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INTRODUCTION

Once again we are delighted to welcome our friends and colleagues, both old and new, to the 21st International Symposium on Logistics in Kaohsiung, Taiwan. Kaohsiung is a dynamic city with diverse industries (especially in sectors like metal fabrication, electronics, fishing, ship-building and container seaport) and an abundance of natural scenery, beaches and diversified cultures. Considering the location and the global challenges and current trends, we have chosen the theme of "Sustainable Transport and Supply Chain Innovation" for this year's event. We hope this gives participants the opportunity to share and exchange their ideas and views on their current and proposed research work. It also presents an opportunity to engage in various discussions and debates during the course of the event and see how various models, concepts and findings are pushing the frontiers of knowledge in the area of logistics and supply chain. Equally, it is important to explore how the cumulative know-how in our discipline can be successfully applied to develop the next generation of experts through teaching and curriculum development as well as helping the practitioner community to enhance the competitiveness of industry.

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 setting 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
- Maritime and Port Logistics
- Transport and Distribution
- Sustainability and Green Logistics
- Knowledge Management and E-Business in Supply Chains
- Value Creation and Customer Service
- Smart Logistics
- Logistics Modelling and Simulation
- 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 historic city of Bologna in Italy, which is also the home to the oldest university in the world, we are very much looking forward to meeting you all at this year's symposium in Kaohsiung, Taiwan.

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, organising team, invited guest speakers, sponsors, partner journals and local organising team for their excellent organisation and contributions. Finally, our special thanks go to Ms Maeve Rohde for her administrative support and Mengfeng Gong for her support and help in preparing the proceedings.

Professor Kulwant S Pawar and Professor Kune Muh Tsai – July 2016

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Section 1: Risk, disruption and complexity management

ASSESSMENT OF POLITICAL DISRUPTIONS ON 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.
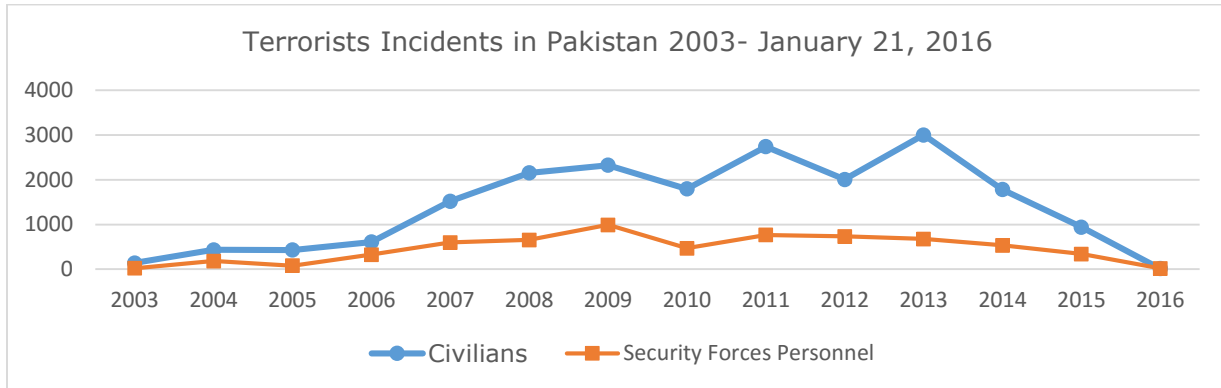
Figure 2: Terrorism Incidents in Pakistan 2003- January 21, 2016 (Satp.org 2015)

Political violence also one of the major reason causing political disruptions in Pakistan. According to World Bank data 2015 (see figure 3). Pakistan rank 7 most political violent country in the world (Bender 2014). Currently, Pakistan's textile supply chain is more vulnerable to disruptions due to its complicity and unexpected consequences. Pakistan supply chain ranked bottom 3 which are more resilient to supply chain disruptions (Scott 2015). Natural and manmade disasters are common in all kind of supply chains and effecting on the normal flow of products and information. Disruptions in supply chain can be occurred in any node (supplier or manufacturer) or linked (transportation of raw material between supplier and manufacturer). The disruption source can be located inside or outside the supply chain network e.g. any disruption in flow of raw material because of natural disasters (Behdani 2013).
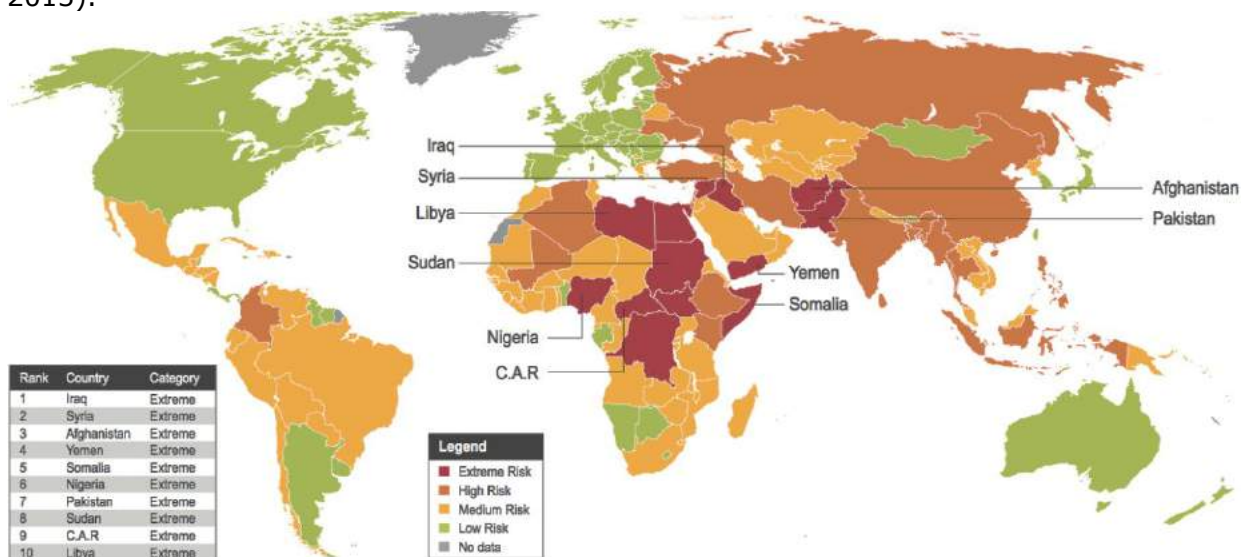
Figure 3: Political Violence Index 2015 (Bender 2014)

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. Although, Pakistani textile manufacturers are using latest computerized machines but still there is no production and planning system available in most of the textile mills. The majority of the industrial planning done by illiterate and less educated persons holding position of a manager, mainly due to presumed cost saving by executives. Even in the available educational institutions related to industry and textile, less importance is given to textile planning and execution issue on practical grounds. 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 (see figure 4).
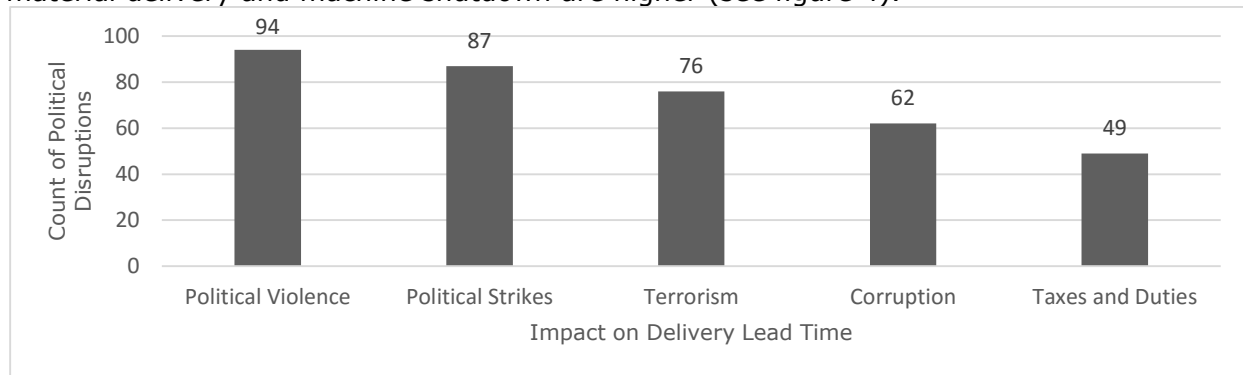
Figure 4: Political Disruption Impact on Delivery Lead Time

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 5) 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.
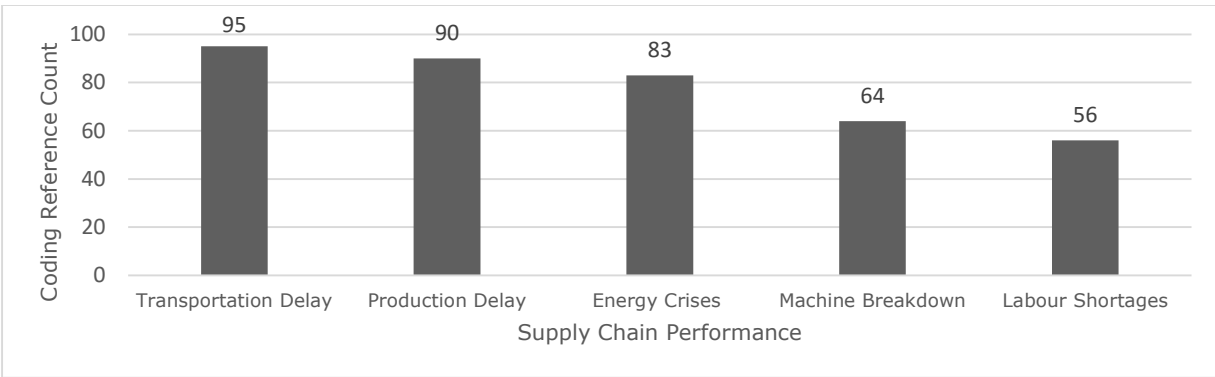
Figure 5: Disruptions impact on Supply Chain Performance

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

Political stability is important for nation building process and survival for any nation. Political stability and its consequences impact anywhere in modern society. Pakistan need political stability to handle internal and external challenges for its identity, society and state. Pakistan facing serious problems with its political system which is not stable at the moment. Current political unstable conditions are not suitable for textile manufacturers. Results (see figure 6) 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.
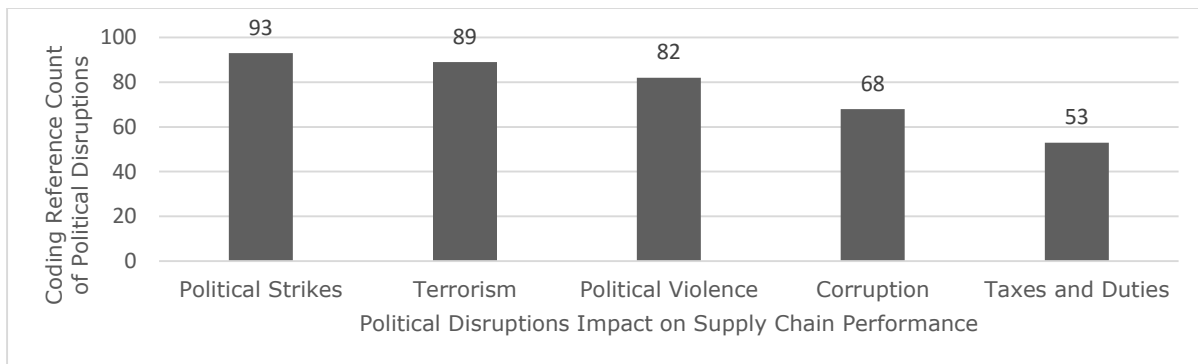
Figure 6: Political Disruption Impact on Supply Chain Performance

4.5 CROSS-THEME ANALYSIS – VICIOUS CYCLE

The following vicious cycle (see figure 7) 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;
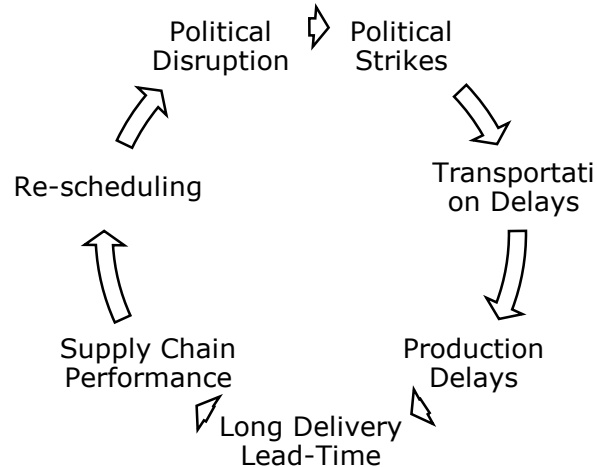
Figure 7: Vicious Cycle of Political Disruptions Impact on Supply Chain Performance

"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.

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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SUPPLY RISK MITIGATION OF SMALL AND MEDIUM ENTERPRISES: A SOCIAL CAPITAL APPROACH

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ABSTRACT

Supply risk is an inevitable part of the supply chain of most businesses. This paper provides a conceptual framework along with a set of research propositions that depict how small and medium enterprises (SMEs) can mitigate supply risk by leveraging social capital gained via networking with their suppliers and peers. Through an extensive literature review, this paper reveals the types of network and dimension of social capital that can be used to mitigate the supply risk of SMEs. The conceptual framework and the research propositions put forward in this study are underpinned by social capital theory. The findings suggest that dimensions of social capital in both the buyer–supplier network and the network of peers can play an influential role in mitigating the supply risk of SMEs, thereby assist SME practitioners in improving operational performance of their firms. This study supplements the inadequacy in research on using the social capital approach in mitigating supply risk of SMEs.

Keywords: Social capital, Supply risk mitigation, Small and medium enterprises
Category of the paper: Conceptual Paper

INTRODUCTION

Supply risk, which arises from deviation in the inbound supply, has become a key concern for all the businesses (Blome & Schoenherr 2011). A study by Snell (2010) revealed that 90% of firms are threatened by supply risk, whereas 60% of firms do not have adequate knowledge about supply risk. Supply Risk has a significant impact on the performance of organisations. For instance, Hendricks and Singhal (2005) found that supply side glitches reduce the operating income of firms by 31.28%. In general, the impact of supply risk on performance is more severe for SMEs – firms having maximum 250 employees and less than 50 million Euros in yearly turnover (EU 2003) – than large corporations (Hendricks & Singhal 2003, 2005; Ellegaard 2008). There are many reasons behind this which include limited resources and capital (Thakkar et al. 2008), inadequate negotiating power (Thun et al. 2011), lack of technology (Hendricks & Singhal 2003) and imperfect strategy (Arend & Wisner 2005).

