challenging; especially in parts of the world where logistics/supply chain management education has failed to keep pace with industry's need for well-educated and experienced staff **(e.g., Aquino and Draper, 2008; Closs, 2000)**, where access to international best practice is problematic **(Sohal, 2013)**, or where graduating students are oblivious to the career opportunities **(Ozment and Keller, 2011)**. Thus, at a time when substantial improvements to logistics and supply chain practice are needed, New Zealand is not alone in finding itself short of supply chain/logistics talent.

Against this backdrop, and in an era of ubiquitous social media technology in which free online courses are altering student expectations, universities are being urged to build significantly deeper relationships with industry **(ABDC, 2014; Ernst & Young, 2012)**. Thus, this paper presents the results of some five years of research with an education integrator concept, aimed at helping the academe "differentiate teaching and learning programs, support the funding and application of research, and reinforce the role of universities as drivers of innovation and growth" **(ibid., p. 4)**. More fundamentally, it is concerned with the types of education and other engagement that supply chain industry needs if productivity is to increase in a profitable, sustainable, and environmentally-friendly manner.

REVIEW OF RELEVANT LITERATURE

Problem domain dynamics

The first step in constructing any conceptual framework is that researchers need to justify the significance of the research questions being pursued **(Nunamaker et al., 1991)**. Earlier fieldwork revealed a relatively low standard of supply chain/logistics education in the NZ workforce **(e.g., Böhme et al., 2008)**. To gain deeper understanding, the relationship between tertiary education providers and their supply chain industry consumers was examined with the aid of a causal map **(Owlia and Aspinwall (1997)**. This captures from experts the causal connections that link key aspects of a particular problem domain and enables the dynamics of the system to be appreciated **(Wolstenholme and Coyle, 1983)**. The domain knowledge contained in the map is typically more comprehensive and descriptive than in other models, such as regression or structural equations, and the collection of interacting elements to achieve a common goal is revealed **(Elmaghraby, 1966)**. This process of knowledge elicitation is also less time-consuming and causes less inconvenience to experts, compared with other techniques such as protocol analysis and repertory grids **(Brown, 1992)**.

Role of the education integrator

The advent of Web 2.0-enabled open learning is facilitating the new role of the 'education integrator' **(Bonk, 2009)**, which is illustrated in Figure 1. In this role, professional educators identify and qualify educational components from many sources, which they then integrate and frame for the learner's unique context. Potentially this can even happen in real time and be directed to specific points of need.

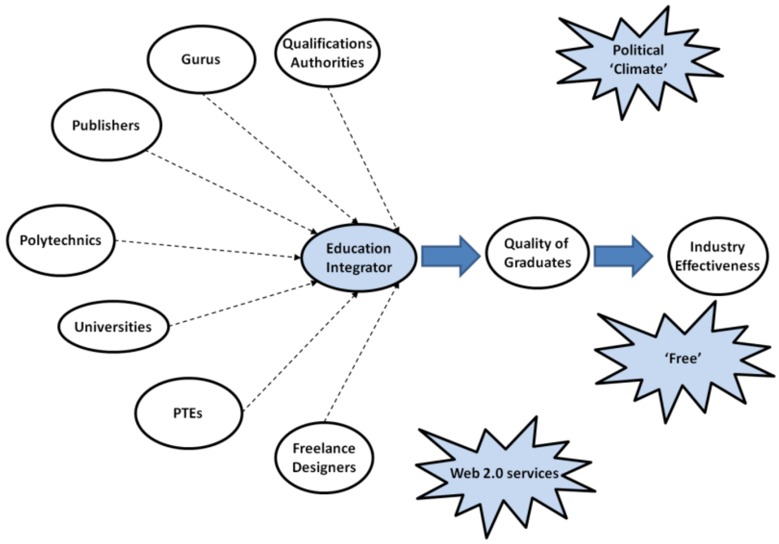

Figure 1: The education integrator role

For supply chain graduates to enter the workforce with essential intellectual rigour and professional competence requires them to have sound understanding of academic theory and principles, plus the practical skills that will enable them to function successfully in the workplace **(Gammelgaard and Larson, 2001; Myers et al., 2004; Sohal, 2013)**. It follows that their learning experiences must be relevant and up-to-date, and should involve hands-on experience. Ideally, educators will also utilise research-based teaching materials relevant to the local situation, case-based teaching, multimedia and simulation **(e.g., Gammelgaard and Larson, 2001; Gravier and Farris, 2008; Lutz and Birou, 2013; Mangan and Christopher, 2005; van Hoek; 2001)**.

RESEARCH BACKGROUND

In order to consider the nature of the gap between logistics/supply chain management education and industry's need for well-educated and experienced staff, views on what constitutes a 'successful' supply chain education system were obtained from samples of educationalists and industrialists, and these views are combined in Figure 2.

The academe's worldview of a successful education system was obtained via three focus group sessions with faculty members and heads of department from a number of universities in New Zealand. Universities have long tended to be 'prestige maximisers' rather than 'profit maximisers' **(Leslie, 1993)**, and the solid objects and lines in the figure indicate how university reputation is traditionally judged by the ability of staff to generate copious amounts of peer-reviewed research output. Also, and of increasing importance, is the cost to serve a more discerning and varied customer base with popular, high quality courses. Quality of research and of learning is a function of the quality of academic staff, the study environment and support services. In this worldview, industry is little more than a bit player as a research subject, source of occasional advice, and destination for graduates. Being ‘out there somewhere’, industry only indirectly contributes to the institution's earned reputation. It is evident from the diagram that success breeds success until some sort of capacity constraint is reached. Conversely a poor reputation creates lower quality and a worsening reputation…

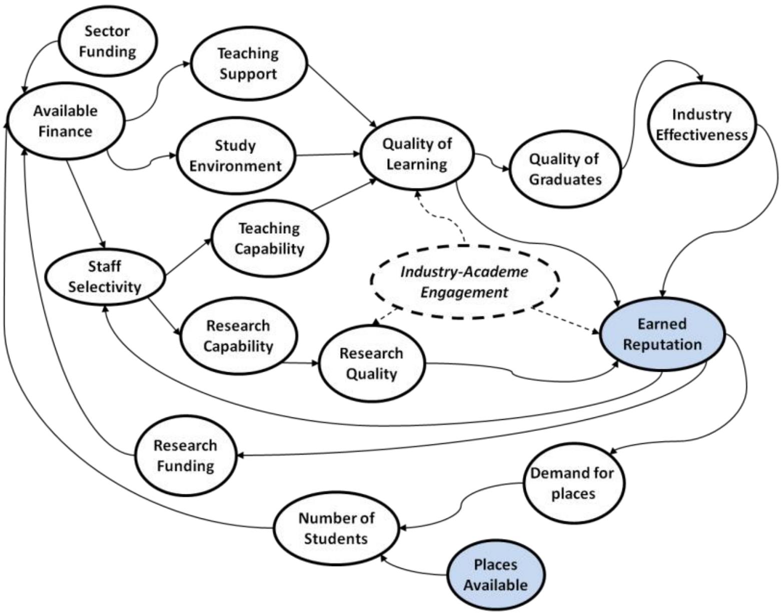

Figure 2: ‘Successful’ supply chain education

Industry's worldview of what constitutes a successful education system was developed from three focus group sessions with senior supply chain managers and their in-house human resource specialists. Although mostly agreeing with the academe's perspective, the key point of difference places academe-industry engagement at the centre of successful education endeavour (indicated by the dashed objects and lines in the figure). This is because strong industry collaboration can contribute directly to the quality of student learning and to uncovering new (research) knowledge; thereby directly contributing to the institution's reputation. As industry often requires flexibility and short lead times, industry's view of successful education has the academe designing research programmes in close collaboration with practitioners, and offering SC courses in either a 'make to order' process **(Schary and Skjøtt-Larsen, 2001)** or an 'assemble to order' process via modularised course offerings. In reality the academe's ability to satisfy industry's supply chain/logistics education needs is likely to be hampered by many factors, including: the multidisciplinary nature of the SCM discipline; lack of trained faculty to develop and teach courses and conduct SC research; lack of technology; lack of university and business community support for the subject; graduate programmes based on research interest rather than industry requirement, and disagreements over which department owns the supply chain programme **(e.g., Lancioni et al., 2001a; b; Onar et al., 2013)**.

Examination of these respective worldviews highlights that lack of purposeful engagement between the academe and industry is a significant issue that ultimately inhibits supply chain productivity and competitiveness. Provider self-interest and structural inflexibility is hindering sufficiently responsive and relevant SC teaching and research that can satisfy specific industry needs. In summary, the motivation to develop an academe-industry engagement alternative resulted from the tensions that currently exist between industry's educational needs and the academe's willingness and ability to deliver **(Lancioni et al., 2001a; b)**.

In light of the foregoing discussion the initial problem statement for this research was expressed as: *"The academe's lack of engagement with industry is hindering supply chain productivity and competitiveness."* This provided focus to the research through the early development process and led to additional approaches, system components, and ideas being considered that could be included into an improved system of academe-industry engagement. Support for the education integrator concept by **Ernst and Young (2012, p. 20)**, which proposed a similar 'Transformer' education role, helped confirm the authors view that an educational institution that is able to differentiate itself along such lines would successfully compete for the best teaching staff and research faculty, and would produce superior graduates sought after by industry. Hence, the initial problem statement for the research was re-stated as: *"The academe's lack of engagement with the needs of contemporary learners to meet industry's needs is hindering supply chain competitiveness." In turn, this led to the* hypothesis that, "*The education integrator role provides the bridge between the academe and contemporary learners in industry, who ultimately will improve (national) supply chain competitiveness*." Due to time constraints, the scope was reduced to considering the important question of whether industry would be willing to engage with the concept.

RESEARCH METHODOLOGY

Methodology is the philosophy of the research that "includes the assumptions and values that serve as a rationale for research and the standards or criteria the researcher uses for interpreting data and reaching a conclusion" **(Bailey, 1982, p. 26)**. A developmental research approach was justified for the present study simply because no physical education integrator facility currently exists of the type and scale that is being proposed; which would otherwise have enabled a more traditional approach to be undertaken **(Galliers and Land, 1987)**. The advancement of practice often comes from new systems concepts since, for instance, many of today's innovative IT applications have origins in researchers' and practitioners' imaginations. However creativity, or research at the basic or concept level, does not ensure success and the system must be developed in order to test and measure the underlying concepts. A systems (development) process parallels the same research process used in the social and behavioural sciences albeit often with different methods and tools. Because the 'solution' to the present research problem is a proposed architecture, i.e. a new way of doing things based on suggested new methods and techniques, it cannot be 'proven' mathematically or tested empirically. Rather, analysis to demonstrate the validity of the solution takes the form of expert opinion on the new 'system' prototype (description) rather than a formal proof, and the results become the argument and evidence in defence of the original hypothesis **(Nunamaker et al., 1991)**. In short, our development of a new system of education-industry engagement can be thought equivalent to 'proof-by-demonstration'. The approach can be classified as being: applied (focused on the application of knowledge needed to solve an identified problem); developmental (directed at developing a new solution); evaluative (directed at evaluation of the solution developed); and formulative (exploratory; aimed at identifying problems for more precise investigation). Simply put, theory building took place via formulation and testing of a conceptual framework.

The remainder of this paper follows the cycle of developmental research that was utilized. Rather than using some type of 'magic wand' approach, to generate competing laundry lists of industry wishes, the intention was to focus industry decision-makers' attention onto a turnkey educational concept (prototype); one developed by the authors and believed to be pedagogically sound (focused on the application of knowledge needed to solve the identified problem) and developmental (directed at developing a new solution). Just to give a flavour of what is intended, the main teaching aim is to develop intellectual independence and a passion for life-long learning irrespective of student ability. Facilitated teaching and learning will ensure that graduates on entering the workplace are capable of making major contributions to the current and future global needs of industry and society, as leaders and innovators. As a diversified student market is demanding convenient and flexible education, with a preference for opportunities to engage with educators, peers and future employers in a structured learning context, the use of materials, media and teaching approaches that are relevant, stimulating and effective, will be utilised. Commercial and academic research projects will be undertaken by research supervisors, students and industry stakeholders working in partnership with an international network of researchers and education specialists that will work together on research projects in an online community of practice. Given an overarching principle of intrinsic industry collaboration, a meeting place will be offered that provides group decision support technology and simulation facilities on site and bring industrialists, academics, and consultants 'together' to work on the most pressing supply chain, logistics, and transport problems and opportunities. (The complete 15-page concept description is available from the corresponding author.)

ANALYSIS

The prototype was complete once the disparate parts of the teaching/learning pedagogy were captured into the overall system architecture by the authors, and evaluation of the developed solution by key industry stakeholders could begin. As noted above, in presenting the new 'solution' to the research problem as a proposed architecture, i.e. a new way of doing things based on suggested new methods and techniques, the result cannot be 'proven' mathematically or tested empirically. However, a proof-of-concept approach to demonstrating feasibility can emphasise new functionalities or innovations, and has the added advantage of enabling further refinement via expert opinion.

A sample of senior export managers and HR managers from some of New Zealand's largest export organisations, plus senior regional decision makers, was selected for interview. These individuals collectively employ some 8,500 employees, the vast majority of whom are engaged in supply chain activity, Table 1.

Industry	***Position held***
Large process industry exporter (forestry products)~1,200 employees Annual revenue ~ NZ$1.0 billion	Supply Chain Manager Group Human Resources Manager
Medium size exporter (bee and pollen products) ~70 employees Annual revenue ~ NZ$96.0 million	Chief Supply Chain Officer
Large process industry exporter (dairy products) ~7,000 employees Annual revenue > NZ$19.87 billion	GM Supply Chain Strategy & Best Practice
Port of Tauranga ~185 employees Annual revenue > NZ$226 million	Commercial Manager
Medium size process industry exporter (forestry products) ~60 employees Annual revenue > NZ$? (private ownership)	CEO
Large process industry exporter (horticultural products) ~250 employees Annual revenue > NZ$ 1.62 billion	Head of Global Technical and Innovation Supply Chain General Manager
Regional Council	Chair of Regional Transport Committee Environment Bay of Plenty Councillor

Table 1: Interviewees

Prior to mail-out, a pre-test of potential interview questions helped ensure concept/question clarity and completeness, and the same researchers attended each interviewee's workplace. During interview the main points of the concept were reviewed and explained with the aid of a presentation, and a set of open-ended questions was used to gather thoughts and opinions. Interviewees also asked questions and commented on aspects that especially interested him/her. Each interview lasted upwards of 90 minutes and written and verbal feedback was collected. The interview transcriptions were analysed using thematic analysis, which allows for a richness of data and quantitative analysis of responses. Themes began to emerge by organising items relating to similar topics into categories and a provisional name and flexible definition was created for each emerging theme before trawling back through the data and re-contextualising in terms of the categories developed through this analysis (axial coding). The name, definition and supporting data were then re-examined for the final construction of each theme, using all the material relating to it. Finally the name of each theme, and its description, illustrated with a few quotations from the original text, helped communicate its meaning.

MAIN FINDINGS

In seeking support for the hypothesis: T*he education integrator role provides the bridge between the academe and contemporary learners in industry, who will ultimately improve supply chain competitiveness*, thematic analysis of the empirical research data revealed strong support for the turnkey education integrator concept. In particular, consensus was noted around four key areas:-

Centre relevance and independence: every interviewee from industry highlighted the advantages afforded by the proposed approach for providing vocational skills and expertise that can be brought to bear directly at points of industry need; although also highlighted was the need to dovetail educational approaches to industry requirements. Several interviewees stressed the need for the Centre to be independent of any individual education provider, in order both to increase flexibility and industry responsiveness, and to be willing to utilise the best expertise wherever it might be found. An attendant desire for the Centre to adopt a governance structure that drives its various activities in line with industrial, regional and educational imperatives was noted. In short, consensus formed around the need for an independent, agile teaching/research facility that offers excellent industry-customer service via close alignment with industrial requirements.

Qualifications: proposed simplification and potential 'stair-casing' of supply chain/logistics qualifications, from basic training through to diplomas, Masters and beyond was well received. Although the subjects of interest varied, they were all within the transport, logistics management, international trade and supply chain management disciplines. Due to the small sample size, no conclusive evidence is available regarding the precise qualifications that the Centre should offer (makeup of specific qualifications fell outside the scope of the study). However, there was general census around the Centre proposal for an integrated, one-stop education facility having national reach and aspiring to set national standards of SC excellence.