Although, there is much research on the different types of risks, attention to risk or risk management of SMEs is relatively limited (Kim & Vonortas 2014). However, SMEs are the most common business entities found across the globe and the main contributor of the majority of the economies worldwide (Rahman et al. 2015). Furthermore, the majority of the existing studies on supply risk mitigation primarily recommend holding buffer stock, developing supplier, and ensuring formal process, each of which requires either significant resources or strong position power to influence suppliers. Usually, these measures are beyond the capabilities of SMEs (Prasad et al. 2012). As an alternative avenue, leveraging social capital to mitigate supply risk of SMEs have been suggested (Cheng et al. 2012; Falkner & Hiebl 2015). The argument is that social capital, exists within the network of a firm, improves the firms' ability to mitigate supply risks (Johnson et al. 2013). Unlike other capitals, however, it requires less investment (Uphoff 2000)

which overcomes the obstacle of resource deficiency of SMEs. However, two critical questions still remain unclear: (1) how can social capital mitigate supply risk and, (2) what type of social network can help mitigate supply risk of SMEs? This paper addresses these issues through an extensive literature review by applying social capital theory – a long-established concept in management and sociology literature – as a strategic lens.

This paper proposes that social capital in both the buyer–supplier network and the network of peers within geographical cluster can play an influential role in mitigating the supply risk of SMEs. It is contended that both types of social capital could significantly help SMEs to mitigate supply risk in the long run because social capital is long lasting in nature (Adler & Kwon 2002). Following a review of the literature on social capital theory and supply risk, the paper puts forwards a set of research proposition that depict how SMEs can mitigate supply risk by leveraging social capital gained via networking with their suppliers and peers. Finally, implications of the findings and the direction for future research are also discussed.

THEORETICAL BACKGROUND

Social Capital

Social capital has been argued as a valuable resource that is available through social network (Granovetter 1992). There are a number of definitions of social capital with broad similarities as well as differences (Inkpen & Tsang 2005). These definitions can be grouped in three classes based on their focus: external ties or bridging social capital, internal tie or bonding social capital, and mixed (Adler & Kwon 2002). The first view of social capital – bridging social capital – focuses on external linkage and argues that important resources can be acquired through the tie with other people or organisations in the network (Burt 2000). The second view of social capital – bonding social capital – focuses on the internal characteristics such as collective cohesiveness or relationship that facilitate the collective goals of the network (Coleman 1988).

The third view of social capital is neutral on the bonding/bridging focus. Nahapiet and Ghoshal (1998, p. 243) defined "social capital [a]s the sum of the actual and potential resources embedded within, available through, and derived from the network of relationships possessed by an individual or social unit." This research adopts the definition of social capital given by Nahapiet and Ghoshal (1998) because it focuses on both bridging and bonding, and it accommodates both the individual and organisation resources (Inkpen & Tsang 2005). From the perspective of small business, combining both individual and organisational social capital is necessary. Furthermore, bonding and bridging view is not mutually exclusive because firms are influenced by both internal and external ties (Adler & Kwon 2002). Several of previous researches on social capital in the supply chain context, adopted the mixed view (Johnson et al. 2013), which comprises three dimensions: structural, relational and cognitive social capital (Nahapiet & Ghoshal 1998; Tsai & Ghoshal 1998; Min et al. 2008).

Structural social capital refers to the connections among the different actors of the network (Yim & Leem 2013; Yu et al. 2013), and can be measured from the perspective of social interaction (Bolino et al. 2002; Chang & Chuang 2011). It focuses on the advantages of multiple social ties (i.e., interaction across different levels and functions) among the firms within the network (Prasad et al. 2012). Relational capital refers to the resources created and leveraged through relationships (Nahapiet & Ghoshal 1998; Tsai & Ghoshal 1998). Relational social capital includes trust, commitment, identification, reciprocity, friendship and mutual respect that actors have developed with one another (Villena et al. 2011; Yim & Leem 2013). Finally, the cognitive social capital refers to the resources that provide shared representations, interpretations and systems of meaning among parties (Nahapiet & Ghoshal 1998). Cognitive social capital includes attributes such as shared language and codes (Bolino et al. 2002; Chiu et al. 2006; Chang & Chuang 2011) and shared goals and values (Tsai & Ghoshal 1998; Krause et al. 2007). In sum, structural social capital refers to the existences of social interaction among the

different members of the network. Relational social capital concerns about the strength of connection, and cognitive social capital focuses on shared understanding and goals.

Network Types

Though all previous researches opined that social capital is the value of firms' network, Inkpen and Tsang (2005) are one of the pioneers who identified the common types of networks that possess the social capital. The three common types of networks identified are intra-corporate network, strategic alliance, and industrial cluster. Intra-corporate network – network of a set of organisations running under a unified business identity, where the headquarter controls the subsidiaries – is not considered for this research because SMEs are mainly one unit business. The second type of network is strategic alliance where group of businesses joint to form a voluntary cooperative arrangement that include sharing, exchange or co-development of products or technologies (Gulati 1999). For example, Chen et al. (2013) mentioned strategic alliance between buying firms and their suppliers can reduce supply risks. In this study, the social capital gained via network of buying SMEs and their suppliers is termed as 'buyer–supplier social capital' in line with the studies of Krause et al. (2007) and Carey et al. (2011). The last type of network is industrial cluster which means a group of independent firms operating in the same or related markets and situated within a geographical location (Inkpen & Tsang 2005). Similar SMEs operating within the same geographical location form network and help out each other to mitigate different risks. In this study, the social capital leveraged through network of similar SMEs within the same geographical cluster is termed as 'cluster social capital' in line with (Molina-Morales & Martinez-Fernandez 2010).

Supply Risk

In the supply chain context, risks are generally classified into two groups: operational risk and disruption risk (Kleindorfer & Saad 2005; Tang 2006). Operational risks arises from the managerial problems and inadequate or failed processes (Lockamy & McCormack 2010) while disruption risks arises from the sudden events such as natural disasters, war and terrorism (Chopra & Meindl 2007). Disruption risk is less predictable whereas operational risk is relatively more controllable (Chen et al. 2013). Relatively speaking, operational risk is more critical as firms are often faced with the more controllable risks in their supply chain which degrade their performance (Byrne 2007). Operational risks include supply risk, process risk and demand risk (Ho et al. 2015). In general, supply risk is most common and has the biggest impact on firm performance due to the ripple effect (Hillman & Keltz 2007).

There is little consensus in the meaning and measurement of risk (Miller & Reuer 1996). In the classical decision theory, risk is conceptualised as 'variation in the distribution of possible outcomes' (March & Shapira 1987, p. 1404). Following the variation-based definition of Kumar et al. (2010), this research defines supply risk as the *potential deviations in the inbound supply from the initial overall objective that may result in uncompleted order*. This definition allows inclusion of any kind of inbound supply deviation as supply risk. These deviations can be manifested in the price, quality, and quantity of products ordered, time of delivery, supplier capacity and overall requirements. Each of these aspects has the consequence on other activities of the firm.

A CONCEPTUAL FRAMEWORK AND RESEARCH PROPOSITION

Based on two premises, this research examines the role of buyer–supplier social capital and cluster social capital in mitigating supply risk. First, it is assumed that social capital improves the cooperation/integration among the member in the network (Wiengarten et al. 2013). Second, it is believed that cooperation among the different entities in the network helps mitigate different risks (Chen et al. 2013). Therefore, this research argues that increasing social capital is conducive to mitigating supply risk of SMEs. This paper proposes a conceptual framework that illustrates that social capital improves cooperation which, in turn, helps mitigate supply risk of SMEs.

FIGURE 1: A CONCEPTUAL FRAMEWORK

Proposition-(1,2,3,5,6): Direct impact
Proposition-(4,7): Mediating impact
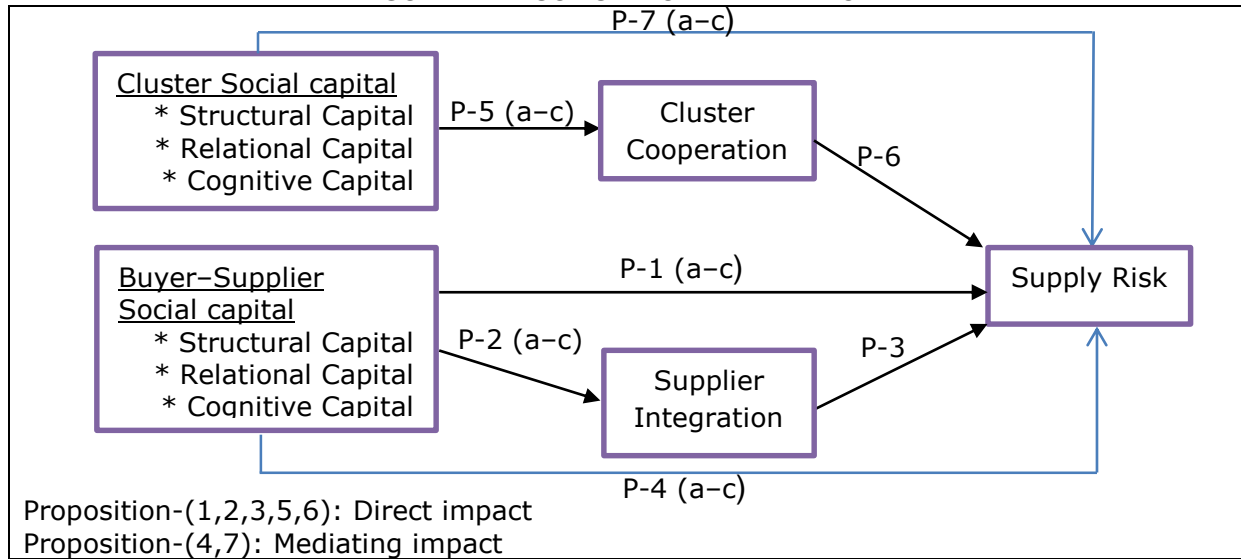
Direct Effect of Buyer–Supplier Social Capital on Supply Risk Mitigation

Dealing with supply risk is a major challenge for SMEs. Nevertheless, SMEs can leverage the network with their suppliers to manage risks (Gilmore et al. 2004). Structural buyer–supplier capital reduces the probability of supply risk for SMEs, and creates awareness of risks present in the inbound supply network (Ellegaard 2008). Close social interaction with key suppliers helps buying firm detect opportunistic behaviour of the suppliers (Burt 2001). Furthermore, higher level of social interaction between buyers and suppliers enhances the effort to meet the buyer's requirement (Uzzi 1997). This drive to fulfil obligation helps reduce deviation of the outcome and mitigate the risks. Relational capital such as trust, commitment, and reciprocity exists within the network of small buying firms and their suppliers plays a major role in managing supply risk (Ritchie & Brindley 2000; Ellegaard 2008). To gain relational capital, buying firms commit to undertake the same activities in future and put their efforts to enhance trustworthiness and belongingness in the relationship with key suppliers. These efforts put pressure on the suppliers to behave reciprocally to timely meet the requirements of their customers (Giunipero & Eltantawy 2004). Cognitive buyer–supplier capital such as common values, beliefs and language can diminish uncertainty and risks (Cheng et al. 2012). Through a case study, Poba-Nzaou and Raymond (2011) found that working with suppliers whom the firms already knew and had a similar value could mitigate supply risk. In light of the above, a direct relationship between buyer–supplier social capital and supply risk postulated as follows:

P-1: (a) Structural buyer–supplier social capital, (b) relational buyer–supplier social and (c) cognitive buyer–supplier social capital has a negative direct effect on supply risk of SMEs.

Effect of Buyer–Supplier Social Capital on Supply Risk Mitigation through Supplier Integration

Integration is the process of amalgamating parts into a whole (Vijayasarathy 2010). Based on the definition of Das et al. (2006), this research defines supplier integration as *"the synchronisation of information, resources and activities of suppliers and buyer in an essence of cooperation to gain mutual benefits."*

Each dimension of buyer–supplier social capital helps enhance supplier integration. Structural capital with the suppliers is essential for successful supplier integration because network ties assist in information sharing and supplier involvement (Prasad et al. 2012). This structural capital, in the form of interaction with both formal and informal social ties, helps in sharing timely and meaningful information between participating

firms (Anderson & Narus 1990). Relational buyer–supplier capital positively affects information sharing, resource sharing and cooperation among members (Mentzer et al. 2001). Trust and commitment between buyer and suppliers facilitates sharing of confidential information and joint problem solving (Dyer & Chu 2003; Johnston et al. 2004). Cognitive buyer–supplier social capital plays a big role in supplier integration (Mentzer et al. 2001; Yim & Leem 2013). Use of common vocabulary and terms facilitate sharing of information and promote collaboration (Masiello et al. 2015). This is particularly true for SMEs because owners of these firms are usually not highly educated and are therefore more comfortable with the use of common language and codes. Shared goals and values further encourage integration and develop a sense of shared responsibility and collective action (Leana & Van Buren 1999). The contribution of buyer–supplier social capital in enhancing supplier integration is addressed through the second research proposition as follows:

P-2: (a) Structural buyer–supplier social capital, (b) relational buyer–supplier social and (c) cognitive buyer–supplier social capital has a positive effect on supplier integration.

In an integrative relationship, it is opined that buyer and supplier work together to solve problems and reduce deviations in the performance for mutual benefit (Droge et al. 2012; Tangpong et al. 2015). The buyer–supplier dyad share timely and reliable information which is the soul of risk mitigation (Lee et al. 2004). Moreover, they help out each other through sharing resources and solving problems jointly. This involvement contributes to risk mitigation because mutual dependency is created when buying firms involve their suppliers in the operation (Das et al. 2006). Zsidisin and Smith (2005) contended that supplier involvement reduces supply risk by removing outcome uncertainty, avoiding adverse selection and moral hazard, ensuring goal congruency, and allowing monitoring of suppliers. Suppliers can provide a high level of customer service when they understand the operation of buyer which helps reduce supply risk of the manufacturing firm (Flynn et al. 2010; Zhao et al. 2013). Based on the above, this study proposes the following relationship:

P-3: Supplier integration has a negative effect on supply risk.

Impacts of social capital on different types of business performance have been explored in previous studies. However, the linkage between buyer–supplier social capital and supply risk mitigation might not be direct. For example, Wu (2008) found that information sharing mediates the relationship between social capital and competitive improvement. Integration mediates the relationship between communication and organisational performance (Baihaqi & Sohal 2013). Yim and Leem (2013) found a mediating role of supply chain integration in the relationship between social capital and firm performance. In another study, Patnayakuni et al. (2008) found a mediating role of supply chain capabilities, such as integration, in the relationship between social capital and firm performance. Literature suggests that buyer–supplier social capital is the direct antecedent of supplier integration (Vijayasarathy 2010) and supplier integration has negative impact on supply risk (Giunipero & Eltantawy 2004; Chen et al. 2013). Therefore, the following proposition on the relationship between buyer–supplier social capital and supply risk is mediated by supplier integration is put forward:

P-4: Supplier integration mediates the relationship between (a) structural buyer–supplier social capital and supply risk, (b) relational buyer–supplier social capital and supply risk and (c) cognitive buyer–supplier social capital and supply risk.

Effect of Cluster Social Capital on Supply Risk Mitigation through Cluster Cooperation
In line with Oprime et al. (2011), this study defines cluster cooperation as the situation whereby homogeneous firms within the cluster share timely and quality information, share resources, and take remedy actions jointly. More than half of the alliances are

formed between competitors (Harbison & Pekar 1998 cited in Gnyawali & He 2006). Cluster Social capital – resources arising from networking with other similar firms within the geographical location – benefits all firms to survive in the market (Schoonjans et al. 2013). Cluster social capital is especially important for SMEs as they do not have sufficient physical resources and knowledge to deal with uncertainty all by themselves individually.

Structural cluster capital – social ties with similar firms within the cluster – assists in knowledge acquisition which, in turn, brings many positive outcomes for the organisation (Yli-Renko et al. 2001). Entrepreneurs of firms within the cluster generally gather in social events. Interactions in social events help enhance cooperation and build trust by breaking boundaries between organisations (Molina-Morales & Martinez-Fernandez 2010). Relational capital with other local similar firms helps SMEs share resources and improve quality of the information shared among themselves (Molina-Morales & Martinez-Fernandez 2010). Firms having high level of relational capital within the cluster usually engage in more cooperation (Chang & Chuang 2011) because they are enjoying the benefit of information and resource from other firms. Cognitive cluster capital helps firms transmit resources more efficiently and effectively (Jansen et al. 2011). Firms working in the same locality generally share a common language, codes, myths and belief. This common cognition enhances quality and quantity of knowledge shared amongst members within the community (Chiu et al. 2006). Common vision and values within the cluster significantly reduces misunderstanding among members and enhances cooperation within the cluster (Molina-Morales & Martinez-Fernandez 2010). The above arguments are summarised through the following proposition:

P-5: *(a) Structural cluster social capital, (b) relational cluster social capital, and (c) cognitive cluster social capital has a positive effect on cluster cooperation.*

Marshall (1961) opined that the cooperation of homogeneous firms that are geographically clustered provides ample advantages, including access to suppliers and improved services from suppliers (cited in Morris & Barnes 2006). This cooperation assists in mitigating the supply risk in many ways. First, SME decision makers are influenced by the diverse pool of knowledge that flows among other SMEs in the connection (Stam & Elfring 2008). SMEs communicate with their competitors to avoid risky transactions when they are doubtful about the creditworthiness of a new party (Gilmore et al. 2004). Cooperation among firms within the cluster facilitates the sharing of authentic information which assists in mitigating supply risks. Second, Gnyawali and Srivastava (2013) has reported that firms working in the same cluster tend to share resources, tangible items and intangible ideas, with one another. These inter-firm exchanges meet the sudden need of firms (Gnyawali & He 2006) and reduce risks. Third, cooperation within the cluster allows firms to participate in joint activities while remaining functionally independent (Best 1990). SMEs operating within a cluster may go for a cooperative purchase (or forming a buying group) to increase bargaining power when dealing with suppliers. As a result, suppliers offer better services which reduce the probability of supply risk. Thus, the following relationship is postulated:

P-6: *Cluster cooperation has a negative effect on supply risk.*

It is opined that the quality of the social capital determines the quality of exchange or cooperation within the network, hence the quality of the risk mitigation (Ferrary 2003). Coleman (1988) argued that social capital facilitates communication which assists in further actions. However, the effect is not always positive (Warren 2008). Sometimes, negative outcomes may occur if there is a cooperation failure (Gabbay & Leenders 2002). For example, when network members are determinative of individual resources, they alter certain relationships to achieve their individual goals. Hard-earned social capital without cooperation among the members may lead to opportunistic behaviour

(Granovetter 1985). In other words, social capital within the network of a cluster can bring positive outcome, e.g., lower supply risk, through successful cluster cooperation. Adler and Kwon (2002) contended that social capital increases ability and opportunity of cooperation which, in turn, provides benefits to participating firms. This argument implies that inter-firm cooperation mediate the relationship between cluster social capital and supply risk. Therefore, it is postulated that the relationship between cluster social capital and supply risk is mediated by cluster cooperation as follows:

P-7: Cluster cooperation mediates the relationship between (a) structural cluster social capital and supply risk, (b) relational cluster social capital and supply risk and (c) cognitive cluster social capital and supply risk.

IMPLICATION FOR MANAGERS AND RESEARCHERS

Despite extensive research has been conducted on supply risk and its mitigation, investigation on the use of the social capital in mitigating supply risk is still very limited (Cheng et al. 2012). In an effort to supplement in the inadequate literature, this article draws from the social capital theory and provides a conceptual framework that demonstrates how social capital can mitigate supply risk of SMEs. This paper proposes that SMEs can mitigate their supply risk through interaction, understanding, and relationship maintenance with their suppliers and peers.

Managerial Implications

This article provides several important implications for the SME practitioners. First, by investigating the potential of leveraging social capital to mitigate supply risk, this research can assist SME practitioners in improving operational performance of their firms, because supply risk has a negative impact on the performance of the firm(Hendricks & Singhal 2005). Second, SME practitioners should understand that not only the buyer–supplier social capital, but also cluster social capital can equally help their firms to mitigate the supply risk. Therefore, SME practitioners should emphasise on leveraging both types of social capital. Third, managers of SMEs should realise that focusing on leveraging social capital without having proper strategies to build cooperation among the entities of the network may not bring positive outcome. Fourth, SMEs should formulate the right strategies to enhance all three dimension social capital, because all three dimensions are complementary with each other. For example, having frequent contacts with suppliers or peers without trust, commitment and respect may be valueless. Finally, the findings are expected to guide the owners/managers of SMEs to formulate proper strategies for inbound supply.

Future Research Implications

This paper takes the first attempt to integrate both buyer–supplier social capital and cluster social capital, which allows this research to develop a more complete view of how social capital facilitates in mitigating supply risk of SMEs. The study intends to expand the body of literature of risk mitigation focusing on SMEs which is relatively scarce at present. Next, this study contributes to knowledge by focusing all three dimensions of social capital. Previous studies of social capital limited to relational and structural dimension, and very few have investigated all three dimensions (Villena et al. 2011). This study also enhances the existing literature of social capital by looking at both the direct and mediating effect of social capital, while previous studies on social capital have mostly investigated the direct relationship between social capital and performance.

As this article is among the first to investigate the role of social capital in mitigating supply risk of SMEs, it provides several immediate research opportunities. This research illustrates some links between social capital and supply risk of SMEs. For purpose of comparison, further studies are required to investigate similar links from the perspective of large enterprises. Moreover, these links should be tested empirically in different contexts to enhance the generalizability of findings. As SMEs have the lack of resources, another study can potentially reveal which type and dimension of social capital are

playing more influential role in mitigating supply risk, which will guide the practitioners of SMEs to develop and implement specific policies to leverage a particular type and dimension of social capital. Additionally, future research should address the antecedents of social capital and consequence of supply risk on the firm performance in order to gain the holistic idea on each component. Finally, a rigorous effort is needed to develop the measurements for the constructs of the proposed conceptual model. A focus group discussion or case study can be conducted to offer the items of the constructs of the proposed framework.

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A complete list of references will be provided upon request

TECHNOLOGICAL DISRUPTIONS AND INNOVATIONS AND THE SUPPLY CHAIN

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ABSTRACT

Purpose of this paper: The purpose of this paper is to present a framework of thinking in supply chain innovation through technology disruptions. These technologies will shift the paradigm of global supply chain management.

Design/methodology/approach: We present our argument by examining the existing literature on new technologies through the literature and company websites and other trade materials. We use some examples of companies to validate our assertions. The theoretical scope of the paper is to present some propositions and pose serious research questions for further investigation.

Findings: Our discussions will centre on the impact of the new technologies on supply chain development within the next decade.

Value: The value of this paper serves to present the state of development in various types of technologies and in different industries. Through our paper, we hope to inform both academia and practice of the waves of change that will supply chain development to the next stage of maturity and development, bringing to bear on the new model of doing business globally in a technology connected environment. This work is entirely original.

R*esearch limitations/implications* (if applicable): Future research can conduct detailed case studies to examine the cultural shift and interventions that must take place to examine the receptivity of enterprises to new technology adoption and measure their preparedness of such disruptive innovations. Our current research paper has limitations as it is largely conceptual without serious empirical validation across a broad range of industries nor of detailed modelling to understand the systemic implications of technological innovation in the supply chain.

Practical implications (if applicable): The paper can provide useful insights to firms especially domestic small and medium sized enterprises keen to feel the pulse of innovation and transformative technologies in the supply chain.

Introduction

The supply chain is evolving and will continue to do so, with the help of innovation, uncertain business environment, and trading and other mimetic pressures. However, anecdotal evidence would suggest that the current state of innovations in the supply chain suffers from a lack of direction, short termism, and a haphazard approach. Most of the innovations call on the help of technology and its related digital platforms to drive higher productivity.

The McKinsey Global Institute (2015) has identified technologies that are likely to have significant and disruptive economic impact by 2025. The supply chain which we know of today is not spared from this disruption in industry's pursuit to embrace innovation in a deeper and real way. In this research paper, we present and highlight some of the technological disruptions that will shift the supply chain to a totally different platform of operation and interaction between stakeholders.

In each of the key technologies mapped, we will present a brief literature review of the state of work done on it. We will, at the same time, present some relevant cases to drive home the point of the impact of these technologies in certain sectors of the supply chain and the attendant industry. Thereafter, we present a framework to signal what we believe should the new innovations that will transform the supply chain for the next generation. This attempt is accomplished through the use of publicly available information whereby we will highlight and package into suitable caselets, their backgrounds and the new developments taking place in a disruptive way to the paradigm of modern SCM. Just as Cooper et al. (1997) offered a framework for understanding SCM and raised a number of research questions, we will in this paper do likewise.

In Asia today, there is a new clarion call for superior supply chain solutions and sustainable innovations either to (i) meet higher customer expectations in an urban environment, (ii) address the imperative for better transport and handling security, or (iii) reducing the efficiencies through wastages in the last mile. For example, RedMart, a Singapore based online grocery service provider has entered a highly competitive grocery and consumer item space by launching an online retail customer marketplace. In this case example, RedMart through its trademarked Redmart Relay uses personal shoppers, legal or otherwise, to go to participating stores, buy the products and deliver to Redmart's customers within the hour of ordering through a smartphone app. The end result is fresher products, higher store turnover, more actual shopping, cheaper transport cost, faster response time and higher customer satisfaction. This is a clear attempt to match on-demand needs with supply, through an express delivery network under localised operating conditions. This shifts the paradigm of supply chain competition to a new micro level, moving from passive to almost active nearly truly real time in response.

Real Time Logistics Systems (RTLS)

Real-time locating systems (RTLS, also known as real-time location systems) are local systems for the identification and tracking of the location of assets and/or persons in real or near-real-time. An RTLS consists of specialised fixed receivers or readers (location sensors) receiving wireless signals from small ID badges or tags attached to objects of interest and/or persons, to determine where the tagged entities are located within a building or some other confined indoor or outdoor space. Each tag transmits its own unique ID. The tag ID is logged against the asset or person to which/whom it is attached. The tags periodically transmit their ID, and depending on the technology chosen, the system locates the tags (and therefore the tagged entities) within a few rooms on one of several floors or to a specific room or part of a room on a specific floor. When staff members require portable assets, they log onto the system at a workstation (or using a mobile device), identify where the closest available item is located, and go and get it (Boulos & Berry 2012; Jones & Schlegel 2014). We now turn our attention to several well documented evidence of RTLS in practice.

Healthcare

RTLS is a well-established technology in the healthcare industry, particularly in hospitals for tracking and locating people and equipment, fulfilling a purpose in increasing efficiency and healthcare safety. The literature suggests that RTLS can be used to improve fall detection in patients (Bowen et al. 2010), provide better estimates of time use by nurses (Jones & Schlegel 2014), and improve healthcare administration (Lawrence & Firth 2013). RTLS can be used to monitor patient flow / movement (handoffs) between wards, e.g., transfer from emergency to radiology, Each patient is given a unique tag to always carry. The time spent by patients in each location is logged by an analytic application. Through this monitoring of the time patients spend in various wards and

consultation rooms in a hospital, management can decide on better allocation efficiency (more staff or equipment) for a smoother and seamless hospital supply chain. Moreover, an RTLS can directly decrease patient waiting and transfer times by reducing the time needed to find staff or to locate a wheelchair, for example, to transport the patient. Using an RTLS also allows quickly locating equipment that is due for maintenance, testing or inspection, as well as a closer synchronisation of housekeeping with patient discharge, enabling faster bed turnaround rates as part of a hospital bed management system. The latter can track real-time notifications of patient or bed status, enabling faster transport of patients and faster housekeeping (Boulos & Berry 2012).

Automotives

BMW uses RTLS to manage the product line and finishing process. Every car on the line has a unique tag and vehicle identification number. The sensors on the product line identify the product type and guarantee all cars arrive at the right location and collect data for the system. In the finishing process, staff monitor the process by using the data. The whole vehicle production data was saving on the tag and then submitted to the BMW database in real time. Customer can better know the car, which they prefer through the tag in the car dealership regardless of where they are in the world. (BMW Group, 2015). RTLS reduces the IT workload and operation and maintenance charge, leading to lower car prices (Ubisense 2015). Moreover, this makes the line less prone to wrong customisation, which would save time for further adjustments that eventually leads to higher on time delivery levels.

Impact of RTLS on Logistics/Supply Chain

RTLS is a precise positioning system that not only enables businesses to identify and track their assets in the supply chain but also provides real-time information through automatic and continuous feedback (Chantzis, Chatzigiannakis & Rolim 2014). The benefits of RTLS are improved *efficiency*, reduced overall *cost*, better *asset safety*, and enhanced *customer satisfaction*. At the same time, RTLS ensures more precise circulation of stock, thereby reducing unnecessary rental expense due to better inventory accuracy which helps to develop better relationships with suppliers (Ding et al. 2008). With RTLS, asset safety is ensured removing the need for manual intervention. In the healthcare sector, RTLS can help staff return to their core competency of providing actual patient care instead of locating medical equipment (Bowen et al. 2010). This in turn helps to increase customer satisfaction, which eventually would lead to better competitiveness. In the RedMart example above, within the retail store, tags can be attached onto the carts or baskets which would show the positions and the things included in the basket in real time for the actual customer, and that the information would be processed in generating a consumer behaviour matrix for predictive analytics. This information is useful for selling store to know in real time what the customers need most from their stores.

Machine learning in an increasingly uncertain environment

For a number of decades, numerous articles have been written and much discussion deliberated on the need of the supply chain to reduce operational risk and improve visibility, especially within an increasingly uncertain global business environment. The need for intelligence, artificial or otherwise, within and from the supply chain has never been greater. The supply chain operating today is and should be different from yesteryear. Good supply chain managers should focus not just on the products moved but also on the services rendered which can be a more significant contributor to profit. With the current buzz on the internet of things, manufacturers must remain watchful and cognizant of the diffusion of the internet into their operations, transport and logistics. The pervasiveness of sensors as suggested in the RTLS points to a new paradigm of products sourced, produced and delivered from cradle to grave and monitored through the life cycle. As the "internet of things" spreads to the factory floor, we can expect more products to be packed with sensors and wirelessly connected to other parts of the supply chain through the internet, using 5G technology. This will transform the way the supply chain is being managed.