Transfer of best practice between major exporters and stakeholders: emphasis was placed on development of shared learning spaces in which new SC techniques and advancements within the discipline could be transferred between the parties. In particular, there was enthusiasm for a 'neutral' place of learning and expertise suitable for solving actual problems and communicating innovative practices between stakeholders. In short, there was consensus around the two-way transfer of best practice and the transfer of theory for specific industrial needs through action research.

Proposed location: there was overwhelming support expressed for the new facility to be located close to a supply chain hub due to its significance to New Zealand's export economy, proximity to primary importers and exporters and its position within the logistical 'golden triangle' formed by Auckland, Hamilton and Tauranga.

DISCUSSION AND CONCLUSIONS

This study identified the lack of purposeful engagement between industry and tertiary education providers as a significant issue hindering productivity and competitiveness in both industries. At a time when Web 2.0-enabled open learning can offer new ways to reach out to the next generation of learners, it is evident that traditional education provider self-interest and structural inflexibility is currently hindering delivery of quality SC teaching and research that is sufficiently responsive to meeting industry's needs.

A developmental research approach was used for this study because the 'solution' to the research problem is a proposed architecture, i.e. a new way of doing things based on suggested new methods and techniques. Analysis to demonstrate the validity of the solution took the form of expert opinion on the 'system' prototype (description) rather than any formal proof, so that the results become the argument and evidence in defence of the original hypothesis **(Nunamaker et al., 1991)**.

Given the clear consensus regarding the desire for best-in-class, regionally aligned education facilities to help improve New Zealand's supply chain industry competitiveness, this study provides considerable encouragement for education providers to adopt the 'education integrator' paradigm. To encourage responsiveness and impartiality, such education integrators need to be located between the traditional providers. There are myriad ways that such a world-class facility could contribute to regional and national economies and knowledge bases, and would attract new businesses and a skilled workforce **(e.g., Chatterton and Goddard, 2000)**. Hence, it was disappointing to also note such comments as, 'industry stakeholders need to have some skin in the game' and, 'sustainability of demand for Centre products/services could be an issue'. Similarly, while several interviewees stated that only industry can drive the initiative, to bypass academic politics and get what it needs, there was unwillingness to engage with detailed design and implementation issues.

In summary, this empirical research demonstrated almost unanimous industry support for creation of an independent, responsive, one-stop education integrator facility that has national reach and which sets national standards of excellence related to international trade, transport and supply chain/logistics. Interviewees agreed the concept was a compelling one and that it should proceed essentially unchanged from the proposed format. It was reassuring that the key themes of excellence and highest quality running through every aspect of the concept were in line with everyone's aspirations. Feedback was also received to further improve the concept. Clearly, the small number of interviewees conducted and the single location (New Zealand) may limit generalisability of the findings. However, future research could usefully address both aspects via interviews conducted in a range of national settings. The academe's inability to engage meaningfully with industry has serious implications for the productivity and competitiveness of both sectors.

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STRATEGIC SUPPLY CHAIN MANAGEMENT: A STRATEGIC CAREER?

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ABSTRACT
The argument that SCM is now the most popular topic in the fields of logistics and operations management can be addressed by looking at job adverts both in industry and academia, or by the volume of SCM titles at popular conferences. Yet the conceptualisation of what a career in SCM – now a term going back 30 odd years - is not clear. This paper addresses part of the question of what is a career in SCM by focusing here on what the literature has recorded about SCM skills. We begin with the RBV view that people are the firm's biggest asset and will address that what we find in the conference presentation.

INTRODUCTION
The notion that competition is now between supply chains rather than between individual firms (Chen and Paulraj, 2004; Lambert and Cooper, 2000; Spekman, Kammuf and Myhr, 1998; Christopher, 1996) is paralled by the shift in RBV studies from the competitive advantage of an individual firm (Barney, 1991) to the collaborative advantage of interconnected firms (Lavie, 2006). In its orginal incarnation RBV (Barney, 1991; Wernerfelt, 1984) focused on the resources that the firm owned and controlled that could be used to create competitive advantage. The concept of supply chain management with its aim of integrating firms into chains or networks extends RBV to the resources that form the interconnections between firms (Erbv).

Barney (1991) had defined resources as both the tangible and intangible assets firms can exploit to execute strategy. Physical or tangible resources are important in both RBV and Erbv; however tangible and intangible assets play different roles. According to Itami (1987) tangible assets like machines, physical structures, warehouses are critical to deliver organizational operations, but intangible assets such as organizational culture, human capital, knowledge, repuational and management skills are more likely, in combination, to be the real basis of competitive advantage. Barney (ibid) further classified these resources into three categories i) physical capital resources ii) human capital resources and iii) organisational capital resources. Physical capital is akin to tangible assets but broadened to include factors such as geographic location and access to raw materials. 'Human captial resources include the training, experience, judgement, intelligence, relationhsips, and insight of individual managers and workers in a firm. Organizational capital resources include a firm's formal reporting structure, its formal and informal planning, controlling, and coordinating systems, as well as informal relations among groups within a firm and between a firm and those in its environment' (ibid: 101).

Barney is explicit that whilst all resources may be used in combination one firm resource required by almost all strategies is managerial talent. His discussion goes on to qualify that whilst some common firm resources may not create competitive advantage nevertheless they may play a vital role for example by simply keeping the business in business (Barney, 1989a). A further twist to deconstructing the nature of human capital resources (and their interaction with organisational capital most notably in the form of organisational routines) is that beyond unique historical conditions and casually ambiguous links is when the resource creating a competitive advantege is socially complex – a statement that fits much management activity. This is as Lavie (2006:641) notes, akin to '… Penrose's (1959) suggestion that it is the services that resources provide, not resources themselves that generate value for the firm'.

The new strategic supply chain management risks collapse into just another management fad unless a reliable conceptual bases is developed (New, 1996, Chen and Paulraj 2004). One strand of that conceptual basis this study proposes is to understand what a career means in this new field.

METHODOLOGY

A literature review is commonly used to identify and evaluate the existing body of knowledge and documents in a specific field (Fink 2010) and therefore a valid approach to structuring an academic field (Tranfield et al. 2003, Srivastava 2007, Denyer and Tranfield 2009). Summarizing the existing literature and evaluating patterns or themes is one aim of this method. However, we undertake a systematic approach of reviewing a literature in order to identify the conceptual content of career practices and issues in the field of supply chain management. Our review approach is based on two key selection decisions. First, we limit our review to double-blind peer reviewed journal articles that are published in a specific academic field, as described later. Second, we adopt the perspective of human resources in combination with the perspective of supply chain management. Our review is consistent with previous studies that suggest a stronger emphasis and methodological rigor in reviews of the management literature (Tranfield et al. 2003, Denyer and Neely 2004, Thorpe et al. 2005, Keupp et al. 2012). This review of the literature contributes to the development of theory in the academic field of logistics and supply chain management, by identifying themes through content analysis.
The analysis for this study represents aspects of a structured evaluation of the content criteria (Brewerton and Millward 2001). In content analysis the researcher makes decisions about exclusion or inclusion criteria as well as assumptions about the development of themes and patterns. We reduce that risk of subjectivity by involving two researchers in the search and review process. In our study, we started with a pre-selected number of keywords which we extended to the full list (provided and further explained in the following paragraphs) while we were searching the literature. This approach helps to increase the study's objectivity and validity (Kassarjian 1977).

Our initial objective was to ensure that we only examine journals that are positioned in the field of SCM research and journals that focus on the broader management research but also publish SCM related articles. Furthermore, we limit our review to peer-reviewed journal articles in English. In our systematic review, we use the journal in which an article is published as an indicator for the research quality (Extejt and Smith 1990). We therefore followed a specific journal sampling framework that was introduced by Zsidisin et al. (2007); published in the Journal of Operations Management. Their review of supply chain related journals within a broader field of general management research covers a similar agenda and is therefore applicable to our study. Hence, we limit the list of journals that are considered in our review to the 27 journals listed by Zsidisin et al. (2007). We then use the ABS journal ranking guide and divide the 27 journals into the following five categories. (1) Operations, Technology and Management (including all dedicated SCM journals), (2) Operations Research and Management Science, (3) Marketing, (4) General Management, and (5) Strategic Management. Vitally, this division enables us to distinguish between career issues raised in the wider management literature and those raised in the more concentrated SCM literature. Out of the 27 journals identified by Zsidisin et al. (2007) the *International Journal of Integrated Management Supply* is not accessible to the researchers, which results in excluding this journal from the review. Finally, we focus our review to an overall sample of 26 academic journals.

After selecting the proper sample of journals, we applied our keyword search terms to the title, abstract, and keywords (depending on the provided search form on the database) over the period from 1980 until 2015 using the electronic databases Business Source Premier, Science Direct, Emerald Insight, Wiley online library, Taylor & Francis Library, IEEE/IET Electronic Library (IEL), JSTOR Business Archive, and EbscoHost. The aim of the review is to capture a snapshot of the diversity of research being conducted in career management in the field of SCM. A prior search using solely the keyword "career" within the selected journals results in a total of 2,993 articles. In order to further limit and reduce the potential articles to a more manageable number, we used the following keyword search strings separately and in combination: "career mentoring", "career coaching", "career changes", "career mobility", "career path", "career ladder", "career attitudes", "career success", "career growth", "career counselling", "career development", "career dynamics", "career satisfaction", "career planning", "career management", "succession planning", "career progression", "promotion", and "employee turnover". This variation of keywords allows us to more specifically narrow down and limit the findings to our identified themes that were derived from the literature. Also, the diversity of career related search terms ensures full coverage of the issues that are commonly mentioned in literature on SHRM and career in SCM. It is worth noting that some articles appear repeatedly across different databases in the initial search due to the overlapping nature of the keywords and the database subscriptions. These duplicates were identified and deleted. Furthermore, editorials, transcribed speeches, book reviews, and interviews were excluded from the analysis.

The application of the keyword search strings among the 26 journals results in a total of 551 potential articles. We then applied a three stage refinement process in order to identify only the relevant research articles for the further analysis that meet our inclusion criteria. We based our evaluation first on examining the title of each paper; second, on reading the abstract of the remaining papers; and third, we evaluated the paper based on the full-text. In each step, we made sure that only papers are included that focus on career related issues specifically in the area of purchasing and supply management by following specific exclusion and inclusion criteria. These criteria can be summarized as (1) the article must focus on career related issues such as employee development, skills or career management , (2) the context of the study must be related to the field of purchasing and supply management, and (3) the focus of the paper must be the human and social factor of career issues. The criteria for including and excluding are described as follows. First, articles were excluded that just mention terms such as career, employment, or succession planning and therefore do not use these terms within any research context, framework or empirical data. We excluded all articles that, for instance, mention career development in the abstract but do not consider any career or employment related factors in their analysis or empirical research. Second, articles that investigate and focus on career and employment related issues in a context not related to the purchasing or supply management function within an organization or industry were excluded. We excluded, for instance, all articles that investigated career development or management skills in the financial or banking industry. Also, many articles were excluded that focus on manufacturing and technological skills and employment training. Third, we excluded papers that focus on employee profitability, the effect of sales promotion, or the scheduling or planning of manpower and workforce.

Our applied three step refinement process that further eliminates articles based on the above inclusion and exclusion criteria is illustrated in the following Figure X. In cases where the decision was not clear, both researchers discussed and agreed on whether to include or exclude that particular paper for further analysis.

After excluding articles that were evaluated based on the title (398 articles) and the abstract (53 articles) our refinement process results in 100 potentially relevant papers for further review. 26 of those were excluded based on the evaluation of the full paper. However, an additional 17 articles, which were not recorded and identified in the initial keyword search, were included as a result of cross-referencing while reading the full-text of the potential papers. The final sample therefore includes a total of 91 distinct papers that meet the inclusion criteria and focus on career issues in the academic field of supply chain management within the wider management disciplines.

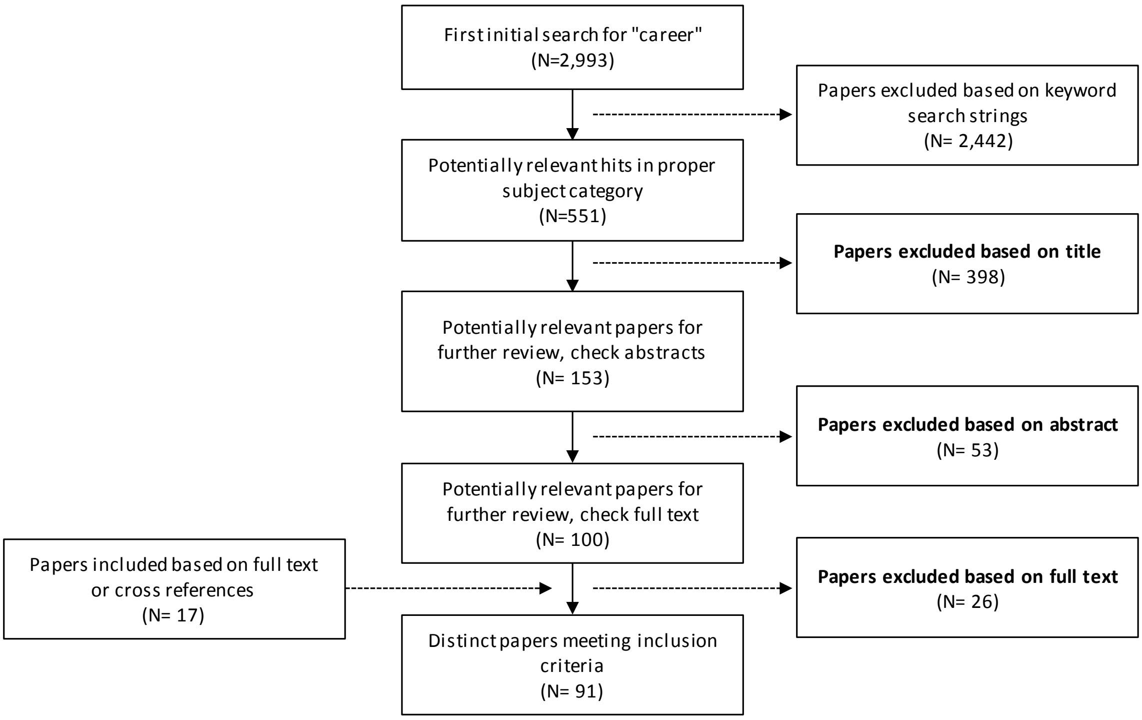

Figure 1: Systematic review and refinement process

FINDINGS

The full study is too large to reproduce in any form here, as it three broad main areas which are then further sub divided. The first section is mobility/promotion, the second area is turnover and retention comprising career mobility and promotion, career and employee' turnover, succession planning and employee retention. The final area covers career development, career and employee's preference, SCM skills and general career insights. Given the interests of this audience and length limitations we will focus here on SCM skills.

SCM SKILLS

SCM Skills featured in 13 of the journal articles used – of which only one paper was from the more general management literature, with the other 12 from SCM focused journals.
SCM has been moving from the functionality of the 1970s focusing on product delivery and quality towards strategy where it services the relationship between the organization and its trading partners, including both the supplier and the customer (Blanco & Caplice, 2013). The "people dimension" (Knight, Tu, & Preston, 2014) of the supply chain is critical in protecting the organization against volatile demand, uncertain supply, and other disruptions (Blanco & Caplice, 2013) leading to the achievement of the supply chain objectives (Myers, Griffith, Daugherty, & Lusch, 2004). In order to fulfil such roles productively, employees should be equipped with a set of knowledge and skills.
Most of the articles covered in this SCM skills part of the study presented putative skills profile for logisticians and purchasing and supply chain employees, with a specific emphasis on managers. However, research on the skills and attributes that make a good logistician is quite rare; what extant research there is appears U.S. based with no studies on the developing nations (Razzaque & Bin Sirat, 2001).
The emergence of globalized logistics systems or supply chains (Razzaque & Bin Sirat, 2001) challenges organizations to focus on how skills and knowledge requirements vary across organizational contexts (Knight et al., 2014). Career planning and development in supply chain careers (Kovács, Tatham, & Larson, 2012) should ultimately contribute to the competitive advantage of the organization (Giunipero & Pearcy, 2000).