The economist (2015) reports that the estimated number of wirelessly connected products in existence (excluding smartphones or computers) will increase from 5 billion to 21 billion by 2020. The possibilities for exploiting the information obtainable for the data generated include the following: the raw material for new services—from windscreen-wipers whose movement can relay invaluable information to met stations to triangulate and validate real-time weather reports, or smart printers that can self order a new spare toner cartridge when it is needed. Such affiliated services will often be more profitable than the products they are based on. Perhaps, the time is ripe to consider setting shared open access platforms whereby supply chain services and applications can be developed and used for both small and large enterprises (the next generation SAP HANA).

These platforms with some form of organic and self organising intelligence should be able to see, analyse, understand new data forms and suggests new behaviour of activity can become the true orchestrator of the supply chain, a level higher the prevalent 4PL control tower notion. This then brings us to the next stage of maturity of the supply chain revolution – the internetisation of the supply chain and the connectedness of all activities. When the internet moves to the industrial stage, manufacturers will have to move out of their comfort zone. No longer can they place and take supplies from their suppliers, make new products either on order or to stock, and push to the marketplace for customisation. With the internet of things and better degree of connectedness, truly mass customisation can indeed be a reality. The contract manufacturers of today cannot compete on cost alone but they must now compete on a number of fronts: cost, customisation, connectedness, and communicability. The old world of traditional manufacturing and job shops must now embrace the new world of craft production and services. Under this new paradigm, the supply chain must become more innovative to the customer, if indeed they compete at all and more co-optitive with other supply chains. Of course, there is a need for an even keel approach, one whereby data privacy and data ubiquity and openness in sharing must maintain a fair balance to facilitate efficiency in operations, less wastage and social concerns. The industrial supply chain will need to move quickly to become a digital supply chain. The supply chain will be more intelligent no thanks to the new of artificial intelligence – machine learning.

The age of machine learning and robotics, or Industry 4.0, (Schwab 2015) is upon the supply chain. These self aware machine learning sensors are very similar to the human brain, the nerve centre of every supply chain. Put simply, en.wikipeida.org/wiki/Machine_learning#Approaches suggests that supply chains will be served by and co-exist with neural networks that will afford deep learning to extract rules of trade and business transaction and form intelligent predictive patterns from diverse sets of large data (the borrowed verbiage from big data analytics). Every supply chain through machine learning can be neuron energised artificially and smart algorithms based on fuzzy logic can digest large chunks of data and information and sieve the right intelligence for the right supply chain. Already, internet service providers and engines such as Google and Baidu have such capabilities, and are to serve as the back-office of the global supply chain using cloud technologies. These deep learning machines can only grow in intelligence and capability with time and some human creativity. Already, there is talk that the next decade should expect an explosion of new forms of service automation (see afr.com, "white collar robots are ways of the future"). The supply chain sector being a service industry will not be spared. The capacity of robotics will extend from the warehouse to call centres, onto the factory. An example is that of Momentum Machines, a west coast US company, that has automated production of gourmet quality hamburgers. The production device, in 10 seconds, can shape burgers from freshly ground meat and grills the meat to order, includes the right amount of char, slices and adds fresh ingredients to the customer order (see www.businessinsider.com/momentum-machines-burger-robot-2014-8).

Impact of machine learning on SCM

While small businesses and small stakeholders for that matter would love to embrace machine learning and artificial intelligence, they would be constrained financially and rightly so too worry about the loss of privacy of their data, operations and markets. However, technology providers such as the SAP of today have come up with an innovative solution, namely, platform as a service (PaaS). The SAP HANA cloud based platform is one such example. This platform is an open standards based platform meant for network and data driven business environment of the supply chain of SMEs. This PaaS becomes the engine of the supply chain in which users can receive the right information at the right time, in the right quality and amount, and for the right customer and supplier location. In short, Paas provides time, place and value utility. Comparing this form of utility to Heskett's (1977) assertion that logistics function exists to create time and place utility for a product, PaaS will be a place medium for business and supply chains to connect. Using Paas astutely, SMEs and supply chains drive continuous streams of innovation throughout their firms and their supply chains. More details can be gleaned from the website, sap.com/simple.

Internet of value

Beyond the internet of things, there is the internet of value. The Internet of value extends the traditional Internet of information, and it has been implemented by the blockchain technology, which is a radical innovation that enables direct value exchange over the Internet. Underpinned by blockchain technology, Bitcoin came about in 2009. Currently, the most widely used Bitcoin blockchain is a shared public ledger of valid network transactions free for all to review and add to

(by transacting on the network), but no one can alter. As a result, it contains a complete and immutable history of online transactions. It is this transaction history that obviates trust and enables multiple entities to securely exchange value over the Internet in the absence of a third party. This is a significant departure from the traditional approach where secure value exchange always requires an trusted third party. In this regard, blockchain is a disintermediating technology that eliminates friction in online value exchanges and the supply chain. Recall Fisher (1997) mentioning about supply chain disintermediation particularly on product flows. Under blockchain technology, we can now have disintermediation in the financial flow of the supply chain. Clearly, such a technology will contribute to digital value exchange by significantly reducing the transaction cost.

The logic of blockchain technology is to significantly simplify the job done by the traditional financial institutions or banks. Banks are aware of this ramification. Recently, several global financial institutions have showed interest in the technology. For example, France's biggest bank, BNP Paribas is testing the potential of blockchain technology for post trade processes and Société Générale posted a job earlier this year for an "IT developer on bitcoin, blockchains and cryptocurrencies". Likewise, Barclays in the UK, Santander in Spain and CitiGroup are all investigating the innovative technology in some capacity (https://www.weusecoins.com/how-banks-can-benefit-from-blockchain/).

Impact of blockchain technology on SCM

There are several ways in which blockchain technology can be applied in a supply chain. First, the technology can be used to increase supply chain transparency. Operating without a central operator, a blockchain features an open database that is secure, auditable but nobody has control over what is seen due to the decentralization of data. This makes the blockchain technology a promising tool for bringing true transparency to complex global supply chains. On the other hand, using blockchains will bring transparency to supply chains in that it allows consumers to make informed purchases and empowers governments to quickly and easily request reliable information related to even the most distant supplier. More transparency can serve as an information sharing mechanism, which coordinates the decisions between supply chain members. Another impact rests in the ability to track products and inventory through a supply chain, confirming receipts and automatically releasing payments to suppliers. This could help to trace items across a decentralised network. The technology could also help to reduce the transaction fees for organisations in their supply chains, as well as speed up payment, with a transaction normally processed within an hour, compared to the usual two to three days. In short, time utility and cash-to-cash cycles can be drastically reduced. Furthermore, blockchain technology can significantly increase efficiency in that it uses smart computer technology to verify transactions without the need for financial intermediaries. This help to reduce friction and costs in the process of transactions, which favors other financially related operational activities in supply chains. The net effect is that consumers will get to enjoy lower prices, coupled with faster of and the greater and ready availability of products in the marketplace. This can only happen with a truly integrated system that tracks trade transactions along the supply chain and the ability to tailor smart contracts for different levels of the supply chain with risk considerations embedded. Effectively, this reduces the frictional cost in trade. However, legislation must be put in place to propel the industry for such a move.

So how does the supply chain achieve the holy grail of a high performance and be precisely driven. The answer lies in the emerging realm of quantum technology.

Quantum Technology (QT)

QT, comprising six areas of quantum metrology, quantum sensing, quantum communications, quantum memories, and quantum computation, has a wide range of applications such as transportation, energy, security, and healthcare. QT delivers useful devices and processes that are based on quantum principles of Heisenberg's uncertainty principle, quantum superposition, and tunnelling, entanglement, and de-coherence. It is Heisenberg's uncertainty principle that has particular value in the networked supply chain. Stated briefly, Heisenberg's uncertainty principle suggests that for every certainty in one measurement eg product units, there is always a simultaneous measurement eg customer demand which is largely random. Indeed, the greater the certainty in one measurement, there is a simultaneous and corresponding uncertainty in the other measurement.

While physicists and scientists have understood these principles, only recently has it become possible to engineer devices according to these principles. In particular, there is now a need to scrutinise

these non-classical physical science and ask if some of the quantum principles can be applied to enhance the performance of the supply chain and accommodate the complexities therein. In addition to fundamental principles of quantum mechanics, quantum technology will require a set of specific tools that are generic. These include quantum metrology, quantum control, quantum communication and quantum computation. Successful technologies are predicated on precise engineering, which in turn requires high precision measurement which is possible from PaaS or cloud computing. Quantum technology will thus require us to develop a quantum metrology. It is well known that measurement in quantum mechanics requires a radical reappraisal of traditional measurement concepts. While many questions remain, it is clear that quantum mechanics enables new types of high-precision measurement. The recent discovery of quantum communication protocols that are more powerful than can be achieved classically suggests new ways for components of a large complex system such as the global supply chain to be interconnected. Quantum communication technologies require new principles of operation. A quantum internet based on quantum optical channels, for example, would require new protocols for communication (eg. distributed quantum computing, quantum packet switching) and might incorporate quantum key distribution and error correction as fundamental components. Already it is clear that there is a need to develop an understanding of quantum communication complexity. Quantum mechanics enables exponentially more efficient algorithms than can be implemented on a classical computer. This discovery has led to the explosive growth of the field of quantum computing. Building a quantum computer is the greatest challenge for a future quantum technology, requiring the ability to manipulate quantum-entangled states for millions of sub-components. Such a technology will necessarily incorporate the previous three quantum applications for readout (quantum metrology), error correction (quantum control), and interconnects (quantum communication).

Impact of QT on SCM

QT will change the speed of intelligence retrieval through large scale data mining. This is evidenced through the quantum algorithms developed to drive information needed for fast supply chain performance. These quantum algorithms are computer programs which, when run on a quantum computer, take advantage of nonlocal, non-classical, quantum entanglement to provide a computational advantage. Let us take one example. In Shor's factoring algorithm, the quantum program runs exponentially faster than the best known classical program. Indeed, Shor's algorithm would be the "killer app" code breaker, cracking secret codes in seconds that would take trillions of years to do on a classical machine. A second quantum computer program, Grover's algorithm, provides a quadratic speedup over the best possible classical algorithm for searching a random database. These algorithms are particularly useful to the global supply chain when it concerns large scale data mining of stock at the item level and historical analysis of market demand, optimization of the complex supply network. Another application area and impact concerns that of supply chain security, in particular information cyber security. Quantum cryptography is the answer to the need for better information securitization of the information flow within the chain. The process of developing commercial quantum key distribution systems. This technology is made possible by recent advances in single photon optical fiber engineering, which allows the distribution of quantum entangled photons over hundreds of kilometers of optical fiber, or even in the air. The quantum cryptographic keys distributed in this fashion are immune to attack, again as guaranteed by the *Heisenberg Uncertainty Principle.*

Conclusion

The future is all about real time information and systems that can support real time demands. This paper has reviewed several disruptive technologies that we think will alter the landscape of the global supply chain, through reducing waste, supply and marketplace uncertainty, cost of transactions, and more importantly increase the value as perceived by the customer. The internet of things brings about the connectedness of entities, enterprises and stakeholders in the supply chain, making the communication channels more seamlessly and without impediment. Machine learning bridges the present with the future seamlessly and cleverly. Blockchain technology is the much hailed disintermediation at the financial level of the supply chain and will radically change the model of supply chain financing. Finally, quantum technology is the smart technology that will expedite algorithm solutioning for the engines needed to drive a truly technology enabled supply chain. Today's supply chain is predicated on ERP and their cousins. Tomorrow's supply chain will be at the micro level and in the cloud. Technology is rapidly changing and the supply chain must change along with it.

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ANALYSIS OF THIRD-PARTY LOGISTICS INTEGRATION AND SUPPLY CHAIN RESILIENCE

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ABSTRACT
Supply chain resilience (SCR) is essential to the success of firms. However, very few studies have focused on the relationships among the different types of integration, SCR and service performance from the perspective of a third-party logistics provider. This study develops and assesses a conceptual model of these relationships. A total of 161 3PLs (third-party logistics providers) in Taiwan were surveyed and their responses were analyzed using partial least squares structural equation modeling (PLS-SEM/PLS). The responses of respondents demonstrated that, of the three types of integration (internal integration, customer integration and logistics collaborator integration) used by 3PLs, internal integration had the greatest effect on SCR. All three types of integration were found to have fully or partially mediating effects on service performance.

Keywords: Supply chain resilience, integration, third-party logistics providers.

1. INTRODUCTION
With the trends of specialization and globalization, companies' supply networks not only have become more complex, but also have to face more frequent and diverse unpredicted risks. In addition, recurrent natural disasters and anthropogenic accidents result in great challenges to company's supply chain management. For instance, the earthquake that struck Kumamoto, Japan, in April 2016 had led to risks of global automotive supply chain disruption (CNN, 2016). Therefore, supply chain resilience (SCR) has become an industrial and academic focus in recent years (Christopher and Peck, 2004; Hohenstein et al., 2015; Petti et al., 2013).

Integration is one of the most important aspects in supply chain management (Huo, 2012). Supply chain integration has been advocated as a key to determine whether a company collaborate well with its supply chain partners, and thereby enhance service performances(Zhang and Huo, 2013). The importance of integration to a company's performance has been proven by many studies (Huo, 2012; Zhao et al., 2013; Zsidisin et al., 2015). Furthermore, a number of recent research has noted that integration has the potential of enhancing a company's resilience (Christopher and Peck, 2004; Jüttner and Maklan, 2011; Petti et al., 2013; Wieland and Wallenburg, 2013). However, there has been relatively little attention given to empirical studies of integration's explanatory power on SCR. There is even less relevant research focusing from the perspective of third-party logistics providers (3PLs). Moreover, to 3PLs, there are no commonly accepted sub-dimensions of integration. A limited number of studies mentioned the influences on the performances of 3PLs when integration is viewed as a single dimension (Shang, 2009). There is very rare empirical evidence on whether different types of integration dimensions would simultaneously affect 3PLs' SCR and performances. A very few number of 3PL-related research investigated integration's impacts on SCR as a single dimension (Wieland and Wallenburg, 2013).

This study intends to develop and assess a conceptual model regarding the relationships among different types of integration, SCR and service performance from a 3PL perspective. The key question posed by the present research is as follows: How do different types of integration simultaneously influence SCR and service performance?

Several contributions have been made by this study in terms of literature and practices. First, this study evaluates the concepts of internal integration, customer integration, and logistics collaborator integration of 3PLs as well as the relationships among them. Next, this research investigates the impact of internal integration, customer integration, and logistic collaborator integration on 3PLs' SCR and service performances. The study further provides several principles for managers of 3PLs to understand the allocation of efforts and resources for different types of integration. The principles explained in details how each type of integration shall be managed to enhance SCR and service performance.