Myers et al. (2004) suggested that it was not job experience or level of education that directly related to perceived performance; instead it is the job skills themselves that are the best predictors of employees’ performance. Based on that line of argument on the importance of job skills, it is vital to identify the skills required of those working in logistics and related areas and for managers of logistics.
Mangan & Christopher, (2005) had introduced the “T-shaped skill profile” for the logistic managers with the vertical bar representing logistics management skills and the horizontal one for the understanding of related areas. To a great extent, there has been an agreement on the set of knowledge and skills of the logistics manager which can be summarized below:

Focus/Theme	**Authors and articles**
Operations and SCM related knowledge	• (Mangan & Christopher, 2005; Murphy & Poist, 1991, 1998; Paul & Richard, 2007; Razzaque & Bin Sirat, 2001) and international logistics (Razzaque & Bin Sirat, 2001)
Related areas knowledge, for example	• Finance (Kovács et al., 2012; Mangan & Christopher, 2005; Murphy & Poist, 1991, 1998; Paul & Richard, 2007; "Skill requirements for logistics license in Taiwan," 2006) and accounting (Kovács et al., 2012; Murphy & Poist, 1991; Paul & Richard, 2007); Marketing (Kovács et al., 2012; Murphy & Poist, 1991, 1998; Paul & Richard, 2007); Customer relation management (Kovács et al., 2012; Murphy & Poist, 1991, 1998; Paul & Richard, 2007; Razzaque & Bin Sirat, 2001); Supplier relation management (Kovács et al., 2012); IT (Kovács et al., 2012; Mangan & Christopher, 2005; Murphy & Poist, 1991, 1998; Paul & Richard, 2007; Razzaque & Bin Sirat, 2001; "Skill requirements for logistics license in Taiwan," 2006); Management/Strategy (Mangan & Christopher, 2005; Murphy & Poist, 1991, 1998; Paul & Richard, 2007); Risk Management (Kovács et al., 2012); Human resource management (Kovács et al., 2012; Murphy & Poist, 1991, 1998; Paul & Richard, 2007; Razzaque & Bin Sirat, 2001); Business ethics (Razzaque & Bin Sirat, 2001)
Key/core competencies and skills, for example	• Analytical (Mangan & Christopher, 2005; Murphy & Poist, 1991, 1998; Paul & Richard, 2007)and problem solving (Kovács et al., 2012; Murphy & Poist, 1991, 1998; Myers et al., 2004; Paul & Richard, 2007; Razzaque & Bin Sirat, 2001); Interpersonal (Kovács et al., 2012; Mangan & Christopher, 2005; Murphy & Poist, 1991, 1998; Myers et al., 2004; Paul & Richard, 2007); Leadership (Kovács et al., 2012; Mangan & Christopher, 2005; Murphy & Poist, 1991, 1998; Myers et al., 2004; Paul & Richard, 2007); Change management (Mangan & Christopher, 2005; Murphy & Poist, 1991, 1998; Paul & Richard, 2007); Project management (Kovács et al., 2012; Mangan & Christopher, 2005); Stress management (Kovács et al., 2012); Time Management (Murphy & Poist, 1991, 1998; Myers et al., 2004; Paul & Richard, 2007)
Related Competencies and skills, for example	• Knowledge of emerging markets (Mangan & Christopher, 2005); Understanding of security (Mangan & Christopher, 2005); Knowledge of international trade (Mangan & Christopher, 2005; "Skill requirements for logistics license in Taiwan," 2006)
Humanitarian skills	

Other Personality traits	• (Kovács et al., 2012) • Proactiveness (Ashenbaum, Salzarulo, & Newman, 2012); Self-management (Ashenbaum et al., 2012)

Table 1 Summary of articles

Logistics executives are expected to be more skilled generalists rather than technical specialists (Razzaque & Bin Sirat, 2001). The skills and knowledge required for senior executives were highlighted, for example, in (Murphy & Poist, 1991, 1998; Paul & Richard, 2007) who grouped the skills into business skills, logistics skill, and management skills; moreover, they emphasized the importance of management skills over business and logistics skills. Again Paul and Richard (2007) suggest that logisticians should be managers first and logisticians second. Another approach to skills grouping ("Skill requirements for logistics license in Taiwan," 2006) categorized skills into basic skills, managerial level skills, and business level skill; suggesting that there is no difference between the skills required by middle and high management. Razzaque and Bin Sirat (2001) built on Murphy and Poist's "Business-Logistics-Management (BML)" model in their cross-cultural survey on the skills required from senior executives in two developing Asian nations; (Singapore and Malaysia). Their results report that senior logistics executives in both countries perceive management skills as the most important followed by logistics skills and business skills respectively. Also noteworthy from that ("Skill requirements for logistics license in Taiwan," 2006) emphasized the importance of a second language to the top management whereas (Murphy & Poist, 1991) viewed it as unimportant. This may be justified based on the research setting was in nations whose English was not the native language.
As the profession continues to grow beyond its roots in distribution roots, supply chain managers are expected to have more expertise and deeper technical excellence (Blanco & Caplice, 2013). Myers et al. (2004) focused on the skills required for entry and mid-level logistics managers; these are social skills, decision making skills, problem solving skills, and time management. Their study found that the more the employee had of these four skills, the higher the employee's performance was rated and also the higher their financial rewards.

Blanco & Caplice, (2013) summarized the shift in the skills required from SCM managers/leaders. (1) leaders were functional experts with a narrow scope to leaders required to have multilingual capabilities and multi-cultural awareness adding to the importance to maintain open and clear communications, (2) Leaders whose solutions were narrow focused to leaders focusing on visibility and coordination aspects, (3) leaders having local and controllable influence over all their functional aspects requiring hard skills to leaders having an influence behavior across the entire supply chain requiring more persuasion ability, (4) leaders whose performance measurement systems were confined to a bounded set of activities with a single focus to leaders whose performance measurement systems are multi-tiered and multi-facets, and (5) leaders who tended to be reactionary in the functional area to leaders who are asked to develop planned responses for potential disruptions and strategies for creating opportunities.
Giunipero and Pearcy (2000) and Knight et al. (2014) focused on the skills of purchasing managers. Giunipero and Pearcy (2000) grouped these skills into strategic skills, process skills, management skills, team skills, decision making skills, behavioral skills, negotiation skills and quantitative skills. They propose that strategic skills and team work skills were the most important. Knight et al. (2014) focused on the effect of the organizational context (described in terms of corporate strategy, purchasing maturity, organizational structure, and business context) on skills and knowledge and how these contextual factors can mean the skills and knowledge required varies.
As the skill profile required changes over time (Paul & Richard, 2007), Blanco and Caplice (2013) advise "be agile and ready to respond to whatever happens". Such an approach would demand continuous investigation of the skills and knowledge required and hence

affect training and recruitment efforts (Blanco & Caplice, 2013) as well as the career planning and development (Kovács et al., 2012).

Focus/Theme	Articles	Findings
Skills	(Dadzie & Johnston, 1984), (Kovács et al., 2012), (Murphy & Poist, 1991), (Myers et al., 2004), (Giunipero & Pearcy, 2000), (Ashenbaum et al., 2012), ("Skill requirements for logistics license in Taiwan," 2006), (Paul & Richard, 2007), (Blanco & Caplice, 2013), (Knight et al., 2014), (Murphy & Poist, 1998), (Razzaque & Bin Sirat, 2001), (Mangan & Christopher, 2005)	Organizations should be able to determine the set of skills and knowledge required by each group of its people to perform effectively, in addition, the importance ranking of such knowledge and skills should be identified, taking into consideration that they may change over time along with their relative importance. In moving beyond a purely functional role SCM leadership skills have migrated to issues like visibility, co-ordination and persuasion and communication. *The Articles in Red were cited elsewhere (Development)*

Table 2: Summary of the main findings from articles covering supply chain skills

REFERENCES

Below are the references for the methodology as being a structured literature review listing the entire references here would constitute nearly a third of the entire paper.

Brewerton, P. M. and Millward, L. J. (2001) *Organizational Research Methods: A Guide for Students and Researchers,* SAGE Publications.

Denyer, D. and Neely, A. (2004) 'Introduction to special issue: innovation and productivity performance in the UK', *International Journal of Management Reviews,* 5(3-4), 131-135.

Denyer, D. and Tranfield, D. (2009) 'Producing a systematic review' in Buchanan, D. A. and Bryman, A., eds., *The Sage Handbook of Organizational Research Methods*, Thousand Oaks, CA: Sage Publications, 671-689.

Extejt, M. M. and Smith, J. E. (1990) 'The behavioral sciences and management: An evaluation of relevant journals', *Journal of Management,* 16(3), 539-551.

Fink, A. (2010) *Conducting Research Literature Reviews: From the Internet to Paper,* SAGE Publications.

Topic / Theme	*Total*	*Strategic Mgmt.*	*OR / MS*	*General Mgmt.*	*OTM*	*Marketing*
Total number of articles as from the result of the review process	**91**	**14**	**24**	**13**	**32**	**8**
Mobility/promotion	**25**	**6**	**11**	**6**	**2**	**0**
Career mobility	14	5	5	3	1	0
Promotion/career advancement / Career Progression	11	1	6	3	1	0
Turnover / Retention	**32**	**7**	**6**	**5**	**10**	**4**
Employee Turnover	17	3	5	0	6	3
Succession planning	7	2	0	4	1	0
Employee retention	8	2	1	1	3	1
Development / Skills	**44**	**3**	**6**	**6**	**24**	**5**
Career development	13	2	1	4	5	1
Career and employee’s preference	7	0	3	0	0	4
SCM skills	13	0	0	0	13	0
Career insights	11	1	2	2	6	0

Table 3: Distribution of articles by journal categories and topic areas (1980 – 2013)

The sum of the articles that were classified into the individual topic areas does not equal the total number of identified articles from the review process because some articles are allocated to more than one single topic area. However, in the following analysis each paper only contributes to one distinct topic area.

Keupp, M. M., Palmié, M. and Gassmann, O. (2012) 'The Strategic Management of Innovation: A Systematic Review and Paths for Future Research', *International Journal of Management Reviews,* 14(4), 367-390.

Pittaway, L., Robertson, M., Munir, K., Denyer, D. and Neely, A. (2004) 'Networking and innovation: a systematic review of the evidence', *International Journal of Management Reviews,* 5(3-4), 137-168.

Srivastava, S. K. (2007) 'Green supply-chain management: A state-of-the-art literature review', *International Journal of Management Reviews,* 9(1), 53-80.

Thorpe, R., Holt, R., Macpherson, A. and Pittaway, L. (2005) 'Using knowledge within small and medium-sized firms: a systematic review of the evidence', *International Journal of Management Reviews,* 7(4), 257-281.

Tranfield, D., Denyer, D. and Smart, P. (2003) 'Towards a Methodology for Developing Evidence-Informed Management Knowledge by Means of Systematic Review', *British Journal of Management,* 14(3), 207-222.

Zsidisin, G. A., Smith, M. E., McNally, R. C. and Kull, T. J. (2007) 'Evaluation criteria development and assessment of purchasing and supply management journals', *Journal of Operations Management,* 25(1), 165-183.

EXPLORING QUANTITATIVE SKILLS PROVISION IN EUROPEAN LOGISTICS AND SUPPLY CHAIN EDUCATION

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Abstract
Purpose of this paper:
This paper reports on an ongoing research project investigating the current state of students' quantitative skills in European higher education, teaching techniques to impart quantitative skills to students in logistics and supply chain courses, and whether such techniques are making a difference.

Design/methodology/approach:
A literature review was used to develop open-ended research questions that at present have been undertaken in the first round of a Delhi method and a protocol to explore the three research objectives outlined in the purpose above. Thirty-one universities in the UK, France, Denmark, Sweden and Finland were approached to participate in the Delphi study and eleven responses were received.

Findings:
A majority of respondents considered students lack sufficient quantitative skills which may inhibit their ability to meet employer needs. However, only a few respondents provide additional techniques to impart these skills and these do not go much beyond basic spreadsheet, statistics and usual inventory economic order quantity analysis. As a result, many respondents could not say if a difference was being made.

Value:
This project and related empirical study is investigating an under-researched aspect of the state of logistics and supply chain management students' quantitative skills and teaching techniques to impart knowledge to them in their programmes, which are important in an increasingly data analytics-driven business environment.

Research limitations/implications:
The empirical study is ongoing and so far has comprised a single-round Delphi method with responses from eleven universities. Thus, study findings are limited however the strength of responses suggests trends may be indicative.

Practical implications:
Preliminary suggestions for European higher education institutions are that they need to validate employer requirements for students with good quantitative skills and accordingly change their curriculum if it isn't meeting such requirements.

Introduction
Logistics comprises functional 'stop' and 'go' activities such as warehousing, inventory management and transport, and logistics strategy has focussed on making these activities more efficient, effective and relevant (Grant, 2012). Techniques for doing so require quantitative skills for logistical system design and analysis and hence logisticians should possess a degree of quantitative skills to undertake these tasks. The broader concept of supply chain management (SCM) includes developing and managing relationships with stakeholders, internally and externally, along the supply chain– such stakeholders include shareholders, employees, customers, suppliers and possibly even competitors in collaborative opportunities. Accordingly, both logisticians and supply chain managers should also embrace 'softer' management and less quantitative skills in order to achieve these functions. However, this is not to say that both types of skills are not required at all levels.

Arguments surrounding the interaction of logistics and SCM (Larson and Halldórsson, 2004) have led to confusion and debate over what curriculum universities should provide to undergraduate (UG) and postgraduate (PG), i.e. Masters of Science (MSc) or Business Administration (MBA) students in logistics and/or SCM programmes. Wu (2007) examined academic curricula featured on university websites across the globe and found inter alia that most courses or programmes tend to be function-oriented. Wu suggested that "a truly integrated and effective logistics program can help students to keep pace with the business world and be equipped with the skills industry desires" (2007: 524).

One school of thought considers that students taking logistics, SCM and operations management (OM) programmes require more 'softer' or interpersonal skills to meet needs of industry and employers (Gammelgaard and Larson, 2001; Bennis and O'Toole, 2005; Gabric and McFadden, 2001). However, another school argues that students lack sufficient quantitative skills to meet industry and employers' needs (Powell, 1997; Sodhi et al., 2008). This view is receiving more weight nowadays as firms are focussing on 'big data' and data analytics, especially in supply chains (Hazen et al., 2014).

Following on from this debate is a view that students in certain programmes, such as general business, shy away from taking quantitative courses or modules due to either a lack skills or confidence in numeracy (Murtonen and Lehtinen, 2003; Pokorny and Pokorny, 2005). If that is the case and if the latter school of thought above has more merit than the former, meaning students may lack sufficient quantitative skills, how then should colleges and universities shape their programmes and curriculum going forward for the rest of this decade?

This paper's reports on an ongoing research project investigating these points of view through a discussion of extant literature and an exploratory study to determine which school of thought regarding quantitative skills has currency with European academics, and if the 'needs more quantitative skills' thought is prevalent, determine how these academics are addressing that issue.

LITERATURE REVIEW

In a logistics education special issue Poist et al. (2001) surveyed US and European logistics managers regarding their skill preferences for logistics managers operating in the new European Union environment. They found experience in international business, a foreign language (i.e. other than English), and general communication and interpersonal skills were important to respondents. In contrast, technological literacy and quantitative skills were only considered neutral by over half of their 279 survey respondents. Poist et al. concluded that their findings should drive curriculum development towards seminars, short courses and management development programmes aimed at the important interpersonal skills identified. Supporting this view in the same issue was work by van Hoek (2001) advocating in-company projects and case studies, Alvarstein and Johannesen (2001) discussing problem-based learning approaches, and Grant (2001) demonstrating the value of short, sharp 'block courses' to deliver logistics and SCM content. Additionally, Gammelgaard and Larson (2001) examined skill sets required by logistics managers to perform SCM as provided by members of the Council of Supply Chain Management Professionals (CSCMP). Their analysis of thirty-nine skill area variables generated three distinct latent constructs: interpersonal/managerial skills such as inter alia critical reasoning, organising, problem solving, time management and communication; quantitative/technological skills comprising information technology (IT), quantitative, statistical and spreadsheet; and SCM core skills such as change and conflict management, leadership and teamwork.

Bennis and O'Toole further suggested that business schools had lost their way by emphasising scientific research rigour and adopting the scientific model that uses "abstract financial and economic analysis, statistical multiple regressions, and laboratory psychology" with little research "grounded in actual business practices" (2005: 96). They considered business akin to a profession such as law and advocated a broader focus on humanities subjects such as: economics, psychology, accounting, politics, philosophy, history, sociology, language, and literature. Finally, Gabric and McFadden (2001) examined employer and student perceptions of desirable entry-level skills for operations management (OM) and found what businesses required were markedly different than what students thought they wanted. They concluded that technical skills are important, but do not outweigh general skills, and that OM courses "should develop students' quantitative abilities with the integration of general management skills, such as problem-solving, team building and listening" (2001: 58). Thus, recommendations stemming from all these articles were for HEIs to provide more holistic general management courses emphasising the 'softer' skills of management that are needed in twenty-first century SCM and OM situations.