2. LITERATURE REVIEW AND RESEARCH HYPOTHESES
2.1 Resource-based theory
The resource-based theory (RBT) studies why there are performance differences between companies and how they utilize resources to maintain their competitiveness and advantages (Barney, 2001). The RBT has been widely applied in logistics-related research to evaluate various resources' contributions to a company's performance.

2.2 Integration
Zhao et al. (2013) indicates that integration is done by internal and cross-organization process management to enhance the efficiency of service, information flow, and cash flow, to improve a company's operational performance. Previous studies mostly divide integration into internal and external integrations basing on the width of integration participants (Kim, 2013). Of the two types of integration, internal integration refers to coordination between departments within a company to accomplish the company's goals (Kim, 2013; Yu, 2015; Zsidisin et al., 2015). Whereas external integration involves collaborations with external partners, such as joint planning or information sharing, to achieve mutual objectives of supply chain partners (Yu, 2015; Zhao et al., 2015; Zsidisin et al., 2015). To 3PLs, external integration can be further divided into customer integration and logistics collaborator integration. "Customer" in this context indicates the service user, while "logistics collaborator" is the company that provides logistics services for 3PLs. Customer integration's reflection on a company's operations include sufficient integration with customers in logistics operations, adequate information system integration with major customers, establishment of fast order system for major customers, etc. Its reflections on planning include complete logistics service planning for the future to satisfy customer needs. Logistics collaborator integration represents the collaborations between 3PLs and other logistics service providers, such as agents, transport companies, and other 3PLs. The integration involves the combination of these logistics collaborators' logistics operations and information systems, sufficient feedback exchange, and cost allocation of logistics services in order to support the expansion of 3PLs' service network and reduce the impacts inter-organizational differences have on service performances (Stank et al., 2009).

2.3 SCR
As of today, SCR is still lacking a grounded definition (Hohenstein et al., 2015). Some academics consider SCR as the ability a corporate has to rapidly respond to disruptions and restore its operation (Brandon-Jones et al., 2014; Sheffi and Rice Jr, 2005; Williams et al., 2009), while others think of it as the ability to restore and advance to a better operation status (Gölgeci and Ponomarov, 2015). This study adopts the concept described by Ambulkar et al. (2015) to consider SCR as the ability a company has to stay alerted to environmental changes and to rapidly adapt disruptions. There have been many studies investigating the enablers of SCR, such as the perception to external environmental changes (Wieland and Wallenburg, 2013).

2.4 Service performance

Service performance or customer value refers to the current service outcomes of a company relative to the respective industry average (Wieland and Wallenburg, 2012). The main mission of 3PLs is to create the value of logistics activities for customers. Service performances include punctuate delivery, customer satisfaction, problem-solving for customers, etc. (Wieland and Wallenburg, 2013).

2.5 Internal integration and external integration

It was found in previous studies that internal integration is an important factor driving external integration (Braunscheidel et al., 2010; Zsidisin et al., 2015). When a corporate lacks collaborations between its internal department and results in conflicts due to different management goals, it often hinders the execution of external integration. If there is no cooperation between various departments within a corporate, 3PLs would find it hard to share information such as timely storage information with customers in the rapidly changing financial environment. Similarly, internal integration can also enhance information exchange and partnerships between 3PLs and their logistics collaborators. This helps logistics collaborators to provide efficient resources and assistances when needed. Thus, we propose that:

H1 Internal integration has a positive effect on customer integration.
H2 Internal integration has a positive effect on logistics collaborator integration.

2.6 Logistics collaborator integration and customer integration

It would be a disadvantage to work with customers in the complex logistics network if 3PLs neglect joint operations with logistics collaborators in various logistics activities. For instance, limited logistics operation integration with a logistics collaborator will prevent a 3PL from efficiently providing operation information to customers in a company's non-service network. Thus, we propose that:

H3 Logistics collaborator integration has a positive effect on customer integration.

2.7 Integration and SCR

Previous research has found that integration is a significant factor influencing SCR (Christopher and Peck, 2004; Jüttner and Maklan, 2011). Effective integration among departments not only increases visibility, but also decreases uncertainty. These are all important elements of forming SCR (Christopher and Peck, 2004). The internal integration of a 3PL enables sufficient circulation of risk information between departments. In addition to effectively lowers the possibility of disruption, sufficient management of impacts brought about by disruptions can also be achieved through coordination between the departments. Thus, we propose that:

H4a Internal integration has a positive effect on SCR.

Hohenstein et al. (2015) indicates that the higher the level of collaborations between supply chain participants, the shorter the time to respond to a disruption. External integration of 3PLs enhances effective circulation of risk information between supply chain partners, enabling them to stay alerted to environmental changes and rapidly respond to the occurrence of a disruption through information sharing, preparation and planning, as well as coordinated operations (Christopher and Peck, 2004). Thus, we propose:

H4b Customer integration has a positive effect on SCR.
H4c Logistics collaborator integration has a positive effect on SCR.

2.7 Integration and service performance

Based on the RBT, integrating resources has become one of the keys to maintain a company's competitiveness (Huo, 2012; Liu et al., 2015). The internal integration has

also been proven to have positive impact on operation performances (Alfalla-Luque et al., 2015; Huo et al., 2014; Zhao et al., 2013). The enhancement of 3PLs' service performances brought about by internal integration includes various aspects. For example, internal information integration system helps 3PLs to dynamically adjust transportation and storage plans basing on environmental changes to ensure delivery dependability. Moreover, effective communications and cooperation between departments help them further understand customer demands, and simultaneous reduce the conflicts resulted from different management goals of the departments, enabling 3PLs to provide a high level of service performances to customers. Thus, we propose that:

H5a Internal integration has a positive effect on service performance.

Close interactions between 3PLs and customers can reinforce the timing and accuracy of information shared. This helps 3PLs provide logistics services from a customer's perspective and adjust the company's logistics activities for customers in advance, thereby improving service quality and enhancing ability to respond to customer needs. Respectively, close collaborations between 3PLs and logistics collaborators enable 3PLs to quickly respond to changes in market demand and meet customer requirements in the complex logistics network. Previous studies also indicate that external integration has a positive correlation with service performances, such as customer satisfaction and deliver quality (Braunscheidel et al., 2010; Huo et al., 2014; Zhao et al., 2013). Thus, we propose:

H5b Customer integration has a positive effect on service performance.
H5c Logistics collaborator integration has a positive effect on service performance.

2.8 SCR and service performance
Apart from reflecting a company's adaptation to external environmental changes, SCR is also represented in corporate performances. Hohenstein et al. (2015) conclude findings from previous studies to find that the shorter the time a corporate requires to restore after a disruption, the better the firm performance. A 3PL with higher SCR has better capability to detect potential risks and threats to prepare and allocate resources in advance. This also means that the 3PL is able to adopt appropriate solutions when a disruption occurs and meet customer requirements in time. Thus, we propose that:

H6 SCR has a positive effect on service performance.

A conceptual model is proposed in Figure 1.
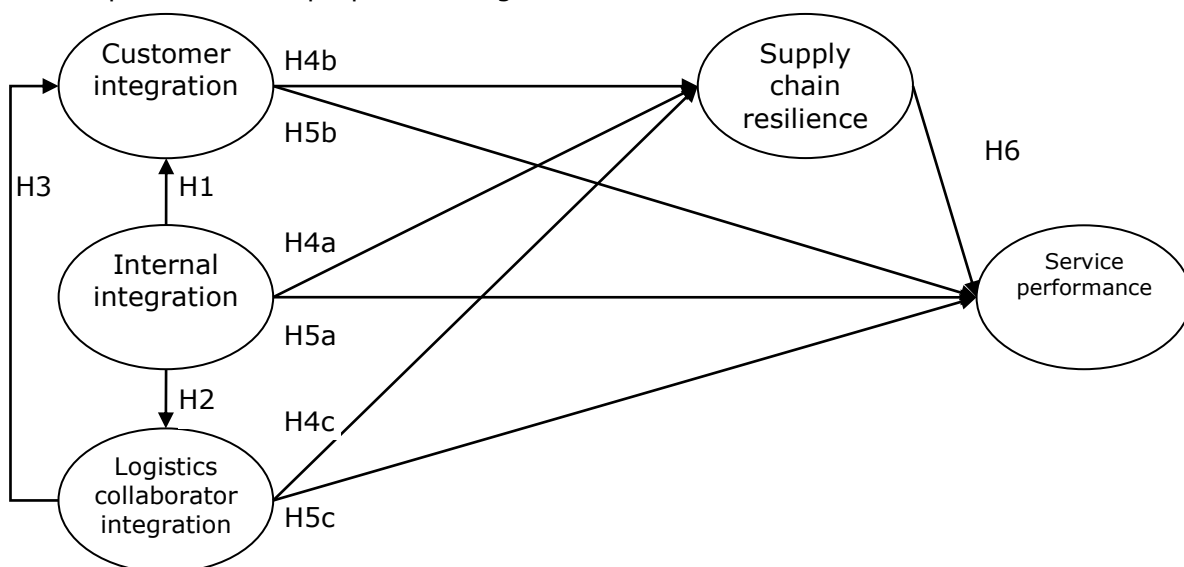
Figure 1. The proposed model.

3. METHOD
3.1 Selection of the sample
There are 539 Taiwanese 3PLs identified on the Taiwan Association of Logistics Management Member List and Taiwan Logistics E-hub Corporate List. All 3PLs provide transportation and storage services to fulfill the range of 3PL services defined by (Langley et al., 1999).

3.2. Survey Measures and Items
The design of this study's questionnaire survey was carried out based on the recommendations of Dillman (2007). A preliminary survey was pre-tested in Taiwan by interviewing experts on 3PLs. The questionnaire covered four topics, which were integration capabilities, SCR, service performance, and background information about the business. Nineteen items were used to measure the integration capabilities of 3PLs, based upon the work of Stank et al. (2001). Four items were selected as measures of the SCR, based on the relevant literature (Ambulkar et al., 2015). Respondents rated their agreement with statements about their firms' integration capabilities and SCR using a seven-point Likert scale ranging from one for "strongly disagree" to seven for "strongly agree." Agreement with statements about four items that were used to measure service performance was measured on a seven-item scale, based on the work of Wieland and Wallenburg (2013). Respondents were asked to rate their company's performance relative to the industry average on a seven-point Likert scale, anchored by "1= much worse" and "7= much better".

3.3 Analytical methods
A partial least squares structural equation modeling (PLS-SEM/PLS) method was used to test the research hypotheses. All analyses were carried out using SPSS version 12.0, AMOS version 19 and SmartPLS version 2.0.M3 (Ringle et al., 2005).

4. RESULTS OF ANALYSES
4.1 Analysis of response rate
The data collection phase of the study ran from the middle of March 2016 to the middle of April 2016. The effective population size was reduced to 479 as 19 respondents indicated that their companies provided only services for internal users, and 41 service providers did not provide transportation and warehousing services. Ten of the 171 returned questionnaires were discarded because respondents had given the same responses to all Likert-scale items. The total usable number of responses was 161. Therefore, the overall response rate was 33.6% (161/479).

4.2 Profile of respondents
The profiles of the respondents and their companies revealed more than 67.8% (95/ (161-21) since 21 respondents did not provide the required information) were provided by managers, vice presidents or more senior executives, providing an integrated and responsible view of a firm's affairs. Over 60% of the 3PLs had been operating in the logistics industry for more than 20 years.

4.3 Measurement model
All of the indicators load higher on the construct of interest than on any other variable, verifying discriminant validity (Hair et al., 2014). All of the individual outer loadings exceeded 0.707 (Hair et al., 2014), providing evidence of the constructs' convergent validity. The composite reliabilities of the various measures ranged from 0.925 to 0.939, exceeding the recommended threshold of 0.700 (Fornell and Larcker, 1981). The AVE for all measures exceeded Fornell and Larcker's (1981) acceptable value of 0.5. These results support the convergent validity of the measures. The correlation matrix demonstrates that the square roots of the AVEs of most of the measures exceeded than the corresponding correlation values for those variables, confirming discriminant validity

(Hair et al., 2014). In summary, the results support the reliability and validity of the measured used herein.

4.4 Structural model

Figure 2 displays the results of a PLS analysis of the research model with significant standardized coefficients at the 0.05 significance level. Bootstrapping with 5000 samples (Hair et al., 2014) was carried out to evaluate the significance of path coefficients. The seven significant path coefficients support the seven hypotheses. A Sobel (1982) test was performed to provide evidence for the mediation effect. SCR was found to have a full mediating effect on the relationship between internal integration and service performance ($z = 2.479$, $p < 0.05$). Customer integration was found to have a full mediating effect on the relationship between logistics collaborator integration and SCR ($z = 1.988$, $p < 0.05$), and a partial mediating effect on the relationship between internal integration and SCR ($z = 2.044$, $p < 0.05$).
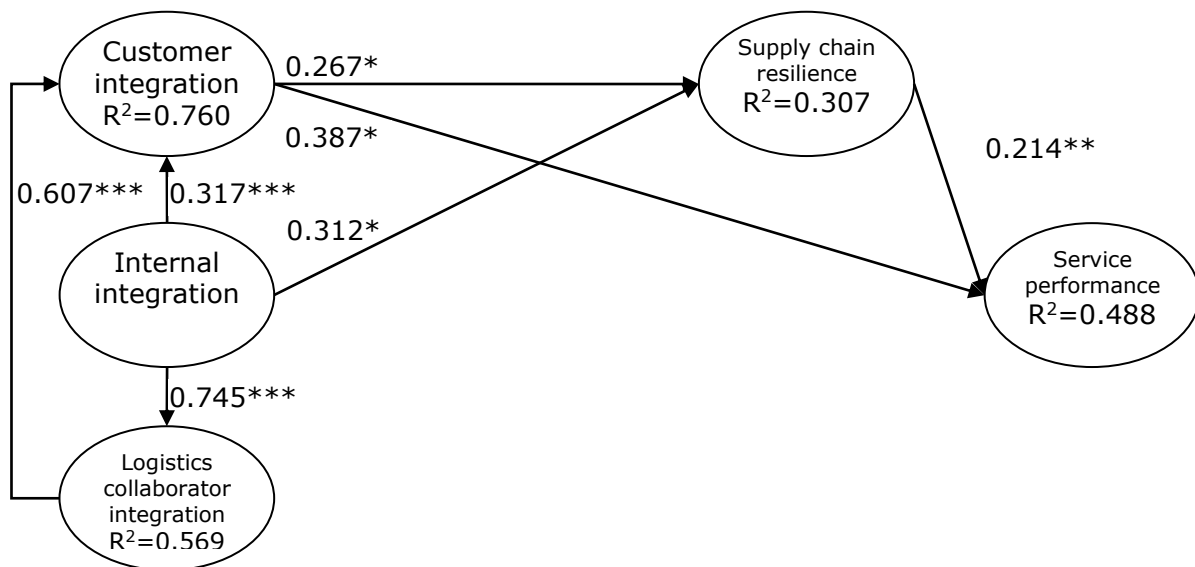
Figure 2. Structural model results

* Significant at level $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; R^2 is variance explained by model.