However, another stream of articles has noted a shortcoming in reducing the amount of quantitative courses and possible resultant skills of university students. Murtonen and Lehtinen (2003) described difficulties experienced in learning quantitative methods by students and found that statistics and quantitative methods courses were experienced by students as being more difficult than other domains, such as qualitative methods and the students' main subjects. They considered students tended to polarise academic subjects into 'easier' language, major and qualitative subjects, and 'harder' mathematical, statistical and quantitative subjects and established five main categories of reasons for difficulties: superficial teaching, linking theory with practice, unfamiliarity with and difficulty of concepts and content, creating an integrated picture of research in order to really understand it, and negative attitudes toward these studies. They found that students who gave high ratings for the difficulty of statistical and quantitative subjects cited teaching most frequently as the reason. Pokorny and Pokorny (2005) noted that the UK government's widening participation strategy and the concomitant development of a mass higher education system has imposed a variety of pressures on HEIs, including assumptions about the resultant skills and knowledge base they provided. The Pokornys identified the lack of numerical literary as one of a range of factors that could explain the variability of student performance on first-year UG statistics courses and challenged the presumption that students can rapidly become independent learners upon initial entry to higher education as an unrealistic one. Lastly, Sodhi et al. (2008) analysed 704 MBA-level SCM job advertisements to determine the proportion of skills required by employers and the curriculum of twenty-one business schools in the top fifty MBA programmes in the US to determine if they provided those skills. They found that the curriculums offered a relative over-supply of conceptual and strategy-oriented i.e. qualitative topics and a relative under-supply of practice- and process-oriented i.e. quantitative topics compared to advertised employment demands.

Thus, there is a limited but important and healthy debate regarding the importance of quantitative skills and their requirement by employers. However, given the origin of quantitative functions in the logistics domain and its continued importance in achieving efficiency gains (Grant, 2012), what level of quantitative skills should UG and PG students possess relative to broader management skills, and how should they acquire them in college and university courses and programmes?

Kretovics (1999) used learning skills profile (LSP) sets and measured quantitative skills within set of analytical skills that also included theory and technology skills. He defined quantitative skills as "the ability to use quantitative tools to analyze and solve problems and to derive meaning from quantitative reports" (1999: 129). Thus, we argue that an inventory of skills needs to satisfy these three criteria: the ability to analyse, the ability to problem-solve and the ability to interpret data to derive meaning. From a holistic perspective, skills need to be integrated and case studies are considered best-placed to do so (Johnson and Pyke, 2000), need to be seen in a globalised setting as SCM is a global activity (Kopczak and Fransoo, 2000), and should be reinforced from outside the academy through guest lectures and site visits (Grant, 2001; van Hoek et al., 2011). Lastly, there are also well-established mathematical techniques and models to improve quantitative learning such as the economic order quantity (EOQ) for inventory management (Harris, 1913), the square root law for rationalising warehouses (Maister, 1976), the Forrestor effect affecting demand (Forrester, 1958), various types of simulations (Fry, 2008), games such as the popular 'beer game' and various derivatives (Knolmayer et al., 2007), and the increasing use of web-enabled tools such as Wikis (Neumann and Hood, 2009).

From this debate about the importance of quantitative or 'hard' skills for logistics and SCM students relative to other general or 'soft' skills, and an uncertainty regarding the balance between them for employer requirements in the workplace, our research projects seeks to investigate in a European context (a) the current state of students' quantitative skills as perceived by academics, (b) what academics are doing about any insufficiency in such skills, and (c) whether any interventions through their curriculums make a difference.

METHODOLOGY

Our methodology is exploratory as we are trying to understand opinions and behaviour by academics in European higher education institutions. Hence, an inductive approach is appropriate for this project and our approach consisted of a Delphi method using a structured series of questions to conduct this exploratory investigation. Our empirical research aim was to obtain a reliable consensus of a group of educational experts in logistics and supply chain management education in Europe. Given the possible dichotomy regarding quantitative skills of students and various approaches in addressing them, a Delphi study was considered appropriate to generate initial qualitative data for analysis and verification in further rounds.

The Delphi method was developed at the RAND Corporation as a means of collecting and synthesizing independent expert judgments (Helmer and Rescher, 1959) and since then the technique has often been used across a broad spectrum of topics in the social and natural sciences. Participants are chosen for their expertise in some aspect of the problem under study and are promised anonymity with respect to their answers. The value of the Delphi method rests with the ideas it generates in studies that evoke consensus and those that do not. The arguments for any extreme positions also represent a useful output.

Based on our research objectives outlined in the literature review, we developed five open-ended questions as shown in Table 1. We have only undertaken a single Delphi round to date.

Q1. Do you perceive that your logistics and SCM students lack sufficient quantitative skills? Why or why not, i.e. how do you know?
Q2. Does your programme provide any additional learning or training in quantitative skills to address any shortcomings? If so, please describe the nature of such additional learning or training.
Q3. Do you incorporate any quantitative-based techniques within modules or courses in your programme to assist students in reinforcing their skills? If so, please describe the nature of such techniques.
Q4. Are you and/or your colleagues able to perceive a difference in students' quantitative skills as a result of either additional learning or training or quantitative-based techniques within modules or course? Why or why not, i.e. how do you know?
Q5. Do you have any other comments or observations on this issue?

Table 1: Open-ended questions for first round of Delphi study

Logistics and SCM academics in thirty-one European universities were invited by e-mail to participate in this Delphi study: eighteen in the UK (58%), six in France (20%), three in Finland (10%), and two each in Denmark and Sweden (6% each). The academics are well-known to the authors and represent in our view leading research and teaching experts in the logistics and SCM domains. Further, the universities selected are also well-known for their undergraduate and/or taught postgraduate (i.e. MSc and/or MBA) logistics and SCM provision. Due to anonymity reasons promised to invitees we are unable to identify the academics and universities selected. Content analysis was used to interrogate the Delphi responses and is presented using usual techniques for qualitative research (Yin, 2003).

FINDINGS

We received eleven completed responses (35% response rate) to our invitation: seven from the UK (UK1 to UK7), three from France (FR1 to FR3), and one from Sweden (SE1).

What is the current state of quantitative skills?

Seven respondents (UK1-2, 4, 6-7; FR1-2) reported students lacked sufficient quantitative skills at either or both UG and PG levels. One reason expressed is the diversity of the student's educational background and/or previous degree, for example:

> "Students …are from diverse backgrounds in terms of their degree discipline. The ones majoring in Geography definitely tend to be short on the quant [sic] side. The ones from the business school tend to be better equipped and the ones from Maths are obviously ahead of the game." UK1
>
> "Yes, it is a reality. I think that quantitative skills are well known in Engineering degrees, not in Management degrees. A sort of 'division of labour' in France." FR1

Another reason is the lack of courses on quantitative skills at lower degrees and the nature of some PG programmes being conversion programmes for newly-graduated UG students, for example:

> "The MSc courses are conversion courses and hence not all students will have a quantitative background. Undergraduates will study logistics and SCM through modules on 'Operations Management' however they too are uncomfortable with quantitative inputs." UK6
>
> "Students lack a formal mathematical background in earlier years (from 1st to 4th year)." FR2

Finally, students are perceived not to have an interest or adequate skills such that they struggle with concepts needed to undertake logistics and SCM analyses, for example:

> "Most [students] do not have adequate knowledge in statistics and maths …some of them do not understand linear programming and simple calculations." UK2
>
> "At undergraduate level ...students often don't choose the logistics/SCM/OM modules because they perceive them to be quantitative (even if they aren't!). ...there are always some who ask as to how quantitative the module would be and how good they would need to be at maths. This observation is also borne out by (i) generally poor performance in accounting modules; and (ii) extremely low take up of quants modules." UK7
>
> "Yes, the students in my Master's program lack math skills to understand the core mathematical formulas. I know because I tried to have them calculate the EOQ by demonstrating the formula and doing some exercises with basic parameters." FR2

Such lack of quantitative skills may prevent students from undertaking placements and might ultimately limit their employability prospect.

> "We have supply chain projects and internships that some students are excluded from because of the quantitative nature of the work." UK4

In contrast, the other four respondents (UK3, UK5, FR3, SE1) cited individual needs assessments where "sufficiency is defined in relation to need which is individually defined," (UK3) and differences in degree classification and student selection as the main reasons their students possessed such skills, for example:

> "Our students are at master levels and they are engineers, e.g. mechanical engineering and industrial management engineering (not MBA), and have a good base in mathematics and optimisation models, etc. They have good mathematical skills, even if our courses are more qualitative. We have a lot of cooperation with industry both in our courses and when they are doing their master's thesis (which is done in a company). From this, we know that our students are very appreciated in industry. They are also getting very qualified jobs direct after their exam." SE1
>
> "Our selection process takes into account the students quantitative skills (tests and serious checking of previous studies) and students without sufficient quantitative skills are eliminated at this stage. There is also a natural selection, in the sense that possible applicants know that quantitative skills are required when they apply to such a master's program." FR3

What are academics doing about the insufficiency of quantitative skills?
The provision of additional training or courses in quantitative skills ranged from none (FR1, FR2, SE1, UK1) through specific seminars and labs on basic statistics and using spreadsheets and SPSS to harmonise skills and eliminate any shortcomings (FR3, UK3, UK5, UK7) to specialist and in-depth courses on quantitative skills (UK2, UK6) and research methods (UK2) and electives on modelling and simulation (UK4). Three respondents (FR1, UK4, UK5) do not offer additional techniques other than specific elective courses in quantitative techniques (UK4). Additional courses offered by the other seven respondents range from small group tutorials (UK2, UK6, UK7), basic inventory and EOQ analysis (FR2, UK1), basic spreadsheet analysis (SE1, UK3), basic statistics or simulation e.g. SIMUL8 or Microsoft Solver (FR3, UK3, UK6), and vehicle routeing and scheduling (UK1).

Is there an improvement in quantitative skills?
Only two respondents perceived no improvement in skills for two different reasons:

> "With a very weak background and limited additional help it is hard for students to achieve significant improvement. Average student performance is usually lower when there are more quantitative [elements] in the assessment." (UK2)
>
> "The students tend to self-select and the better ones take the quantitative questions [on exams] and the weaker ones avoid them." (UK1)

Four respondents perceived there was improvement in skills that was seen in the master's thesis (UK5), regular assessment to test this improvement at UG level (FR3, UK4, UK6), students from different educational backgrounds that can "…understand without any problem the cross docking managerial stakes and they are able to organize a cross docking platform! But these students are engineers with a hard background in quantitative skills." (FR1) While SE1 did not consider this an issue, the remaining four respondents either did not know (FR2, FR3) or found it is difficult to tell since "students have numerous different backgrounds (e.g. Engineering to Law) and interests. Quants [sic] is one of perhaps 10 skills on logistics courses – very difficult to pin down particular outcomes to particular causes" (UK3) or "students either 'get it' or not in relation to quants [sic]. The majority tend to not to jump between categories, and the ones that do are the ones who work hard, spend time outside lectures studying the topic and seek help as appropriate" (UK7). Two respondents commented on the implications of this issue. UK1 "would be interested to know – engage in a debate about – what quant [sic] skills we think might be the appropriate ones – or the minimum requirement" while FR1 considered that cultural dimensions, "for instance between the French system and the Anglo-Saxon system, should be investigated," which is a very Northern Europe perspective. On the other hand, UK6 posited a broader cultural approach when he opined that "that quantitative inputs to the courses- 'Operations Management' and 'Logistics and SCM' within the UK are limited. This may be because students are not receptive to quantitative methods. The courses in USA, India and China for example are more quantitative (more towards OR) and this is also evident when comparing text books from the UK and US." This was echoed by UK7 who noted that at PG level "there is a cultural aspect to this. Chinese/Asian students seem to do well in quants [sic] and have the skills to cope."

UK6's reference to different disciplines was also raised by FR2. He considered that there are two different schools of thought in management studies. Those that favour soft sociological skills and those that favour hard analytical, process oriented organizational ones. To my mind, SCM and OM are both OR based and should be taught using quantitative methods and positivist normative scientific tools." The 'soft' side of management education was also noted by SE1 who considered this "might be a problem on MBA programmes, but not on the engineering master programs." However, there is "a risk that a more quantitative programme or a programme that requires quantitative skills as a pre-requisite would be less attractive hence our approach to using the elective modules as the quantitative route" (UK4). UK2 observed that there may be a tendency to make "the quantitative part or the courses 'easier' or reduce the quantitative part." As a result "…graduates are becoming less capable of making decisions based on quantitative method, most tutors choose to teach quantitative methods which are easier to grasp but such methods would not be applicable in the dynamic and complex real-life."

CONCLUSIONS

Almost two-thirds of respondents considered their students lacked sufficient quantitative skills, supporting concerns that the educational landscape has changed over the last decade (Murtonen and Lehtinen, 2003; Pokorny and Pokorny, 2005; Sodhi et al., 2008). Accordingly, students may not be getting the skills that they need in some logistics and SCM programmes to enable them to meet the requirements of the workplace and which may be frustrating employers about their abilities as well as the academy's ability to ensure employability. However, this is not a simplistic assertion as there are possible background factors affecting students' abilities to acquire quantitative skills such as lack of interest or a perception of difficulty, and previous education and cultural factors such as country of origin and language abilities that may inhibit or enhance those abilities.

Given this concern raised by respondents there were surprisingly few suggestions offered to address it; four respondents do not offer any additional training, three do not offer additional techniques within courses, and four only offer basic skills courses. Unsurprisingly, two respondents considered there was no improvement in quantitative skills and four did not know if there was a difference. Part of the reason for the latter was lack of information on individual students' backgrounds to determine if that made a difference to improvement or not. Additional observations reinforced the generalist school of thought wherein the curriculum was being changed to reflect qualitative or 'softer' skills and as a result it was implied that primarily teaching and assessing students on these skills and downplaying the quantitative aspect is perhaps a self-fulfilling prophecy. The notion of cultural differences of students was raised here also.

As a result, we have two preliminary suggestions for colleges and institutions. First, it should validate employers' needs regarding a proportion of qualitative and quantitative skills in light of Sodhi et al.'s (2008) desk-based study to ensure its curriculums are relevant, particularly in an increasingly data analytics-driven business environment. Second, and based on the results of that exercise, the academy will need to revisit its logistics and SCM curriculum to ensure relevancy not only for employers but also for students. Students and young people in the twenty-first century are 'switched on' regarding technology and 'social media' and the teaching of quantitative techniques need to reflect and embrace these initiatives – quantitative techniques cannot be a 'turn-off' for students and innovative teaching should include the use of technology such as cases, simulations, games and even Internet platforms to solve problems (Johnson and Pyke 2000; Fry, 2008; Neumann and Hood, 2009).

As with all research, there are two limitations to our study. Only eleven experts and well-known logistics and SCM academics across Europe participated in our study out of 31 invitees. While a large percentage response rate the absolute numbers are low and thus our findings may not totally reflect the current state across the entire sector. But, we are satisfied that our findings are indicative of the situation today. Also, we have so far only conducted a single-round Delphi study. Thus, we still need to validate them further to ensure a truly emerging consensus. There was a partial consensus in our findings however four respondents offered different views. As this phenomenon is still under-researched, we consider that our future efforts should continue to explore these issues and we consider finding another and much larger sample to replicate the first round.

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REFLECTIONS ON 1993 AND ALL THAT: WHERE ARE WE NOW?

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Abstract
Purpose of this paper: 1993 saw the inaugural International Symposium on Logistics (ISL). 1993 also saw the establishment of the European Operations Management Association (EurOMA) the European wide extension of the then United Kingdom Operations Management Association (OMA). OMA had already begun the path to creating the inaugural EurOMA conference but, seeing the need for a distinct yet related activity focussed on logistics, part funded the first ISL. Given the strategic nature of the creation of ISL we seek to review the long term impact of the inaugural conference and determine the value that has been gained by the EurOMA committee's initial investment and the wider academic community from the first cohort of papers that were presented.

Design/methodology/approach: We undertake a bibliometric analysis of the inaugural ISL proceedings (Pawar, 1993), as well as any subsequent journal publications of the conference papers, using an approach inspired by information science research. We utilise a combination of Google Scholar, Scopus and CrossRef to identify citing journal publications. The analysis includes determining the time series of citations from 1993 to 2014, reviewing the citing papers regarding their scope and method, and evaluating the extent to which the cited papers have contributed to the logistics, supply chain and other disciplines.

Findings: Altogether 54 papers were included in the inaugural ISL proceedings in 1993, of which ten were converted to journal papers. We found 65 citations for 17 conference papers and 189 citations for 10 journal papers. Conference paper citations demonstrate a cyclical pattern while journal paper citations grow gradually to a current level of ~13 per year. These citations indicate the benefits of the inaugural ISL beyond the discipline of what we call 'logistics'. Much of the research presented focussed on method and/or tool development with a strong emphasis on practical problem solving. The papers cover a broad range of topics with the unit of analysis ranging from a single firm to networks, and covering different elements of the value added process from supply to distribution.

Value: The research has utilised a method more often associated with information science. We have provided insights into the impact of the 1993 cohort of papers and shown their value to the logistics, supply chain, and management community. EurOMA's initial investment has led to a long term effect that shows continued growth in terms of number of citations received. The method adopted may be utilised by other researchers to determine the impact of other logistics and operations management conferences.

Practical implications (if applicable): The paper demonstrates that conference publications can bring value to the academic community, both directly and as a bridge towards journal paper publication. This evidence is useful for both conference organisers and attendees when evaluating the benefits of such events.

INTRODUCTION

1993 saw the inaugural International Symposium on Logistics (ISL). 1993 also saw the establishment of the European Operations Management Association (EurOMA) the European wide extension of the then United Kingdom Operations Management Association (OMA). OMA had already began the path to creating the inaugural EurOMA conference but, seeing the need for a distinct yet related activity focussed on logistics, part funded the first ISL.

While it may be argued in the general business studies discipline that journal publications are of more scientific value than conference papers, other disciplines give equal credence to both types of publication (Lisée et al., 2008). Given the strategic nature of the creation of ISL we seek to review the long term impact of the inaugural ISL and determine the value that has been gained by the EurOMA committee's initial investment and the wider academic community from the first cohort of papers that were presented.

In doing so, we draw from information science and adopt techniques that have seen use evaluating the value of conference papers in other disciplines such as the medical and natural sciences. Our research has identified such studies of conference papers are limited in management studies generally, with notable exceptions being Anderson and Haley (1984), Hofer et al. (2010) and Wuehrer and Smejkal (2013).

LITERATURE REVIEW

Conferences represent an important part of the fabric of academic life, and one with which many scholars engage. There are a wide range of reasons for participating in conferences. Presenting research is probably the most important of these (Fennewald, 2005, González-Albo and Bordons, 2011). Often, the research presented is at an early stage (Drott, 1995, Chen and Konstan, 2010) and the objective is to receive feedback to improve later activities, either in data collection or the development of journal paper publications from the research (Garvey et al., 1972a, Frandsen and Wouters, 2009, Montesi and Mackenzie Owen, 2008). However, it is also noted that some conference presentations may encompass application papers or be by authors, for example practitioners, who are not considered "mainstream" academics (Drott, 1995). In these instances, the research is still useful but may not be considered of appropriate rigour, originality or significance to warrant publication in a peer reviewed journal.

Complementary to presenting research is learning about the current research activities in the discipline (González-Albo and Bordons, 2011, Drott, 1995, Fennewald, 2005), although whether this constitutes the 'state-of-the-art' has been debated (King, 1961, Hofer et al., 2010). The benefit a conference offers is that this learning process can take place in a concentrated period of time (Drott, 1995). This enables the researcher to remain abreast of the latest developments in their own specific field of interest, as well as providing the opportunity to learn more about activities being undertaken in related disciplines (Chen and Konstan, 2010, Rowley-Jolivet, 1999, Garvey et al., 1972b).

Finally, conferences enable researchers to maintain and develop their networks (Chen and Konstan, 2010, Zhang and Glänzel, 2012), often in an attractive venue (Oseman, 1989). Socialising and exchanging experiences is an important aspect of conferences, and can often have subsequent benefits in terms of developing future research activities and bids for funded research projects. For example, both Lacy and Busch (1983) and Rowley-Jolivet (1999) highlight how research collaborations often emerge from the informal communication that occurs in conferences, leading to the exploration of new research areas.

In this research, we consider the presentation of knowledge at conferences. This can be through a variety of forms including papers, panels, posters or roundtable discussions (Fennewald, 2005) and our focus is on the first of these. While conference papers can be seen as an output in their own right (Drott, 1995), they are frequently considered as one stage on a research process, which starts with research activities in the "laboratory" and concludes with a journal paper publication (Rowley-Jolivet, 1999, Garvey et al., 1972a). This emphasis on journal papers may reflect wider pressures in academia, such as in the evaluation of individuals, say for promotion, and institutions for research quality (Schmenner et al., 2009, Montesi and Mackenzie Owen, 2008).

However, there is debate around this with various authors both within and outside of logistics arguing that the focus on journal papers, and the ranking of these titles to create "league tables", leads to other publication types being devalued (for example, Mingers and Willmott, 2013, McKinnon, 2013). There are also disciplinary aspects to this. For example, disciplines such as computer science, engineering and medical science regard conference papers as formal research outputs (Montesi and Mackenzie Owen, 2008, Lisée et al, 2008, Zhang and Jia, 2013). Advantages for conference papers include shorter publication times (Montesi and Mackenzie Owen, 2008, Michels and Fu, 2014), an interactive environment and the ability to reach non-academic audiences (Lisée et al, 2008) which are major drawbacks of journal papers.

Various studies have shown that conversion rates for conference papers to published journal papers are variable, with a range from 13% to 75% (see Table 1). Fennewald (2005) also considers the conversion ratio to be reflective of the research quality of a conference, while González-Albo and Bordons (2011) highlight that links between journals and conferences can be mutually beneficial. Many of the studies in Table 1 have been carried out in the medical and information sciences, with none considering logistics/operations management. In converting the papers, a lead times to the journal paper being published appear to be extending, with earlier works suggesting 1 to 2 years (Garvey et al., 1972b, Oseman, 1989) while more recent work give typical values between two and three years (Fennewald, 2005, Michels and Fu, 2014). There is much debate within the literature as to the extent of changes being made to the conference paper during this conversion process and evidence of discipline specific practices (Garvey et al., 1972a, Fennewald, 2005, Montesi and Mackenzie-Owen, 2008, Frandsen and Wouters, 2009, Zhang and Jia, 2013).

Source	***Discipline***	***Date(s) of Conference(s)***	***Conversion Rate***
Garvey (1972b)	Physical, Social and Engineering Science	1966-1968	Almost 50%
Oseman (1989)	Medical Science	1979	22.6%
Drott (1995)	Information Science	1987	13%
Fennewald (2005)	Medical Science	1977-1998	26-74%
	Natural Science	1989	51%
	Information Science	1999	32%
Miguel-Dasit et al. (2006)	Medical Science	2000	46%
González-Albo and Bordons (2011)	Medical Science	Not stated	30-50%
	Information Science	Not stated	33%
McRoberts et al. (2014)	Natural Science	1994-2006	28.2%
Michels and Fu (2014)	Social Science, Humanities, Science and Technology	2000-2010	27%

Table 1: Conversion rates of conference papers to published journal papers

An alternative approach to evaluating research quality is through citations (Andras, 2011, Michels and Fu, 2014), although a number of authors highlight the low usage of conference proceedings as a source. Chen and Konstan (2010) found that, for conferences in computer science, over 70% of papers received fewer than 2 citations in the two years after publication. In the context of management, Lisée et al (2008) show that conference proceedings represented between 0.1% and 0.2% of all references over the period 1981 to 2005. Further, Lisée et al (2008) discovered that conference proceedings get cited and exploited by practitioners more rapidly than journal papers, but also become obsolete in a shorter time span. Zhang and Glänzel (2012) suggest, as future research, that these citations may be from conference attendees and collaborators, in other words, those who are familiar with the paper's contents. Interestingly, both González-Albo and Bordons (2011) and Zhang and Glänzel (2012) highlight that papers that are converted into journal versions receive fewer citations than those which have not been to a conference. Further, papers in conference themed special issues of journals receive fewer citations than those appearing in regular issues (González-Albo and Bordons, 2011).

The above discussion provides an overview of the research into the usefulness of conference papers and provides a basis for the method and analytical approach adopted in this paper.

METHOD

The first stage in the research was, for each paper in the proceedings, to determine whether it had received any citations or if a journal paper version existed. Journal paper versions are important because, as found through the literature review, the conversion rate is one metric of conference quality (Fennewald, 2005). In the Proceedings (Pawar, 1993), 54 papers were listed and a search of Google Scholar was carried out using the following terms:

- Conference paper title in full, with and without quotation marks
- Partial conference paper, with and without quotation marks
- As above, but with author names added

For many of the conference papers, there was often a record within Google Scholar for the paper and this was used to determine citations. In some instances, and particularly where only one citation existed, the citing paper was listed but with the conference paper highlighted as being in the main text. Journal paper derivatives were determined based on the criteria of Oseman (1989), where the published version should include at least one of the original authors, a high degree of match between the titles and abstracts and, if numerical results were provided, commonality exists between the two papers. Once identified, the details of the journal paper were recorded against the conference paper.

Another metric of conference quality is the number of citations received by papers (Andras, 2011). To identify the details of citing articles, the "Cited by" link on Google Scholar was initially used, with the results then filtered to consider English language journal papers. This limitation was imposed to reflect both the language skills of the research team and the fact, discussed previously, that journal papers tend to be viewed by the academic community as the main focal point for outputs (Drott, 1995). Self-citations were also removed from consideration given the interest in considering the wider impact of the conference. Where the conference paper did not have a specific entry within Google Scholar, the citation(s) were manually evaluated against the same selection criteria. For journal paper versions, reference was made to other databases such as Scopus and Crossref to identify any other publications not already included. From this process, a list of citing works for each conference paper was identified and information such as the year and journal of publication noted. Random checks were carried out to ensure the accuracy of this list.

For each of the conference papers with citations, a review of the content was undertaken by the research team to consider aspects such as the focus of the research and the method adopted. Further, for the most cited papers, a review of the nature of the citations was undertaken to determine why these papers proved to be the most popular.

The analytical approach was influenced by both the literature presented in the above review and also more general approaches adopted in literature review methods. Tables and charts were used to capture the bibliometric data, while clustering of qualitative information identified common traits and features. To ensure consistency, the qualitative data was cross-checked amongst the research team to ensure common understanding.

FINDINGS

Conversion to journal papers

The research identified that 10 of the ISL 1993 conference papers have additional versions that were subsequently published in journals, of which four were for the inaugural ISL Special Issue that appeared in the International Journal of Logistics Management (published in 1994). Two others appeared in Logistics Information Management (1994), one in Journal of Business Venturing (1994), one in Supply Chain Management: An

International Journal (1997), one in Technovation (1997) and one in International Journal of Operations & Production Management (1999). This results in a conversion ratio of 18.5% and an average publication lead time of 2.1 years.

Citation analysis

We found 65 citations for 17 conference papers and 189 citations for the 10 journal papers. As shown in Figure 1, conference paper citations demonstrate a cyclical pattern (with perhaps an indication of a very small increasing trend) while journal paper citations show a clear growing trend with some cyclical behaviour around the trend, reaching a level of approximately 13 citations per year. Some of the cyclical trend, particularly for conference papers, can be attributed to 'snowball citations' (Salomon, 1998) whereby the paper is cited by a later paper and then a further paper cites both the original and second paper. The lead time between these publications result in cycles emerging. Some conference papers were cited in journal papers during the same year as the conference, while there was a one year time lag for citations of the journal papers to emerge, from 1994 to 1995.

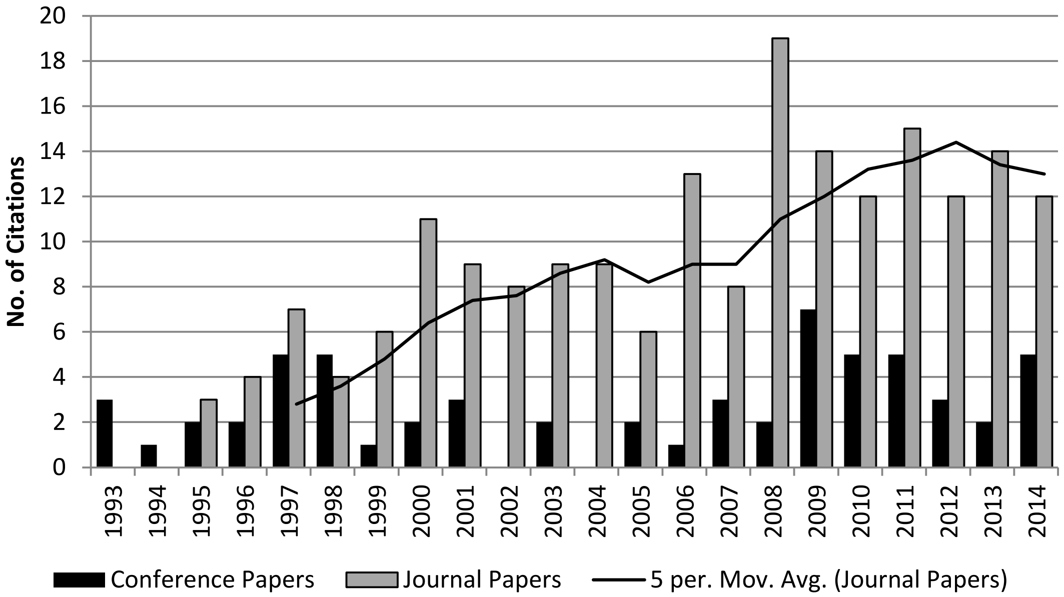

Figure 1: Citations over time

The most cited conference paper, with 50% of total citations, is Ghobadian et al., 'A computerised vendor rating system', often in papers related to supplier selection using multi-criteria decision analysis tools and normally for the statement "Material costs could account for up to 70 percent of the cost of production". While true back in 1993, it could be questioned whether this statement still applied when cited in papers published in 2014. With 28% of total conference paper citations, the second most cited paper is Forza et al, "Telecommunication services for quick response in the textile-apparel industry". The paper is particularly popular for its use of process visualisation and has been picked by papers advocating lean thinking and especially the use of value stream mapping. In terms of the citations made of conference papers, the majority of them are by authors who were also at ISL 1993 or worked closely with either the authors or someone who was there.

The most cited paper across both categories is Lipparini and Sobrero (1994), 'Innovation and small firms…', an extended version of the ISL conference paper, with 50% of the total journal paper citations. The journal version was published in the Journal of Business Venturing indicating the impact of the inaugural ISL beyond the discipline of what we call 'logistics'. Lipparini and Sobrero are generally cited to highlight the tenets, or antecedents, of innovation in organisations especially with respect to SMEs. Such innovations may be in the product, process or technology being developed by the organisations. A key precursor identified for innovation in SMEs is the role of networking. Such capability by SME entrepreneurs to develop linkages with other organisations ensures development of collaborations with other members of the network to leverage capabilities, including knowledge, to ensure innovation and competitive advantage.

Three other relatively well cited journal version papers are by Stainer (1997) with 14% of citations, Sohal (1997), which has 7%, and Bamfield (1994), with 5%. Stainer is cited for determining the characteristics of logistics performance measures while Sohal, although focussing on the traceability of faulty automotive parts, showing recent popularity with respect to ensuring visibility and integrity of food sourcing. Bamfield is concerned with the interplay between the use of EDI and the ability to adequately communicate and establish working relationships between manufacturers and retailers.

It is notable that the special issue papers are far less cited. The one that receives the highest citations, with only 4% of the total cites, is Hines (1994) that proposes a model for the establishment of supplier associations especially for exploitation outside of Japan.

Indicative of the cross-disciplinary nature of logistics is the wide range of journals in which the ISL papers have been cited in. In total there are 143 different journals with an average number of citations per journal under 2, although there is a long tail with 103 journals citing an inaugural ISL paper just once. The most highly citing journal is the International Journal of Production Economics, although it only account for 17 citations. The next most citing journals are International Journal of Logistics Management (8 citations), International Journal of Physical Distribution and Logistics Management (7) and Technovation (7). Table 2 gives the categorisation of citing journals and the number of citations per category. The categories are primarily based on the Associations of Business School's journal ranking guide (Harvey et al., 2010) with a number of additional categories for those journals that are outside of business and management studies. The categorisation exercise of Table 2 is repeated specifically for the top cited papers and is given in Table 3.

Most citations are concentrated in Operations and Technology Management journals, although Entrepreneurship and Innovation journals also feature highly due to the high citation count of Lipparini and Sobrero (1994). There is some indication of influence outside management, especially Engineering. Some of the titles that appear within the Operations and Technology Management category, such as International Journal of Production Economics and International Journal of Production Research, are multidisciplinary and may also be categorised as Engineering, for example, as per the ISI Web of Knowledge subject categories.