5. DISCUSSION

The study results show that internal integration has positive effects on both 3PLs' customer integration and logistics collaborator integration. This indicates that a 3PL's internal integral planning system and coordination between its departments can enhance information exchange between the company and external members and facilitate establishment of long-term partnerships. This study result is similar to the findings of previous research (Alfalla-Luque et al., 2015; Braunscheidel et al., 2010; Huo, 2012). For example, Huo (2012) found that internal integration can also improve customer integration and supply chain integration from a manufacturer's perspective. Furthermore, this study also found that for 3PLs, logistics collaborator integration facilitates a company's customer integration. This shows that 3PLs can enhance the level of information and operation integration between 3PLs and customers through collaborations with logistics collaborators.

Although there are differences in the direct effects on SCR between various 3PL integration dimensions, SCR can still be improved by all dimensions through customer integration. This result is consistent with previous study findings (Christopher and Peck, 2004; Jüttner and Maklan, 2011; Wieland and Wallenburg, 2013). For a 3PL, internal integration can directly enhances the company's SCR, thereby elevating service performances. In other words, the 3PL can reinforce the company's response ability to

external environmental changes through standardization of internal operations, coordination between department, and integral planning system, thereby creating customer value. Furthermore, internal integration can also elevate SCR through the partial mediator effect of external integration, improving service performances. This finding is similar to previous research results which indicate that a company can cultivate external ability and create competitiveness through internal resource integration (Huo, 2012; Xu et al., 2014). For example, Huo (2012) pointed out that internal integration can improve external-oriented performances through customer integration and supply chain integration separately.

Customer integration can directly enhance a 3PL's SCR and thereby improve its service performances. This indicates that close interaction between a 3PL and its customers facilitates information sharing, preparation and planning, as well as coordinated operations. This helps prevent and rapidly respond to the occurrence of disruption. Eventually, it reflects the increase of customer satisfaction. This result is similar to the findings of Wieland and Wallenburg (2013), which indicate that information sharing and operation integration between a manufacturer and external members is beneficial to the improvement of a company's SCR and thereby enhancing the customer value. Logistics collaborator integration has no direct influence on SCR. It can only indirectly elevate SCR through the mediator effect of customer integration. In other words, a 3PL cannot neglect customer integration if it wishes to improve SCR through logistics collaborator integration.

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Section 2: Supply chains and networks

3D PRINTING SERVICES AND THEIR IMPACT ON SUPPLY CHAIN CONFIGURATIONS

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ABSTRACT
This paper reports on a study that investigates the current state of the art of 3D printing services in the German, Austria and Swiss Area, as well as the Benelux markets. The aim is to understand the size and composition of the 3D printing industry in these markets, how 3D printing services operate (indicative business models) and the impact they could potentially have on supply chain configurations, both within this industry sector and beyond. In this way, the research has potential to inform how future supply chains are likely to develop and how the industry should respond to these changes to secure long term business success. The results provide an accurate snapshot of the current players in 3D printing services. The next stage will involve a survey and follow up interviews with primary stakeholders (e.g. employees, suppliers and customers) to gain a deeper understanding of the key current and future requirements of the industry and how this will specifically impact future supply chain configurations.

BACKGROUND
Although on demand 3D printing services for consumers are expected to play an important role in the adoption of the technology in the coming years (Canalys, 2014; Weijmarshausen, 2015), academic research focusing on this area has so far been very limited. Most research published in business-related fields has focused on the possibilities 3D printing presents for existing companies, and/or the impact of the technology on manufacturing processes (Hopkinson & Dickens, 2003; Gebler, et al., 2014; Mellor, et al., 2014; Weller, et al., 2015; Baumers, et al., 2016). In parallel, the research focus is shifting away from companies that manufacture their products using 3D printing, towards looking at the possibility of consumers being the producers in the future (Fox, 2014; Rayna, et al., 2015; Bogers, et al., 2016). This trend has been fuelled by the rapid decrease in the cost of owning a 3D printer (Berman, 2012; Lipson & Kurman, 2013) and improvements in the accuracy and speed of the printers. Nonetheless, while consumer-producers and 3D printing at home are likely to have a big impact on the 3D printing business of the future, industry predictions of when widespread adoption will take place are vague (see for example Gartner, 2010 compared to Gartner, 2014 and Gartner, 2015). With the age of home 3D printing being delayed further into the future and most current research focusing exclusively on how additive manufacturing technology impacts the business models and supply chain models of existing firms, the question that arises is "how do 3D printing services fit into this research landscape?"

Rayna, et al. (2015) addressed 3D printing platforms in which they analysed the services offered by 22 online printing platforms to identify both which types of services they offer

and how these platforms embed user co-creation into their processes. The authors identified two key universal components of the business model and supply chain of these services: design and manufacturing. The configuration of the two components can be considered the key difference between the platforms identified by the researches. These findings about the state of 3D printing services were used as a starting point in creating the basic supply chain configuration described later on in this study.

RESEARCH OBJECTIVES

This paper forms part of a larger research project that examines the nature and composition of the 3D printing industry in Europe, more specifically the industry of the DACH (Germany, Austria, Switzerland) and Benelux (Belgium, Luxembourg and the Netherlands) countries. The main research question concerns understanding the types of on demand 3D printing services currently available to private consumers in these markets. The broader goals include investigating the size and composition of the 3D printing industry, including types of 3D printing services available in these markets; understanding the impact on supply chain configurations and evaluating how the identified 3D printing services are likely to develop in future.

RESEARCH METHODOLOGY

In the context of the aforementioned larger-scale research project, the research was separated into two parallel layers; an analysis at industry-level and a deeper investigation of the services sector. The first stage of data gathering involved creating a comprehensive list of companies in these markets that belong to one of four categories: 3D printing services (B2C service providers), 3D printing specialists (B2B service providers), 3D printing equipment and material manufacturers and 3D printing equipment and material distributors. This entailed scanning publicly available local and global databases of firms offering 3D printing-related services, browsing newspaper and business magazine repositories, identifying company websites through multiple keyword combinations on widely-used internet search engines and examining exhibitor lists for major 3D printing conferences. Important sources of secondary data on each firm included both information made publicly available by the companies themselves and information provided by trustworthy third parties. Sources made available by the companies included company websites, brochures, catalogues, marketing material and press releases.

Data collection was carried out between October and December 2015. All of the companies that were originally added to the data set during the collection period but no longer operated at the end of 2015 were removed from the final data set. From the resulting database of 558 companies operating in the 3D printing industry, 105 were classified as 3D printing service providers and thus subjected to a deeper level of analysis. The aim of the data collection process was to provide a solid understanding of the basic structure of the companies' supply chains, as well as identify the key differentiation points of their service package and business model. Collected data points also included factors about the companies' product and service offering, infrastructure, channels and pricing models, in line with the business model building blocks proposed by Osterwalder, et al. (2005).

TYPES OF 3D PRINTING SERVICES

The analysis revealed that 3D printing services can be separated into three distinct categories depending on the type of activities offered before the additive manufacturing process takes place. Table 1 presents an overview of the number and percentage of identified companies that provide on demand 3D printing services, by country. The first category of services, named generative services in the context of this study, includes all services that create a 3D model for the customer before proceeding to 3D print it. The two main versions of generative services include classic construction with computer-aided design (CAD) software, whereby a designer from the 3D printing service provider creates

the 3D model for the customer (Figure 1), and 3D scanning, whereby a pre-existing object is photographed and digitalized using specialized equipment (Figure 2).

Table 1: Number of identified companies that offer on demand 3D printing services

Country Code	Total unique providers	Data Point	Generative Services	Facilitative Services	Selective Services
DE	51	*No.*	37	30	7
		%	73%	59%	14%
AT	9	No.	8	5	1
		%	89%	56%	11%
CH	11	No.	9	6	1
		%	82%	55%	9%
LU	2	No.	2	1	0
		%	100%	50%	0%
BE	11	No.	7	10	2
		%	64%	91%	18%
NL	21	No.	12	19	2
		%	57%	90%	10%
Total	105	No.	75	71	13
		%	71%	68%	12%

The second category of identified services, named facilitative services, includes all services that assume the customer has already acquired a 3D model that they would like to have printed, and as such, tend to reduce design-related activities to a minimum. The primary difference amongst facilitative services can be reduced to the way the customer transfers the 3D model to the 3D printing service provider. The most popular option in this case is for the customer to upload and send their 3D model to the service provider (generally in the form of an STL file) either through a contact form, through an email or using the service provider's upload interface (Figure 3).
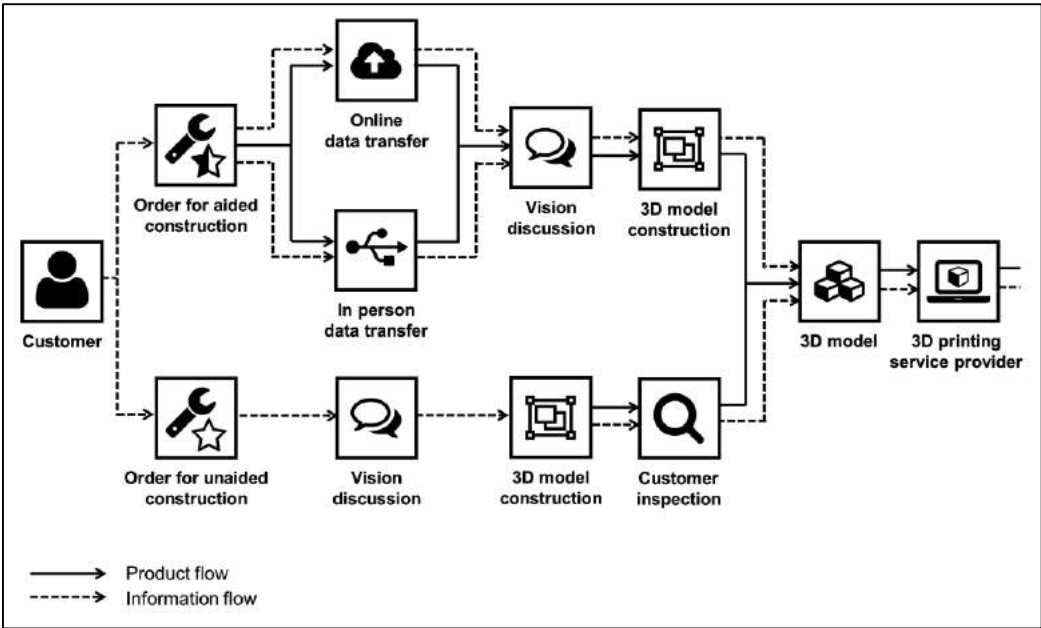
Figure 1: Supply chain of the construction services module
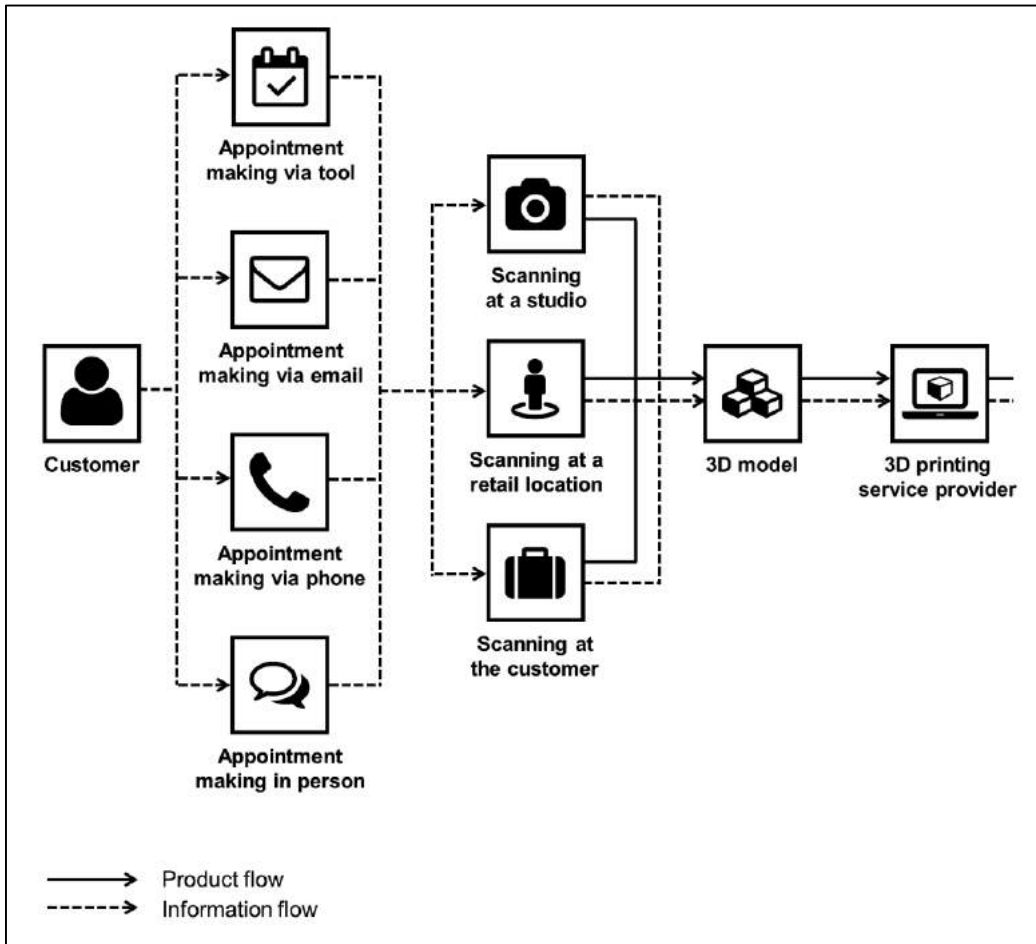
Figure 2: Supply chain of the scanning services module
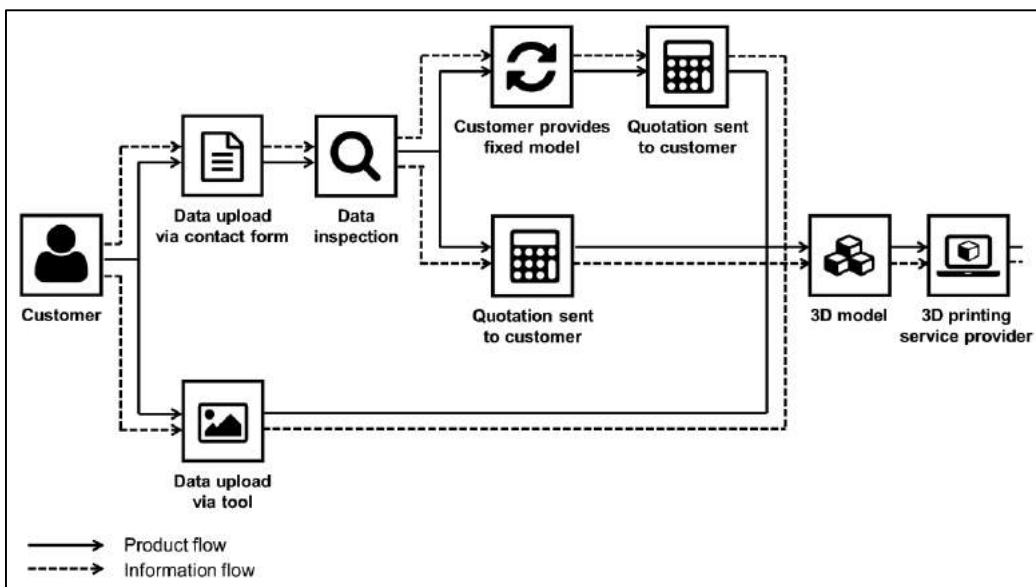
Figure 3: Supply chain of the upload services module

Following the manufacturing process, the final stage of the cycle involves the packaging and shipment of the final product. Packaging for 3D printing goods tends to be tailored to

their size and material of the end-product. Distribution is generally carried out by third party logistics provider or by customer collection at a retail location of the company.

It is important to note that a large number of service providers chose to not only offer 3D printing services, but also provide additional 3D printing-related products and services. These included consulting, educational workshops and seminars, 3D printing equipment repair or rental, as well as the sale of 3D printers, 3D scanners, accessories and filament.

CONCLUSIONS

The initial data gathered revealed that there are multiple areas in which the service providers could improve their operations, including but not limited to, the overall accessibility of the services, the choice of ordering and communication channels, the complexity of the supply chain, customer data handling and the consideration of copyright. Furthermore, 3D printing service providers should aim to reduce the complexity of their operations and improve their service offerings by outsourcing their manufacturing activities to a broad range of 3D printing specialists, shifting the focus of their activities to offering an attractive package of design-oriented services. Developing a lean business model and supply chain model will become increasingly important in the future, owing to the comparatively low barriers to entry. These conditions will allow anyone ranging from private owners of 3D printers to established retail chains to quickly start competing on the market for such services. Further work is now warranted to better understand the current supply chain models, in particular for selective services that offer customers the opportunity to choose a pre-existing model from the service provider's databases and the role played by auxiliary services. This will then lead to the development of alternative future business models and supply chain scenarios.

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A REVISED BIBLIOGRAPHIC ANALYSIS OF THE LEAN LITERATURE

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1. INTRODUCTION

As part of an ongoing stream of research into the conception of 'value' within logistics and supply chain management (SCM), the authors presented a working paper at ISL 2015 (Francis *et al*., 2015) that explored the interpretation of this concept within the Lean operations and management paradigm (after Womack and Jones, 1996). Our paper presented an evolving bibliographic analysis (BA) approach. Using that approach, it drew upon Google Scholar to identify the most highly cited Lean publications. Using this as a starting point, the purpose of our ISL'16 paper is to detail a more fully developed BA method that draws upon Scopus as well as Google Scholar, to first identify and then characterise the top 50 most highly influential publications on Lean as measured by citation. This method yielded rich findings. However, inherent space constraints preclude the detailing of these. As a consequence, the following paper focuses on explaining the method and the top 50 publications identified by using it. The ISL'16 conference presentation at Kaohsiung will be dedicated to the characterisation and analysis of these findings, although a brief overview of some of the key summary statistics and top 50 Lean publications is provided within the discussion section of this paper.

2. METHODOLOGY

An overview of the BA method developed for this exercise is presented in Figure 1. The first step in this method was to select the bibliographic databases that were to form the source of the raw material for subsequent analysis. Recalling that the intent was to identify the most highly *cited* publications, then such databases were to be limited to those that provided *citation statistics* per individual publication. The extensive personal experience of the authors with the Lean literature suggested that this topic is highly un-theoretical, and that many of the most influential publications were likely to be books and reports as opposed to journal papers. Google Scholar (GS) was consequently selected as the first database as this claims to be among the most extensive of indexing sources, and includes such publication types. However, in order to triangulate the journal papers that were identified via GS, it was decided to also use a second database that was dedicated to academic journal articles. After deliberation, Scopus (SS) was selected as this is the most extensive abstract and citation database of this type; covering nearly 22,000 journal titles from over 5,000 publishers, of which 20,000 are peer-reviewed journals in the scientific, technical, medical, and social sciences.

Having established the databases, the second step was to formulate the key word (KW) search strategy. Even though 'Lean' can boast a lineage of over three decades (Francis *et al*., 2015), it suffers from an issue of interpretive viability (after Benders & van Veen, 2001), whereby the term means different things to different people within the operations and management field (Papadopoulou & Ozbayrak, 2005; New, 2007, Shah & Ward, 2007). Taken in conjunction with lay meanings of the word 'Lean', this issue poses a particular challenge to constructing a KW search strategy that will identify the population set of publications that are specifically and most pertinent to the Lean paradigm. In due course, we chose to use six separate KW search queries across GS, and then duplicate these across SS (ie twelve KW searches in total). Each KW search was for an *exact phrase match* in the article *title*, with no date restrictions and for articles only (excluding patents, case law and citations). Based upon a consensus between the authors, the six selected Lean synonym KW phrases were: '*lean manufacturing*', '*lean production*', '*lean thinking*', '*lean management*', '*value stream*' and '*Toyota*'. These were identified as S1-S6 respectively, and prefixed with a 'G' for the searches across GS and 'S' for those across Scopus (ie the use of KW search phrase '*lean thinking*' across Scopus is labelled 'SS3').

Figure 1. Overview of revised bibliographic analysis method
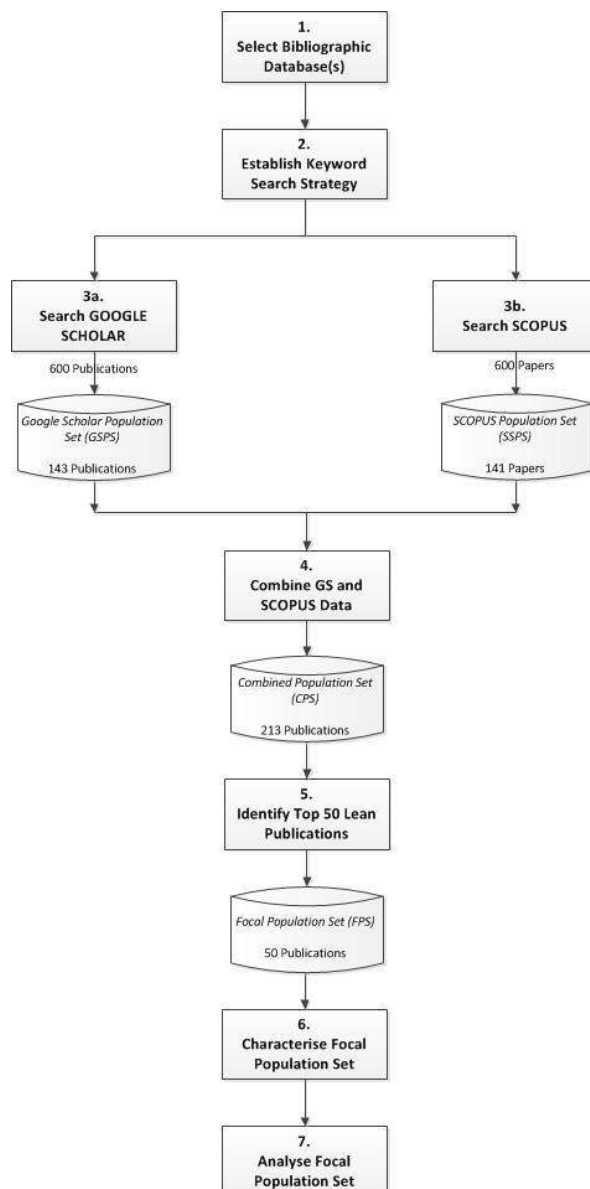
Any number of additional KW search phrases could have been added to increase the relevance of the identified population set, but some practical limit needed to be established. For example, we subsequently chose not to use the potential synonyms '*Japanese manufacturing*' or '*world class manufacturing*'. We likewise chose not to use any of the many Lean tool specific phrases such as '*kanban*', *kaizen*' or '*SMED*'. This was because a 'sanity check' of the population set derived using G/SS1-6 revealed that these additional phrases would yield a diminishing marginal return of relevant publications; ie those with a high enough citation count to be included in the *Combined Population Set (CPS)* – see following. The only exception to this was Womack *et al*.'s seminal (1990) book entitled *The Machine That Changed the World*, which is the most highly cited of all Lean publications[1]. However, the authors decided that the inclusion of an additional KW search phrase specifically to include this single publication would represent an inappropriate distortion. This omission should therefore be recognised as a notable limitation.

Step 3 of the method was to now implement this KW search strategy. The six KW searches were first applied to GS. Each individual search (GS1-6) presented its results in the sequence of highest to lowest number of citations per publication. For some searches, thousands of publications were identified. The top 100 *most relevant* publications for *each* such search were then identified, and the full reference details copied into an Excel spreadsheet. This entailed reading the abstracts of each publication to ensure relevance to the Lean paradigm in question, until the 100 most highly cited relevant publications were identified. For example, many of the publications identified by GS6 '*Toyota'* concerned technical issues such as the Prius' power train rather than the Toyota Production System (synonym of Lean), and needed to be rejected for our purposes. The net result was 600 individual reference details contained within the spreadsheet. These were then merged and [the many] duplicate entries removed to form a *Google Scholar Population Set (GSPS)* of 143 unique Lean publication reference details; ranked in descending total GS citations sequence. The KW search strategy implementation exercise was then repeated within Scopus (SS1-6) to yield a further 600 individual reference details, which were copied into a separate spreadsheet. Again, these were merged and the duplicates removed to form a *Scopus Population Set (SSPS)* of 143 unique Lean academic journal paper reference details; ranked in descending total SS citations sequence.

Step 4 was to combine the GSPS and SSPS to form the *Combined Population Set (CPS).* Where a [journal paper] publication appeared in both the GSPS and SSPS, its GS and SS citation counts were *added together* to form a *total citations* figure. This is contentious as there is a clear risk of 'double counting' some of the same citation sources. However, due to the number of citations attributed to each of the publications that made it into the CPS, it was not practical to deconstruct and compare these sources. It was also felt that this simple cumulation of the two database citation totals would reflect the importance of those publications that were influential enough to have been included in both database population sets. After the above exercise was completed, there were 213 unique publication details remaining in the CPS.

Step 5 was a simple process that involved ranking the CPS in descending total citations sequence, then copying the top 50 most highly cited into a separate Excel spreadsheet to form the *Focal Population Set (FPS).* This marked the start of Step 6, which involved establishing the structure and content of the data fields summarised in Figure 2 for every FPS publication. The *IDENTIFICATION* and *REFERENCE DETAILS* were yielded during the course of the previous steps.

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[1] 13,376 citations on Google Scholar when checked on 02/02/2016.

However, characterisation of the subsequent data fields necessitated additional processing. Completion of the *ABS (2015) DETAILS* simply required reference to ABS (2015) for each journal paper concerned. The remaining details required more extensive effort.

Table 1. The focal population set (FPS) record structure

FIELD	COMMENT
IDENTIFICATION DETAILS	
Rank number (total citations)	Rank 1-50 based upon *Total citations* figure.
Total citations	*GSPS total citations* + *SSPS total citations*.
Rank number (average citations per annum)	Rank 1-50 based upon *Average citations per annum* figure.
Average citations per annum	*Total citations* / number of years since year of publication.
GSPS rank number	Publication rank posn. within GSPS (based on *GSPS total citations*).
GSPS total citations	Total citations identified within GS for this publication.
GS source search	Source GS search that identified this publication (GS1-GS6).
SSPS rank number	Publication rank posn. within SSPS (based on *SSPS total citations*).
SSPS total citations	Total citations identified within SS for this publication.
SS source search	Source SS search that identified this publication (SS1-SS6).
REFERENCE DETAILS	
Authors	List of authors in Harvard format (surname, initials).
Year	Year of publication.
Publication title	The title of the book, paper.
Publication details	Publisher, place, journal title, volume, issue, pages, etc.
Publication type	'Book' or 'Journal Paper'.
Journal acronym	Unique acronym for journal title, if publication type 'Journal Paper'.
ABS (2015) DETAILS	
Listed?	Is the journal title listed in ABS (2015)?
Journal rank	The journal rank (1-4*) if the journal title is listed in ABS (2015).
Journal subject area	The journal subject area if the journal title is listed in ABS (2015).
FOCAL SUBJECT MATTER DETAILS	
Focal criterion	The focal criterion discussed (eg 'model changeovers').
Lean aspect	Aspect of Lean discussed (eg 'Application', 'Paradigm' or 'Tools').
Geographic context	The geographic location of fieldwork.
Sector/ industry domain	The sector/ industry within which the fieldwork was undertaken.
METHODOLOGICAL DETAILS	
Publication category	Based on the 'Article type' classification used by Emerald.
Methodological disclosure	Degree to which methods/ procedures explained/ justified.
Research strategy	Methodological strategy claimed (eg 'Case' or 'Survey').
Data collection instruments (DCIs)	List and number of data collection instruments (DCIs) used.
Type of data collected	Overarching approach ('Qualitative', 'Quantitative' or 'Mixed/ Both').
Type of data source	'Primary only', 'Secondary only', 'Primary & Secondary', 'Theoretical'.
Amount of source data	Actual data derived via the DCIs (extend of evidence base).
List of informants/ types	List and classification of informants (eg 'Executives', 'Managers' etc).
CONCLUSIONS	
Position/ conclusions on Lean	Position adopted on *Lean aspect* discussed within the publication ('Positive', 'Negative', 'Indeterminate').

Each of the 50 FPS publications was read then systematically scanned. Using the 'comment' feature of Excel, every sentence that was possibly pertinent to each of the remaining field entries was cut and pasted from the source publication into the spreadsheet cell comment space in order to form an 'evidence base' per publication/ field. On completion of this exercise, the authors were then able to establish the final content per field with reference to this evidence. For some of these fields, such as *Data collection instruments (DCIs)*, this entailed merely paraphrasing the evidence pasted into the associated cell comment space. However, for others, it necessitated the development and application of a taxonomy. For example, the development of the 'None', 'Partial' and 'Comprehensive' categories for the *Methodological disclosure* exhibited by a publication, along with the criteria for classifying each. Such an undertaking is by nature a subjective exercise. Therefore to maximise consistency, all such criteria were made explicit and transparent, and three independent iterations of this classification exercise were conducted by the authors to finalise the characterisation of the FPS that was analysed in Step 7 of the method summarised in Figure 1.

3. DISCUSSION

The KW search strategy developed and applied during Step 2-3 of the above method underscored the sheer scale of the Lean literature in terms of the number of 'hits' (publications matching the search criteria) achieved using each KW search query. These are summarised in Table 2, along with the associated hits for each query when 'anywhere in the article' rather than 'in the title of the article' was used as the exact phrase match criterion. This table clearly reveals that the citations indexed in GS are of a significantly larger scale than Scopus. It also reveals that hits achieved for each phrase are proportionally comparable between GS and SS in each case.