Journal Subject Area	***No. of Journal Titles***	***No. of citations***
Accountancy	1	1
Business Ethics and Governance	2	2
Economics	4	4
Engineering	7	7
Entrepreneurship and Small Business Management	16	39
General Management	10	13
Geography	1	1
Human Resource Management and Employment Studies	1	1
Information Management	8	19
Innovation	14	20
International Business	4	4
Management Development and Education	2	2
Marketing	9	14
Operations Research	5	5
Operations and Technology Management	31	90
Organisation Studies	4	4
Other	1	1
Sector Studies	12	15
Social Science	8	11
Strategic Management	3	3
Grand Total	**143**	**256**

Table 2: Spread of citing publications by journal type.

Journal Subject Area	***Ghobadian et al.***		***Forza et al.***		***Lipparini & Sobrero***		***Stainer***		***Sohal***		***Bamfield***	
	JT	***Cit.***	***JT***	***Cit.***	***JT***	***Cit.***	***JT***	***Cit.***	***JT***	***Cit.***	***JT***	***Cit.***
Accountancy												
Business Ethics and Governance					2	2						
Economics					2	2	1	1				
Engineering	3	3							1	1		
Entrepreneurship and Small Business Management	1	1			15	38						
General Management	2	3	1	1	4	5	4	4				
Geography					1	1						
Human Resource Management and Employment Studies					1	1						
Information Management	1	4			3	3					4	5
Innovation					12	18						
International Business					2	2						
Management Development and Education					1	1			1	1		
Marketing					7	9	1	1			2	2
Operations Research	4	4			1	1						
Operations and Technology Management	11	17	6	8	6	6	10	15	4	5	2	2
Organisation Studies					3	3	1	1				
Other									1	1		
Sector Studies					5	5	4	4	4	5		
Social Science					7	10	1	1				
Strategic Management					2	2						
Grand Total	**22**	**32**	**7**	**9**	**74**	**109**	**22**	**27**	**11**	**13**	**8**	**9**

JT = Journal Title; Cit. = Citations

Table 3: Location and number of citations for top 6 papers

The paper by Lipparini and Sobrero (1994) has a wide reach across disciplines but, reflecting the content of the paper, with a clear focus on innovation and entrepreneurship. Forza et al. (1993), Ghobadian et al. (1993) and Stainer (1997) are concentrated in Operations and Technology Management although the latter two have some impact outside that core discipline. Sohal (1997) and Bamfield (1994) are as influential outside that core discipline as they are within it. The former has been taken up by food (Sector Studies) supply chain researchers while the latter paper, based around EDI, has seen interest in the Information Management discipline.

Content Review

Looking at the content of the papers in the inaugural ISL, and with a focus on the papers being cited, we find limited theoretical foundations and little methodological justification. This is reflective of the early stage research presented in many papers. The single dominant approach was the use of case studies with 12 papers utilising such a method. Much of the research presented focussed on method and / or tool development with a strong emphasis on practical problem solving. There is also some development of computer aided systems such as vendor rating and product tracing approaches. We identified 14 non-academic authors, six of them sole, in 13 conference papers (from the total sample of 54 papers), although none of these papers later appeared in journal form.

The papers cover a broad range of topics with the unit of analysis ranging from a single firm to dyad, supply chain, and supply network, and covering different elements of the value added process from supply through manufacturing to distribution. Lipparini and Sobrero (1994), in researching the precursors for innovation, do have a broader audience for their research but do focus on the role of networks, which is pertinent to the logistics discipline.

DISCUSSION

We have sought to review the long term impact of the inaugural ISL and determine the value that has been gained by the EurOMA committee's initial investment and the wider academic community from the first cohort of papers that were presented. In meeting these objectives we have utilised a method more often associated with the general area of information management encapsulating library studies and information science. We have provided insights into the impact of the inaugural ISL cohort of published papers and shown their value to the logistics, and the wider operations, management community but also beyond. Particularly significant is the paper by Lipparini and Sobrero (1994) which has a broad reach but a particular focus on Innovation and Entrepreneurship. We have shown that EuroMA's initial investment has led to a long term effect that still shows continued growth in terms of number of citations being received.

While our analysis was specifically for the inaugural ISL, some of our findings resonate with the existing body of literature on the value of conference proceeding more generally. We enumerate these as:

- The conversion ratio, while low is consistent when compared against Table 1 with those for subject areas where journal papers are generally considered as the main 'unit of currency' in evaluating research. The lead time between conference and journal publication is also consistent with the literature from that period (such as Oseman, 1989), while also affirming the results of Gonzalez-Albo and Bordons (2011) in terms of special issues having a quicker publication lead time.
- Distinguishing characteristics between ordinary and conference special issue journal publications is that the latter tend to be shorter and have fewer citations (Gonzalez-Albo and Bordons, 2011). We have also found this to be the case. The papers that were selected for the inaugural ISL special issue remaining relatively unchanged from the conference versions (hence also supporting Fennewald's (2005) results) while those papers that independently appeared in a journal were enhanced. Such papers also received far more citations than the special issue papers.
- Lisée et al. (2008) found that proceedings are cited more rapidly but obsolescence is faster. When comparing the conference and journal versions of the papers that appeared in the inaugural ISL proceedings, we clearly find evidence of the former attribute. In doing so, we confirm the proposition of Zhang and Glänzel (2012) that this is linked to conference attendees and collaborators. With regards to

obsolescence, we find that the journal versions of the papers have a great number of citations and show increased growth. The conference papers show cyclical behaviour indicating an initial obsolescence but then resurgence. While that may attributed to a rekindling of interest in specific topics it is an indicator that obsolescence may not be permanent. This supports Drott's (1995) observation that conference papers can have a scholarly impact.

- The nature of the data collected is such that we cannot conclude if journal versions of conference papers have fewer citations than those that go direct to the journal. However, it is found that those papers in the special issue had fewer citations that those sent independently to a journal, reflecting Gonzalez-Albo and Bordons (2011).
- The literature review suggested that conference papers generally represented early stage or application papers, which gave an indication of the state-of-the-art, and collectively provided a multi-disciplinary perspective on a subject area. The same can be said for ISL 1993, with evidence of paper development post-conference and citations in a broad range of journals. It was also found that the papers often lacked a theoretical underpinning, although this may well be reflective of the nature of logistics research at that time (Walker et al., 2015)
- Finally, we confirm Drott's (1995) observations that authors not in the mainstream academic track, such as practitioners, can publish in conference proceedings, with almost 25% of the papers featuring non-academic affiliations.

In addition, the method we have adopted may be utilised by other researchers to determine the impact of other logistics and operations management conferences. As with Andras (2011) and Chen and Konstan (2010) citations is the key indicator of the impact of published papers and hence also of conference papers.

CONCLUSIONS

While we have shown the impact of that inaugural ISL there is the possibility to extend the research to include subsequent ISLs in order to determine the continuous exploitation of the series of conference papers. Our approach has also been limited to the tracking of immediate citations and where they have been cited. We have yet to extend the tracking to further downstream citations (that is, what papers cited the citers) and who were the citing authors. A form of (social/citation) network analysis may help to address these two limitations. Also, an in-depth analysis of how the citations were exploited is lacking.

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MODELING SUSTAINABLE SUPPLY CHAINS USING SERIOUS GAMES: A COMPARATIVE ANALYSIS OF GERMANY AND POLAND

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ABSTRACT

This paper investigates how to measure the performance of sustainable supply chains and furthermore how to model those supply chains using educational games. Few studies to date have investigated best practices in sustainable supply chain management from a German-Polish perspective. Although the infrastructure of both countries differs substantially and their development in terms of sustainable supply chains is at different stages, these issues do not appear to have been investigated in any detail by any previous studies. More specifically little exists that shows dependencies, similarities and differences. This gap has led this research which focuses on the development of a tool to identify, assess and model sustainable supply chains, using serious games to aid decision making. We believe this will be of value in a number of contexts. The academic community will benefit from a modelling point of view to expand and acquire new knowledge. Secondly, the government and business communities will benefit from a practical point of view, as additional 'decision support' information will assist them in making informed decisions in logistics process modelling, taking into account environmental aspects.

INTRODUCTION

Sustainable supply chains (SSC) have been of growing interest to researchers and practitioners during recent years. Research also shows, however, that there are difficulties in understanding the complexity of SSCs, which in turn leads to challenges in the implementation of SSC concepts. Game-based learning (GBL) (Prensky 2003, Gee 2003; Ebner and Holzinger, 2007) is a concept proven to be valuable in the educational context of supply chain management (Michael & Chen, 2006; Semini et al. 2006, O'Sullivan et al., 2011; Chryssolouris and Mavrikios, 2006, Baalsrud Hauge et al., 2012), and today there are a number of games addressing various challenges within supply chain management. GBL is now an established learning method that has been used in engineering and management courses in countries such as Denmark, Germany and the UK, often as a supplement to courses using traditional teaching methods. The uptake of Game-Based Learning has, however, received less interest in Eastern European countries. As a second step to this research, we investigate how existing game-based courses can be reused and adapted to a Polish educational environment, before we finally look at how a specific game can be adapted and implemented for this purpose.

AIMS OF RESEARCH

This research focuses on two European economies, Poland and Germany, each of which plays a significant role in the flow of goods across Europe. The economic situation in both countries is, however, quite different. The Polish economy, following the economic transformation of the 1990s, is at the stage of building its position as the country in which the service is the modern logistics and crossed by important transport routes from west to east Europe, and from north to south. It can be seen as a huge improvement, and even it can be said that since Poland's entry into the EU in 2004, there have been revolutionary changes in the logistics infrastructure (linear and point), international supply chains operations and in the supply of services. Poland is an emerging economy that, owing to its transit situation in central Europe, plays a key role as a supply chain hub to Eastern Europe and in turn to the rest of the world. Its supply chain infrastructure is expanding but still contains bottlenecks and other inefficiencies. Germany, on the other hand, is one of the world's largest economies; an export leader with a well-developed logistics market, a world class logistics infrastructure and highly advanced sustainable supply chain practices.

The research imperative can be summarized as follows: there are few existing studies that have investigated best practices in sustainable supply chain management from a German-Polish point of view; although there are many companies indicate aspects of sustainable development in their business, it is very difficult to find a holistic approach that takes into account the whole chain. Moreover, there is currently no systematic theoretical framework in the literature in the field of performance evaluation and development of sustainable supply chains.

Taking the viewpoint that supply chain competitiveness will increasingly depend on the use of sustainable logistics, we test the following hypotheses:

H1: Simulating sustainability-related supply chain flows using serious games can contribute to improved supply chain management activities.

H2: The use of serious games enhances student appreciation of the practical implication of/potential impact of sustainable issues along the supply chain.

To verify the hypotheses and achieve the aims we will critically analyse the academic literature, government reports and associated documents. The data collected will be used to write a case study/scenario. The main result will be the development of an approach for using serious games in sustainable supply chain management.

STATE OF ART – SUSTAINABLE SUPPLY CHAINS AND GAME BASED LEARNING

This paper identifies the need to link the two elements of Sustainable Supply Chain Management (SSCM) and Game-based learning (GBL) concepts. Most definitions of SSCM include a consideration of environmental, economic and social issues, while improving the long-term economic performance of the supply chains (Carter & Rogers, 2008). A sustainable supply chain concept integrates a strategic approach, which aims to improve long-term economic efficiency and customer satisfaction, while taking into account social, environmental and economic aspects. Supply chain management is categorized into three main aspects of sustainable development; environmental and social criteria which must be met by the supply chain (business units), and the competitiveness of the chain, which will help to meet the needs of the customer (Adams, 2006, Beamon, 2008, Carter, Rogers, 2008, Seuring & Müller, 2008). Sustainable Supply Chain Management (SSCM) has been defined as "the strategic, transparent integration and achievement of an organization's social, environmental and economic goals in the systemic coordination of key inter-organizational business processes for improving the long-term economic performance of the individual and its supply chain" (Carter & Rogers, 2008). SSCM is integrating environment thinking into supply chain management, including: product design, material sourcing and selection, material sourcing and selection, manufacturing processes, delivery of the final product to the consumer and end-of-life management of the product (recycling, close loop).

Before sustainable strategies can be implemented in the supply chain, various influencing factors need to be taken into account, including understanding the concept of sustainability, government and social policies and legislation, financial capabilities, organisational culture and degree of resistance to change and the availability of environmentally supportive suppliers and socially friendly systems (Rajesh, 2008). In a later study by Gopalakrishnan et al., (2012) the main imperatives in implementing sustainable supply chains were identified (see Figure 1).

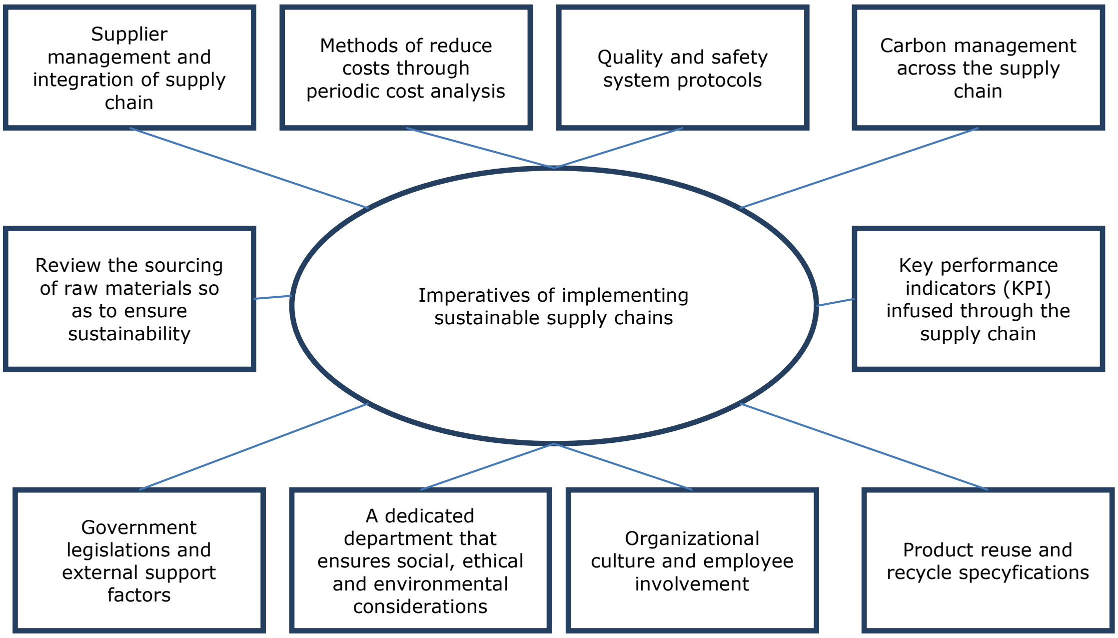

Figure 1. Imperatives of implementing sustainable supply chains (Gopalakrishnan et al., 2012)

The main focus in logistics has traditionally been efficiency and cost reduction. From the point of view of sustainability, the most important factor is the environment, with an emphasis on transportation (Pieters et al., 2009). What is particularly important is the synergy between organisations within the supply chain, that have the same aims and a similar supply chain philosophy. Only this situation can lead to an improved environmental performance, together with minimization of waste and cost savings/reductions.

STATE OF ART SIMULATION GAMES AND GAMEBASED LEARNING FOR SUPPLY CHAIN MANAGEMENT

Owing to highly motivational effects and the active involvement of the participants, the use of experiential learning forms has been increasing within education at all levels (Baalsrud Hauge et al. 2013, Campbell, 1999). The most famous SCM game is still the Beer Game, which simulates the dynamics of a supply chain while explaining the Bullwhip Effect (Lewis & Maylor, 2007). Games focusing on various aspects of SCM including manufacturing can be found in Baalsrud Hauge et al. (2013); Campbell, (1999); Macdonald et al. (2013) and Zhou et al. (2008).

Most of these games are multi-player games, which also aim to convey the relevance of communication and collaboration in a supply chain context through the players' own experience during game play. An investigation of available games used for SCM (Campbell, 1999, Forrester, 1958) shows that various sustainability aspects are covered by several games, and games such as the Fresh Connection, also take business consideration into account at a certain level.

TRANSPORT AND LOGISTICS IN GERMAN AND POLAND

The geographical and geopolitical location of German and Poland and their intersecting transport routes (i.e. routes both terrestrial and marine), mean both of these economies are key players in the logistics services market. For Poland, Germany is the most important trading partner, both in terms of imports (41%) and exports (38.9%). Additional economic data is shown in Table 1.

According to the Polish Central Statistical Office – the value of the Polish Transport and Forwarding Logistics market exceeds 6% of GDP. In Poland in 2012 there were approximately 90,000 transport and logistics companies, of which 25,000 provided services in the international market.

2014	GDP		Economic growth	population	area in km2
	in bn USD	per capita (in USD)			
Germany	3860	47 590	1,6%	80,767,463	357 340
Poland	546,6	14 378	3,3%	38,017,856	312 679

Table 1. Economic and social dates about Germany and Poland (www.ec.europa.eu)

In Germany in 2012 in the transport area there were 88,000 companies with 2 million employees and a 276 billion Euro turnover, with 77% of goods transported by road (www.destatis.de). An important element is the infrastructure, including storage area. Despite the gradual development of the sector many problems remain, which are compounded by rising fuel costs and foreign exchange differences. Other problem areas include payments and settlement of debts. Moreover, legal requirements for emissions, pollution and the need to invest in a modern fleet incur higher costs. The most important factors are the competitiveness of the sector (and individual companies), including competence, quality, timeliness and flexibility.

The amount of freight tonne-km travelling via Polish rail ranks second amongst the 28 EU countries, with participation of over 14% in overall EU transport. In terms of international transport Poland has a share of 25% and it was in first position (ahead of Spain and Germany). The transport infrastructure and modal split of Poland and Germany is shown in Table 2.

		Length of other roads by category of roads (in km)			Modal split of freight transport %		
		motorways	state roads	provincial roads	railways	roads	inland waterways
Germany	2011	12 879	39 604	178 034	23	65,8	11,2
	2012	12 917	39 389	178 071	23,1	64,6	12,3
Poland	2011	1 365	19 182	154 202	20,5	79,4	0,1
	2012	1 482	19 286	153 753	18	81,9	0

Table 2. Transport infrastructure in Poland and Germany (Transport 2014, Statistisches Jahrbuch 2014)

Germany, perhaps unsurprisingly, has the most kilometres of motorways in Europe. Despite a significant increase in the length of motorways in Poland in 2013, it still lags behind most other European Union members. This indicates there is considerable potential for growth, especially given the recent performance of the Polish economy. The supply of modern warehouse space in Poland exceeded 8.8 million sqm. Data such as these clearly indicate the dominant role of road transport in the total transport of goods. Rail freight transport - in the cyclical growth of bulk cargo for the construction and modernization of roads - carries more freight by volume, but there are indications that this figure may reduce over the coming years. This may also reduce transit traffic through Poland. The only exception is the transport of containers to and from ports.

In terms of the supply chain management-related decisions it is important to assess the impact of the transport sector and overall logistics processes on the environment. Relevant data on pollution and greenhouse gases for the Polish and German are presented in Table 3.

		Road transport				
		Sulphur oxides - tonnes	Nitrogen oxides	Ammonia	Non-methane volatile organic compounds	Particulates < 10μm
Germany	2011	795	480271	14390	118363	32820
	2012	787	460012	13287	110145	30970
Poland	2011	1347	282707	783	149194	26675
	2012	1286	271253	749	145708	25464
		Non-road transport				
		Sulphur oxides - tonnes	Nitrogen oxides	Ammonia	Non-methane volatile organic compounds	Particulates < 10μm
Germany	2011	143978	346371	1851	14045	9171
	2012	135639	342122	1919	14152	8882
Poland	2011	470	18172	1	3133	1068
	2012	683	20578	1	3151	1046

Table 3. Pollution and greenhouse gases for the Poland and Germany (*www.eea.europa.eu)*

EXAMPLES OF THE USE OF GAME-BASED COURSES

There are several examples of game based courses described in the literature (Baalsrud Hauge et al. 2013, Lewis & Maylor, 2007, Corriere, 2003). Here we describe two case studies showing two different ways of embedding games in a course. The first uses a simulation game specifically developed for a course, and later used in a different context. The second case study uses an existing game (COTS) and embeds that in a different course.

The University of Bremen, Germany offers several GBL courses, including "Decision making in a distributed production environment", a 3 ECTS Master course, which uses a blended learning concept. The course uses two games, with the one relevant for sustainability being called Seconds. This is a facilitated multi-player online game. The game creates a safe learning environment in which the students can apply different approaches for improving the flexibility and efficiency of manufacturing and subsequently analyse the impact on the SC. It is configurable and the appropriate level depends on the knowledge level of the player (pre-configured). The goal is adaptable (depending upon course setting), but is mostly used for collaborative production in a distributed environment. A simplified accounting system is implemented, i.e. the game delivers several performance indicators that are used for the analysis and calculation. The students receive a role and a starting scenario including the necessary business information, so that they are able to develop a strategy for their company.

The gaming scenario evolves as the players play the game. It is important to note that the executive level is separated from the game engine. Depending on production volume and time, the player can gain the experience and skills needed for producing higher quality. In Bremen, this game is used in a blended learning setting, where methods for strategic decision making are successively introduced. Each session lasts 5 hours. On average, the play time is 3-3.5 hours for each session, with at least 30-45 minutes needed for debriefing and reflection. The game was specifically designed for this GBL course. It has also been tested in a wider setting, as for two years, Seconds was also used at the University of Nottingham, UK as a supplement to a Supply Chain Management course. Here sessions were as follows: 2x2.5 hours. Consequently, aspects such as play time, learning goals, etc. change as the user group changes, and thus some adaptions of the game play and its integration in the learning environment have been carried out; so far with positive feedback from the students. However, as with the original course, after the first year there were many lessons learnt, with improvements being subsequently made, leading to a much better user perception in year 2. This indicates that the underlying simulation model and the possibility to adapt scenarios are given to some extent.

The second game we looked at for its appropriateness is called SHORTFALL. SHORTFALL (Corriere, 2003) is a strategy game with implicit role-play mechanics. SHORTFALL is used at the University of Bremen and at Heriot-Watt University. The game is played in teams of three players per computer. Each player manages their individual entity (company) and together they constitute a whole supply chain. Each 'company' makes their decisions based on a set of KPIs: profit, green compliance, number of products sold, etc. and about the external conditions (prices of material, parts and products). Although not explicit, a turn-base mechanic regulates each player role to set some numerical values. The game is a repetitive loop of 10 rounds, interspersed with real-world unplanned events (such as strikes). Events may occur which may go on to influence the next period. At the University of Bremen SHORTFALL has been integrated into an existing course on re-engineering of supply chains for over three years. Each cohort plays the game twice. In the first lesson it is used as a refresher of existing knowledge and at the end of the course (and at the debriefing session) to focus on sustainability issues. In between, the students play several other games dealing with re-organisation, process design and process quality in complex production networks. The first years' results showed that the learning effect was lower than expected and that the students got rather stressed while playing it. As a result we changed the playing mode and added a longer introduction. This sequence of events indicates the typical process of integration of COTS games and goes part of the way to explain why it so time consuming and expensive to integrate games in existing courses.

ADAPTION TO POLISH EDUCATIONAL SYSTEM

Compared with Germany, UK and Denmark, the deployment rate of experiential learning methods within Higher education in Poland is low. This requires the adaption of a serious game embedded in a course, so that both the low experience levels of the teachers (in using this form of teaching), as well as that of the students is specifically addressed. In most cases when we look at the deployment of serious games for SCM, most of the games are 'facilitated' (i.e. led), which requires a lot of knowledge on how the teacher must facilitate the learning (de Freitas et al. 2012). As argued by Iverson (Michael & Chen, 2006), serious games offer a paradigm shift in training as they change the role of the trainee from passive to active and the role of the trainer changes from just delivering material to being an active facilitator. The role of the teacher becomes central as the facilitator of balancing the educational game experiences to other practices. For the teacher to become a facilitator means, in design terms that he or she must be involved in the game experience itself, either participating in the game or as a close observer. Furthermore, the second question is related to the adaption of a specific existing game and its integration in an existing course. Here it is a matter of what is possible with a game, which depending on the flexibility of the game, access to source code or authoring tool as well as the flexibility of the curriculum (Baalsrud Hauge et al., 2013).

EMBEDDING AN EXISTING SERIOUS GAME IN AN EXISTING COURSE

The course where we are planning to implement a serious game is on supply chain management given at the University of Szczecin, Poland. The main objective of the course is to learn about how a supply chain function (dependencies, strategies, functions, roles of leadership, how the decision making process affects the SC). Furthermore, it is focusing on the environmental aspects of the decision making in SC and the intention is that the students should be able to identify areas and processes that affect the environment, as well as assessing the economic, environmental, social impact (e.g. change of use of modal split to other transportation systems, cross docking, the use of space allowance, shortening of the supply chain, elimination of waste/MUDA). So far in the planning stages it has been anticipated that the game play will take approximately 15 hours and that the existing course will be extended. The course is taught to mostly Polish students, and it is important that what they learn reflects the specific Polish situation, as well as a more global context, in order to ensure that the students are prepared both for a working career in Poland as well as abroad. Based on the main learning goal of the course and the limitation defined above, a game has to fulfil the following requirements:

1. Reflect the real environment of the supply chain i.e. also be able to mirror different types of supply chains (the German and Polish cases)
2. Measure Performance Indicators both to allow the students to make decisions based on these but also to give feedback to the teacher and the facilitators
3. The game needs to be adaptable to the knowledge of the players
4. The game will evolve depending on the decisions made.

In a next step the learning goal for the game play itself has to be formulated, before a match with existing games or a requirements specification can be made. In our case with our Polish course the goal of the game play will be to successfully manage the supply chain by taking the boundary conditions, as well as make different decisions based on how the weight the social, environmental and economic factors (e.g. customer expectations, costs of action, efficiency, etc.). In order to do so the underlying simulation model has to be able to visualize multi-modal transport and relate them to the different indicators and report them back in real time to the player. Furthermore, the students should be able to apply best practice strategies and the basics strategies in supply chain like FIFO and LIFO, push and pull in order to deepen their understanding of such concepts.

Here we have briefly described two GBL courses, one with a game developed specifically for a course (SECONDS) and secondly a COTS game (SHORTFALL). Both are computerized games. Shortfall can easily be embedded in order to cover the sustainable aspects, since the underlying models contains sufficient indicators allowing that the facilitator ask the student to focus on this. However, the simulation model is not changeable, and cannot cover multimodal transport, since the transport is not modelled at all. SECONDS, on the other hand, allows more freedom in the configuration of the scenario. At first sight it seems usable, since there are possibilities to set up production processes with different efficiencies, and also using the authoring tool. However, the strongest limitation of SECONDS is the lack of proper model transport solutions and a realistic connection to transport modes, social, environmental and economic factors. SECONDS is not able to do that in its current version. It would require a modification of the simulation model, which is 'doable' but not in real time during a course by a teacher. Instead this requires a multi-disciplinary team consisting of programmers, teachers/users and field experts. Depending on the scenario, the granularity of the simulation level will have to change. This illustrates very briefly why there are so many serious games for SCM, but most of them only used in one specific course and why it is so difficult to adapt existing games.

CONCLUSIONS AND NEXT STEPS

This paper discussed some of the differences that exist between German and Polish sustainable supply chains, prior to looking into how this can be built into educational courses. We then focused specifically on GBL and how such approaches can be transferred. The final part showed the process of how to actually 'embed' the games. In our case it can be concluded that SECONDS and the corresponding curriculum is a good starting point for transferring to the Szczecin course in Poland, but that the underlying simulation model does not adequately mirror the transport modes. In terms of future research, there are many directions that this research could take. To strengthen and further validate the results, additional testing in a wider range of educational settings is needed. Attention also needs to be paid to how to accurately measure the environmental impact. Of no less importance is investigating the interdependencies for the various multi-criteria decision making processes in these highly dynamic systems.

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THE IMPACT OF LEAN INITIATIVES ON EMPLOYEE'S SATISFACTION: THE CASE STUDY OF A PILOT PROJECT IN A SERVICE COMPANY

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ABSTRACT
When lean is applied in services benefits rapidly emerge if employees are committed. Organizations examine conditions that foster greater employee satisfaction, because satisfied employees make positive contributions to organizational effectiveness and performance. This paper aims at analysing if lean initiatives from a pilot project in a bank had any impact on employees' satisfaction at work and which adjustments are required to expand the pilot. Findings show that although employees state that they have Lean Understanding and a positive perception of new Job Characteristics, they tend to go back to old practices. This shows lack of both employee engagement and reinforcement from the leading Training Team. Lack of reinforcement led to a poor employees' perception of Lean Success. Although Lean initiatives have had a positive impact on employees' satisfaction at work, they perceive higher level of Autonomy, Leadership and Work Facilitation when Management Commitment is high and Lean Tools are used more.

INTRODUCTION
Companies face increasing levels of competition and at the same time have to cope with internal changes. These challenges have accelerated cost-cutting and capacity constraints in corporate operations (Allway and Corbett, 2002). The use of a lean approach in the service areas leads to rapid benefits and a sense of continuous improvement is achieved (Allway and Corbett, 2002). The Toyota Production System (TPS) claims that process optimization and continuous improvement require employees fully committed to their work (Treville and Antonakis, 2005).
Major interest has been given by organizations to examine conditions or factors that foster greater employee satisfaction as satisfied employees make positive contributions to organizational effectiveness and performance (Meena and Dangayach, 2012). Nonetheless, the lean philosophy may also lead to more pressure on the employees. In fact, Niepce and Molleman (1998) posit that lean concepts such as short lead times and standardization increase stress in employees and reduce their autonomy and consequently their satisfaction.
Implementing lean management in the service industry is a long and intensive changing process that participants must continuously manage (Karlsson and Ahlstrom, 1996). However, what employees actually perceive, think and feel about lean implementation has received little attention, which constitutes a gap in literature (Treville and Antonakis, 2005).
de Haan et al. *(*2012) defended that the effects of lean implementation depend on how leaders and managers influence their employees. According to Carroll (2001), in order for continuous improvement to be possible and effective, it is necessary to provide employees with autonomy and responsibility over their work.
Not only lean thinking aims to increase process efficiency and strive for continuous improvement among teams there has also been an increased interest in employee's satisfaction at work (Meena and Dangayach, 2012; Sageer et al., 2012).
Millennium bcp is a private Portuguese bank facing the need for deep restructuring due to its financial situation. To overcome its constraints the bank created Lean Academy with the purpose to disseminate and implement Lean methodology and techniques. A pilot project was implemented in four departments in order to slim processes and practices, but the bank is concern with its impact on employees' satisfaction. The purpose of this paper is to analyse the impact the pilot project had on employees' satisfaction at work and suggest adjustments before its expansion.

In order to achieve its goal this article grounds its literature review on lean in the services area and on the evaluation of job characteristics. Methodology follows a quantitative approach by using a survey to assess employees' satisfaction. Hypotheses emerge from literature review. These are tested and recommendations are provided to adjust the project before it is spread to other Divisions of the bank.

JOB SATISFACTION IN LEAN ENVIRONMENTS AND HYPOTHESES

Womack and Jones (2003) shaped lean thinking focused on customer value and waste elimination by removing steps in the process that do not add value, saving time and money while also delivering higher quality products and services.

Recent authors refer to lean thinking as a philosophy of continuous improvement, which incorporates cultural and behavioural transformation (Hines et al., 2008; Mann, 2009; McCuiston, 2010). According to Mann (2009), 80 per cent of a lean transformation is achieved with change of procedures and leaders' mind-sets. The remaining 20 per cent regards implementing lean tools and techniques.

A main barrier to lean transformation is the unawareness and misunderstanding of lean philosophy, focusing only on the tools, as well as poor communication and lack of leader's involvement (Hines et al., 2008). Lean implementation requires inspiring Leadership to be successful (Piercy and Rich, 2009; McCuiston, 2010; Mann, 2009).

According to Hines et al. (2008), there may be many reasons for Lean programmes not to sustain, but nearly all have something to do with people, their Leadership and engagement. Scherrer-Rathje et al. (2009) argue that failure in lean implementation is a consequence of lack of management commitment, poor lean understanding by the employees and the lean tools used.

For lean implementation to be successful it is essential to have people fully engaged in change. People perform better when they know why change is necessary (Scherrer-Rathje et al., 2009), therefore communication from management is essential to gain employee's motivation for change. These need to be made aware of the reason for introducing the lean approach in their organization, the expected outcomes and their role in the new organization (Hines et al., 2008).

Hines et al. (2008) add that effective strategy, alignment and leadership are the first steps to reach employee engagement. Building the right cultural environment for sustainable change and overcoming employee resistance is crucial to embarking on an organizational change programme such as a Lean transformation. Accordingly, employee satisfaction facilitates lean success implementation, and it is strongly influenced by management commitment and management decisions about the implementation process. Nonetheless, there is not yet a consensus about lean implementation impacts on job satisfaction (Delbridge et al., 2000).

Taking this context into consideration the following hypothesis is formulated:

H1: The Division, the Department and the Lean Implementation Date influence employee's perception of Lean Success.

According to the TPS, process optimization and continuous improvement require employees fully committed to their work, which are given responsibility for the tasks (Ohno, 1988). In order to have employees fully committed to their work, they need to be involved in process optimization procedures because they are the ones who really know how the process operates (Treville and Antonakis, 2005).

Lean initiatives, using appropriate skills and tools, seek for employees to contribute with ideas, make decisions, look for improvements and have responsibility for their work (Barber, 2011), which are factors that contribute to empower them.

According to Niepce and Molleman (1998), lean concepts such as continuous flow and work-in-process with tight times and specific tasks, increase stress and reduce employee autonomy impacting their satisfaction. Lean tools disempower and control employees by increasing managerial surveillance (Barber, 2011).

Jackson and Mullarkey (2000) posit that the balance between positive and negative effects of lean implementation depends on how leaders and managers influence their employees. Treville and Antonakis (2005) claim that lean will reduce

autonomy, but Haan et al. (2012) posit that being able to make suggestions in lean environment leads to employee satisfaction. Ohno (1988) highlighted the relevance of leadership and empowerment through education and training. The sense of ownership increases employee's willingness to excel (Womack et al., 1990).
According to Treville and Antonakis (2005), the Job Characteristics Model (JCM), developed by Hachman and Oldham in 1976, imply that a job designed according to lean principles cannot bring satisfaction since it reduces autonomy due to the fact that lean philosophy is based on standardized processes and individuals have almost no freedom in how the work is scheduled or the procedures to be used. Considering these issues, Treville and Antonakis (2005) extended the JCM to the lean philosophy context, proposing that a lean production system have an effect on individuals' motivation and incorporated the degree of leanness as a moderating variable in employee's satisfaction. Taking into consideration the previous arguments, the following hypotheses are formulated:
H2: The Division, the Department and the Lean Implementation Date influence employee's satisfaction with Job Characteristics.
H3: Lean Success is positively and significantly correlated to the Job Characteristics.

THE COMPANY
Millennium bcp is the largest Portuguese private bank with nearly 8000 employees. It started to implement process based management in 2005. In 2009 a Unit for Operative Transformation (UOT) was created under the Operations Division. UOT started its activity by developing a top-down reengineering and process optimization approach in some Divisions. This experience let UOT wondering about a how to achieve quick benefits and assure continuous improvement: they needed a complementary bottom-up approach. In 2013 Lean Academy emerged to spread this philosophy in the company. The team started with two persons and grew to five (one coordinator and four implementers of Lean initiatives). Each implementation is promoted by two elements from Lean Academy and consists of a 14 day plan in a specific Department, providing mechanisms aiming for continuous improvement and the involvement of all employees in that Department. The implementation has four phases as shown in Figure 1.

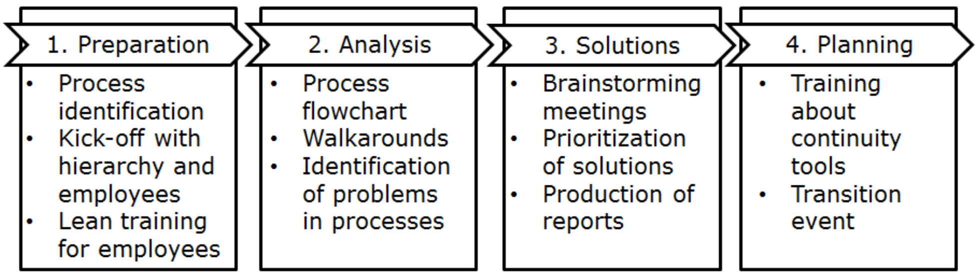

Figure 1 – Phases of the Lean initiative implementation
Source: Lean academy - Millennium bcp (2014)

Continuity training in the last implementation phase is focussed on enhancing daily briefings, use of whiteboard for visual management, 5S system, and motivate the Department to flowchart the remaining processes for optimization.

DATA COLLECTION

Research instrument
Data was collected using a questionnaire based on Scherrer-Rathje et al. (2009) perspective of lean success and Treville and Antonakis (2005) dimensions to assess Job characteristics. This questionnaire has four groups of questions. The first group comprises demographics: the Division and the Department where the employee

works and when implementation occurred. The second part of the questionnaire lists the items reported in literature to assess Management Commitment (MC), Lean Understanding (LU) and Lean Tool Use (LTU) as dimensions of Lean Success. The third part comprises the dimensions of Job Characteristics: Skill Variety (SV), Task Identity (TI), Responsible Autonomy (RA), Leadership (L), and Work Facilitation (WF) and corresponding items. The dimension Choice Autonomy was not considered in the analysis as the bank allows no freedom in terms of procedures and timing. The fourth part aims at assessing employee's satisfaction with both the training received and the impact of the lean initiative in his work.
Likert scales were used in the questionnaire. In the second and third parts scale ranged from 1 – "Totally disagree" to 5 – "Totally agree". In the last part scale varied from 1 – "Totally dissatisfied" to 5 – "Totally satisfied".

Sample

The target population of this research included all the employees (111) from in the four Departments where the pilot was implemented (two in each Division). These were individually contacted using an email sent through their directors with a link to the questionnaire. The survey was available during a period of 3 weeks starting on the first of September 2014 and 79 answers were received, yielding to a response rate of 71%. The number of employees per department was used to compare the fit of the sample. Findings allowed concluding that the distribution of the elements in the sample is similar to the population.
A pre-test was conducted to assure proper wording and item interpretation.

RESULTS

Demographics

Variable Division comprises two categories, the Operations Division (OD) and the Human Resources Division (HRD). In variable Department four categories were considered: "COD" – Credit Operations Department; "PCD" – Planning and Control Department; "EAD" – Employee Administrative Department; "LR" – Labour Relations. 58,2% of the elements in the sample are from the OD-COD, 21,5% from OD-PCD, 13,9% from HRD-EAD, and 6,4% from HRD-LR.
Although four departments were involved in the pilot study, the initiative was not implemented in the entire department at the same time. Consequently not all employees in the same department received training and started using tools at the same time. Taking this into account Date of Implementation was categorized in "Not Recent" (more than 8 months ago); "Somewhat Recent" (between 4 and 8 months); and "Recent" (less than 4 months). 20,2% of respondents received their training more than 8 months ago, 67,1% between 4 and 8 months ago and 12,7% less than 4 months ago.

Instrument reliability

Results allow stating that the instrument is sufficiently reliable for the Job Characteristics as all of them registered alphas higher than 0,7 (Skill variety: α=0,748; Task identify: α=0,783; Responsible autonomy: α=0,712; Leadership: α=0,743; Work facilitation: α=0,801), but lacks reliability in two of the dimensions of Lean Success: Management Commitment with α=0,371 and Lean Tools use with α=0,504. As a consequence the results from these last two dimensions are of limited consequence.

Descriptive

As distributions lacked normality analysis per dimension in each construct was based on the median and the interquartile range. Results are shown in Table 1. Findings show that the highest level of agreement in terms of Lean implementation success is in LU, which shows that employee's recognize effectiveness in the training received. Nonetheless, LTU does not show such high agreement, which translates that although the quality of the training in terms of the overall concepts was recognized the implementation of the tools was not as successful.

Construct	***Dimension***	***Median***	***IQ range***
Lean Success	Management commitment (MC)	3,67	1,00
	Lean understanding (LU)	4,33	0,67
	Lean tools use (LTU)	3,20	0,80
Job characteristics	Skill variety (SV)	3,50	0,75
	Task identity (TI)	4,00	0,50
	Responsible autonomy (RA)	3,75	0,50
	Leadership (L)	3,75	0,75
	Work facilitation (WF)	3,75	0,75

Table 1: Median and Interquartile range per dimension

Table 2 shows the results from the last part of the questionnaire in which employees were asked about their satisfaction level with both the training received and the use of the tools. Findings show consistency with the results from the dimensions of Lean success, i.e., although training was well received, the implementation of the tools cared for more attention from the Lean team.

	Item	***Median***	***Interquartile range***
Lean satisfaction	Satisfaction with lean training	4,00	0,00
	Satisfaction with lean tools' use	3,00	1,00

Table 2 – Median and Interquartile range for the Lean satisfaction items

In terms of the Job Characteristics, employees show a stronger agreement in terms of identifying themselves with the tasks performed, only showing a slight lower agreement in terms of having variety of skills. Nonetheless, all dimensions of this construct show a strong agreement with their job characteristics, which demonstrates that the implementation of lean tools did not reduce job richness.

Hypotheses testing

The Kolmogorov-Smirnov test showed that the independent variables do not follow a normal distribution in any of the items considered. As a consequence non-parametric tests were used to test H1 and H2.

Mann-Whitney test showed a significant differences (p=0,015) in the agreement with the Management Commitment, with the Operations Division showing a significantly higher agreement in that Commitment. The Divisions also showed significant difference (p=0,033) between them in the use of Lean Tools, with the Operations Division showing significant higher agreement in the use of the tools than the Human Resources Division.

In terms of the Departments, significant differences were found (p=0,002) in terms of Lean Tools use. Bonferroni post-hoc test showed that this difference emerge between the Employee Administrative Department (from the HR Division) and the Credit Operations Department (COD) (from the Operations Division), with the COD showing a much stronger agreement in terms of the use of Lean tools.

For the Implementation Date, significant differences were found for Management Commitment (p=0,002) and for Lean Tools use (p=0,000). Bonferroni tests showed significant differences between "Not Recent" and "Recent", which translates a tendency from Management to reduce their commitment in the initiative after its implementation. In parallel Bonferroni tests also showed that for Lean Tools Use there are significant differences between all Implementation date categories, with "Recent" scoring the highest and "Not Recent" scoring the lowest, showing that

throughout time the tendency of the employees is to abandon the tools introduced during implementation.
Findings lead to not reject H1, i.e., that the Division and Department the employee comes from and Implementation Date influence the Success of the Lean initiative.

In terms of Job Characteristics dimensions, findings showed significant differences between Divisions in terms of Responsible Autonomy (p=0,005), Leadership (p=0,001) and Work Facilitation (p=0,001). For the first two dimensions the Operations Division shows higher scores, i.e., stronger agreement from employees that the lean initiative contributed positively to their Job Characteristics. For the Work Facilitation dimension the Human Resources Division was the one showing a stronger agreement in terms of the positive contribution of the lean initiative to Job Characteristics.
The different Departments showed significant differences in terms of Job Characteristics dimensions in Responsible Autonomy (p=0,000), Leadership (p=0,000) and Work Facilitation (p=0,000). Bonferroni tests showed the Credit Operations Department with significantly stronger perceived contribution of the lean initiative to both Responsible Autonomy and Leadership. The same test showed the Planning and Control Department (PCD) with significantly lower perceived contribution to the Work Facilitation. This last result may emerge from the fact that the PCD department, due to its nature, was already more efficient, therefore not experiencing so much added value from the implementation of the lean initiative.
The Implementation Date highlighted significant differences also in the Responsible Autonomy (p=0,016), Leadership (p=0,003) and Work Facilitation (p=0,000) between time categories. Bonferroni tests showed no significant differences between time categories for the Responsible Autonomy dimension, but showed that for Leadership the recognition of its involvement and improvement vanishes as time passes. In terms of Work Facilitation findings showed that after implementation the perceived contribution of the lean initiative to facilitate employees work is stronger and declines afterwards, but only to increase again after some time. This might show that although the tools are abandoned for some time, employees latter recognise their utility and contribution to their work.
Findings allow to not reject H2, i.e., that the Division and the Department where the employee comes from and Implementation date influence the employees satisfaction with the new Job Characteristics.

In order to assess H3, and due to the fact that ordinal scales were used for the variables, Sperman's correlation was used. Findings showed that Management Commitment is significantly correlated to all Job Characteristics dimensions by Skill Variety; the use of Lean Tools is significantly correlated to Responsible Autonomy (r=0,338), Leadership (r=0,335) and Work Facilitation (r=348); and Lean Understanding is significantly correlated to Task Identity (r=0,312), Leadership (r=0,234) and Work Facilitation (r=0,280). This suggests that respondents' sense of Autonomy, Leadership and Work Facilitation are somewhat positively influenced by the level of Management Commitment and of Lean tools' application, and that their sense of Task Identity, Leadership and Work Facilitation are somewhat influenced by the level of Lean Understanding. This leads us to not reject H3.

DISCUSSION
The results show that there is an overall agreement that the lean initiative contributed to the enrichment of the Job characteristics.
Work enrichment is positive in all Departments, but findings showed that some departments experienced stronger positive impacts than others. It should also be considered in the analysis that the initial situation of the several departments in the pilot was not the same. The Planning and Control Department is the one that, by its nature, was already more streamed and standardize, which can explain the lower

positive impact of the lean initiative. Although the use of lean tools tends to fade away as time passed, employees also tend to return to the use of those tools later in time to facilitate their work, which can be explained by a self-recognition of the efficiency and effectiveness of such tools.

Although the Success of the Lean initiative can be classified as high (choice autonomy is not allowed and all the other Job Characteristics showed a high degree of leanness), as it shows a performance of "just right" in terms of the degree of leanness, according to Treville and Antonakis (2005), and consistent, especially in terms of employees understanding of the initiative, findings showed that it is not consistent in terms of Management Commitment between Divisions and through time. In fact it is possible to conclude that although an initial enthusiasm exists both in terms of Management Commitment and the Use of Lean Tools it tends to fade away as time passes.

Although Lean initiatives have a positive impact on employee's satisfaction at work, they perceive higher level of Autonomy, Leadership and Work Facilitation when Management Commitment is higher and they use lean tools more.

It is possible to state that during the pilot implementation Millennium bcp faced the lean initiative more as the implementation of a set of tools than the consistent shift in mind sets. Lack of continuous monitoring, reinforcement and consistent management commitment also contributed to the decline of the success of the initiative in terms of both turning processes leaner and enriching employees' jobs.

As a consequence, the following management recommendations are provided to adjust the current pilot before it is expanded to the remaining Divisions of Millennium bcp: 1) The Operations Division should be used as a benchmark as it is the one that shows better results in terms of both Lean success and Job Characteristics enrichment; 2) managers in the several Divisions and Departments should continuously show their commitment in the initiative and reinforce the use of the lean tools; 3) the team in charge of the pilot study should monitor the use of the tools and techniques and provide continuous training and reinforcement.

CONCLUSIONS

This research aimed at analysing if lean initiatives from the pilot lean project undertaken by Millennium bcp, a Portuguese private bank, had any impact on employees' satisfaction at work and which adjustments are required to expand the pilot project to other bank Divisions.

Findings lead to not reject any of the hypotheses, i.e. the Division, the Department and the Lean Implementation Date do not influence employees' perception of Lean Success neither their satisfaction with Job Characteristics, and the success of the lean initiative contributes positively to employee engagement with his job. These findings are in line with Piercy and Rich (2009), Hines et al. (2008) and McCuiston (2010) in terms of the need for leadership involvement for the success of lean implementation and that it cannot be limited to implementation of tools. Findings also corroborate Scherrer-Rathje et al. (2009) in terms of the enrichment of the work when employees are informed of the reasons for change. Findings contradict Niepce and Molleman (1998) argument that lean concepts reduces employee autonomy, increases their stress and leads to lower satisfaction. In fact, the current study shows that the implementation of a lean initiative and the introduction of lean tools in current activities, when accompanied by proper training, lead to the recognition of better job characteristics and, taking into consideration Niepce and Molleman (1998)'s arguments, increased employee satisfaction.

These findings emerge from four different company departments, all of them from the same case study. As a consequence findings cannot be generalized (Yin, 2009). Nonetheless, results are in line with findings from previous research.

This research was focussed only on the results of the lean initiative and did not consider the initial situation of management commitment and job characteristics. It would be of interest to measure the level of performance in these departments both before and after implementation to assess ranges of improvement instead focussing only on perceived improvement. It would also be interesting to analyse if after the implementation of the managerial recommendations provided the Success of the initiative was more sustained through time and the Job Characteristics we consistently enriched. Pursuing similar implementations in other service companies and contribute to the ability to generalize these findings can also be a future research path.

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