Table 2. Scale of the lean literature

	IN THE TITLE OF THE ARTICLE (About …)	ANYWHERE IN THE ARTICLE (About …)
GOOGLE SCHOLAR (GS1-6)		
GS1 (*Lean manufacturing*)	2,090	35,300
GS2 (*Lean production*)	1,470	54,400
GS3 (*Lean thinking*)	617	20,400
GS4 (*Lean management*)	1,020	22,800
GS5 (*Value stream*)	831	22,800
GS6 (*Toyota*)	2,630	429,000
SCOPUS (SS1-6)		
SS1 (*Lean manufacturing*)	391	1,944
SS2 (*Lean production*)	381	4,700
SS3 (*Lean thinking*)	143	569
SS4 (*Lean management*)	311	4,049
SS5 (*Value stream*)	200	11,013
SS6 (*Toyota*)	328	1,218

The 213 publications represented in the CPS established in Step 4 represented a total of 68,950 citations. This was composed of 32 books (15%) yielding 25,055 citations (36%), 3 conference papers (1%) yielding 305 citations (0.5%), 2 reports (1%) yielding 241 citations (0.5%) and 176 journal papers (83%) drawn from 91 separate journal titles yielding 43,349 citations (63%).

By contrast, the 50 publications of the FPS established in Step 5 of the method represented a total of 52,745 citations (equivalent to 77% of the CPS total). The FPS was composed of 14 books (28%) yielding 22,877 citations (43%) and 36

journal papers (72%) yielding 29,868 citations (57%). There were no conference papers or reports.   The key identification and reference details of the FPS are summarised in Table 3. Those [journal papers] that were identified via both GS and Scopus are highlighted in bold.

Table 3. Top 50 most highly cited Lean publications

RANK NO.	TOTAL CITATIONS	AUTHOR(S)	YEAR	PUBLICATION TITLE	PUBLICATION DETAILS
1	6,729	Womack, J.P. and Jones, D.T.	1996, 2010	*Lean Thinking: Banish Waste and Create Wealth in your Corporation*	Simon & Schuster: New York
2	**4,751**	**Dyer, J and Nobeoka, K**	**2000**	**Creating and managing a high performance knowledge-sharing network: the Toyota case**	***Strategic Management Journal, 21(3), pp.345-367.***
3	4,329	Ohno, T	1988	*Toyota Production System: Beyond Large-Scale Production*	Productivity Press: New York
4	3,747	Liker, JK	2005	*The Toyota Way*	McGraw-Hill: New York
5	**1,920**	**Shah, R and Ward, PT**	**2003**	**Lean manufacturing: context, practice bundles, and performance**	***Journal of Operations Management, 21(2), pp.129-149***
6	**1,804**	**Naylor, B, Naim, MM and Berry, D**	**1999**	**Leagility: integrating the lean and agile manufacturing paradigms in the total supply chain**	***International Journal of Operations and Production Management, 62(1-2), pp.107-118.***
7	1,679	Monden, Y	2011	*Toyota Production System: An Integrated Approach to Just-In-Time*	4th ed, CRC Press: Boca Raton, Florida
8	1,545	Shingo, S	1989	*A Study of the Toyota Production System: From an Industrial Engineering Viewpoint*	Productivity Press: New York
9	**1,520**	**Adler, PS, Goldoftas, B and Levine, DI**	**1999**	Flexibility versus efficiency? A case study of model changeovers in the Toyota production system	***Organization Science, 10(1), pp.43-68.***
10	**1,317**	**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***
11	1,310	Spear, S and Bowen, HK	1999	Decoding the DNA of the Toyota Production System	*Harvard Business Review,* Sept-October, 77(5), pp.96-106.
12	**1,297**	**Sugimori, Y, Kusunoki, F, , Cho, F and Uchikawa, S**	**1977**	**Toyota production system and kanban system materialization of just-in-time and respect-for-human system**	***International Journal of Production Research, 15(6), pp.553-564***
13	**1,286**	**Shah, R. and Ward, P.T.**	**2007**	**Defining and developing measures of lean production**	***Journal of Operations Management, 25(4), pp.785-805***
14	1,259	Rother, M and Shook, J	2003	*Learning to See: Value Stream Mapping to Add Value and Eliminate Muda*	The Lean Enterprise Institute: Cambridge, MA.
15	**1,040**	**Holweg, M**	**2007**	**The genealogy of lean production**	***Journal of Operations Management, 25(2), pp.420-437***
16	972	Krafcik, JF	1988	Triumph of the Lean Production System	*Sloan Management Review, 30 (1), pp.41-52.*
17	**950**	**Hines, P and Rich, N**	**1997**	**The seven value stream mapping tools**	***International Journal of Operations and Production Management, 17(1), pp.46-64.***
18	**828**	**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.***
19	**779**	**Davies, A**	**2004**	**Moving base into high-value integrated solutions: a value stream approach**	***Industrial and Corporate Change, 13(5), pp.727-756.***
20	**750**	**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***
21	681	Morgan, JM and Liker, JK	2006	*The Toyota Product Development System*	Productivity Press: New York
22	659	Ward, A, Liker, JK, Cristiano, JJ and Sobek II, DK	1995	The second Toyota paradox: how delaying decisions can make better cars faster	*MIT Sloan Management Review, Spring,* 36(3), pp.43-61
23	**658**	**Karlsson, C and Ahlstrom, P**	**1996**	**Assessing changes towards lean production**	***International Journal of Operations and Production Management, 16(2), pp.24-41.***

24	646	**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.
25	640	**Bruce, M, Daly, L and Towers, N**	**2004**	**Lean or agile: a solution for supply chain management in the textiles and clothing industry?**	*International Journal of Operations and Production Management,* 24(2), pp.151-170.
26	583	Liker, JK and Meier, D	2006	*The Toyota Way Fieldbook*	McGraw-Hill: New York
27	522	**MacDuffie, JP and Helper, S**	**2002**	**Creating lean suppliers: Diffusing lean production through the supply chain.**	*California Management Review,* 39(4), pp.118-151.
28	494	**Lewis, MA**	**2000**	**Lean production and sustainable competitive advantage**	*International Journal of Operations and Production Management,* 20(8), pp.959-978.
29	492	Cusumano, MA and Nobeoka, K	1998	*Thinking Beyond Lean: How Multi-Project Management Is Transforming Product Development at Toyota and Other Companies*	The Free Press: New York
30	464	**Spear, SJ**	**2004**	**Learning to lead at Toyota**	*Harvard Business Review,* May, 82(5), pp.78-86.
31	452	Berggren, C	1993	*Alternatives to lean production: Work organization in the Swedish auto industry*	Cornell University Press: Ithaca, NY.
32	421	Dennis, P	2007	*Lean Production Simplified: A Plain-Language Guide to the World's Most Powerful Production System*	2nd ed., Productivity Press: New York
33	451	**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.
34	407	**Parker, SK**	**2003**	**Longitudinal effects of lean production on employee outcomes and the mediating role of work characteristics**	*Journal of Applied Psychology,* 88(4), pp.620-634
35	430	Dahlgaard, JJ and Dahlgaard-Park, SM	2006	Lean production, six sigma quality, TQM and company culture	*TQM Magazine,* 18(3), pp.263-281
36	394	**Pettersen, J**	**2009**	**Defining lean production: some conceptual and practical issues**	*The TQM Journal,* 21(2), pp.127-142
37	390	**Sako, M**	**2004**	**Supplier development at Honda, Nissan and Toyota: comparative case studies of organizational capability enhancement**	*Industrial and Corporate Change,* 13(2), pp.281-308.
38	387	Arnheiter, ED and Maleyeff, J	2005	The integration of lean management and six sigma	*TQM Magazine,* 17(1), pp.5-18
39	382	Feld, WM	2000	*Lean Manufacturing: Tools, Techniques, and How to Use Them*	CRC Press: Boca Raton, FL
40	366	**De Treville, S and Antonakis, J**	**2006**	**Could lean production job design be intrinsically motivating? Contextual, configurational, and levels-of-analysis issues**	*Journal of Operations Management,* 24(2), pp.99-123
41	354	**Pavnaskar, SJ, Gershenson, JK and Jambekar, AB**	**2003**	**Classification scheme for lean manufacturing tools**	*International Journal of Production Research, 41(13), pp.3075-3090*
42	347	**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 Research,* 129(2), pp.251-261
43	327	Rinehart, JW, Huxley, CV and Robertson, D	1997	*Just another car factory?: Lean production and its discontents*	Cornell University Press: Ithaca, NY.
44	319	Womack, JP and Jones, DT	1996	Beyond Toyota: how to root out waste and pursue perfection	*Harvard Business Review, Sept-October,* 74(5), pp.140-158
45	312	**Liker, JK and Morgan, JM**	**2006**	**The Toyota way in services: the case of lean product development**	*The Academy of Management Perspectives,* May, 20(2), pp.5-20.
46	310	**Lincoln, JR, Ahmadjian, CL and Eliot, M**	**1998**	**Organizational learning and purchase-supply relations in Japan: Hitachi, Matsushita, and Toyota compared**	*California Management Review,* Spring, 40(3), pp.241-264.
47	309	**Forza, C**	**1996**	**Work organization in lean production and traditional plants: what are the differences?**	*International Journal of Operations and Production Management,* 16(2), pp.42-62.
48	304	Liker, JK and Hoseus, M	2008	*Toyota Culture*	McGraw-Hill: New York

| 49 | 303 | 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. |
| 50 | 301 | **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** |

4. CONCLUSIONS

As indicated in the Introduction to this paper, the analysis and hence conclusions drawn will be detailed during the ISL'16 conference presentation session at Kaohsiung. However, even the brief summary statistics presented in the previous section lead us to conclude that the Lean literature is indeed vast and continuing to grow, underlining its continuing influence within the field of operations and supply chain management. The proportion of the FPS made up of academic journal papers (72%) was a genuine surprise, and seems in conflict to the claim made by some commentators that the Lean paradigm is inherently a-theoretical in nature. However, by contrast the [citation] influence of the books contained within the FPS is in no doubt, as the average number of citation per book was 1,634 as opposed to an average of 830 citations per journal paper (nearly twice as much). Interestingly these books were overwhelmingly categorised as 'Viewpoints' (journalistic opinion pieces). This dichotomy and other issues will be explored in more detail at Kaohsiung.

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A WIREFRAME MANUFACTURER UTILIZING A 3D PRINTING TECHNOLOGY TO THE PRODUCTION SYSTEM: PROSPECTS OF SUCCESS AND FAILURE

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INTRODUCTION

The development of three-dimensional (3D) printing technology has had a strong impact on the manufacturing industry (Anderson, 2012). This technology allows 3D replication of solid objects and can virtually shape any item from a digital graphics file using a powder or resin. The range of applications for this manufacturing technology is extensive and includes applications in the automobile industry, consumer electronics, medical organs, and architectural models (Foroozmehr, et. al., 2011. Karunakaran, et. al., 2010. Kenney, 2013). The price of a 3D printer for personal use, which has limited functions, is less than 100,000 yen.

Nakamura (2015, 2014) advanced research focused on investigating cost structure, in-process, and product inventory when introducing 3D printer technology to manufacturing companies. The following issues and considerations are taken from this research:

  i. Scheduling: 3D printing is suitable for build-to-order manufacturing products, based on customer requests for original products. It is also fit to made-to-stock manufacturing products. Therefore, scheduling management is important to maintain efficient operations.
  ii. Delivery time and place: 3D printing does not require a factory and can be performed anywhere. Various options can be considered, such as those close to a consumer, facilities that are more cost effective, and those with suitable infrastructure systems.
  iii. Stock levels: 3D printing is suitable for build-to-order manufacturing and customizing products because the process uses a single material to create a product. As a result, there is no in-process inventory.
  iv. Business management: If 3D printing technology can make parts and in-process products, 3D printers can be used on-site rather than in specialized facilities. It can also be used to create parts during the manufacturing process. Therefore, decision-making in business management has to change according to human resources and goods and money allocation.

Currently, research is taking the next step by applying 3D printing in real companies. This paper focuses on a plastic wireframe (PW) company to determine company-specific issues and discuss how the PW company could introduce 3D printing technology. Merit, demerit, and competition elements are relevant to this case as well as the different process and cost structures, which were determined using Integration Definition for Process Modelling 0 (IDEF0) (Kumagai, 1998). To investigate delivery time and placement of the 3D printing technology, a simulation was conducted to determine a production plan, cost, profit, delivery time, and location. Ultimately, this study discusses the introduction of 3D printing technology in a real company and outlines future problems and possibilities.

ABOUT THE PW COMPANY AND THE APPLICATION OF 3D PRINTING TECHNOLOGY
The PW company's overview and problems
The PW company makes a net from a plastic wire, which is used to remove and filtrate impurities. The denseness of the plastic decides the rate of filtration. Figure 1 illustrates the manufacturing process and time, cost, and stock management are explained for 1 m × 5 m plastic wire products. Weaving refers to the process of weaving nets in the machine, which requires a half day for completion.

The company requires made-to-stock production to maintain an inventory of 500–800 sheets. Currently, when a customer orders a product, employees loom the wire and cut it to the ordered size by hand over three days, which is a build-to-order process.

Weaving half day	1st set 1 H	Base fabric stock 500~800	Loom 3 days	2nd set 1 H	Product stock	Delivery 100~200
Make-to-stock			Build-to-order			
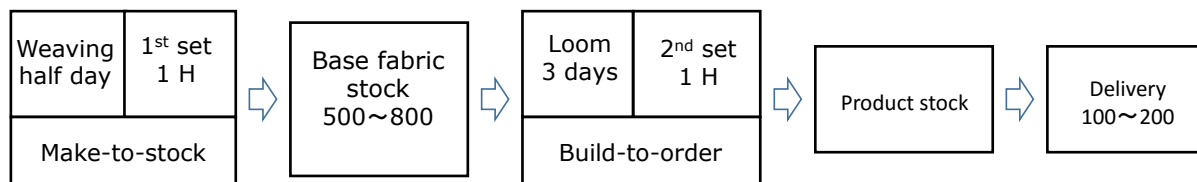
Figure 1: The process of making PW (current situation).

The issues with this process are:
· The looming process is done by hand, making it time consuming and expensive in terms of labor and product costs.
· During the final step in the process, product loss is common, creating a low rate of yield. This is why product is cut according to the ordered size.
· The final product is changed depending on the customer's order, which costs, time, money, and materials.

The case for introducing a 3D printer
In recent years, the PW company has used a production seat booking system (Tsubone, et. al., 2002), which takes into account sales, supply and demand adjustments, and the production process. This system was used to compare the current PW production process with a 3D printing production process. It also analysed the process using the IDEF0 method.

Figure 2 depicts the PW company's sales, supply and demand adjustments, and production process using the production seat booking system. The weaving scheduling was calculated based on fabric stock to decide on a framework for the material. The production capacity of the looming process was calculated based on a neck process. Using these calculations, real orders are booked through the production seat booking system.
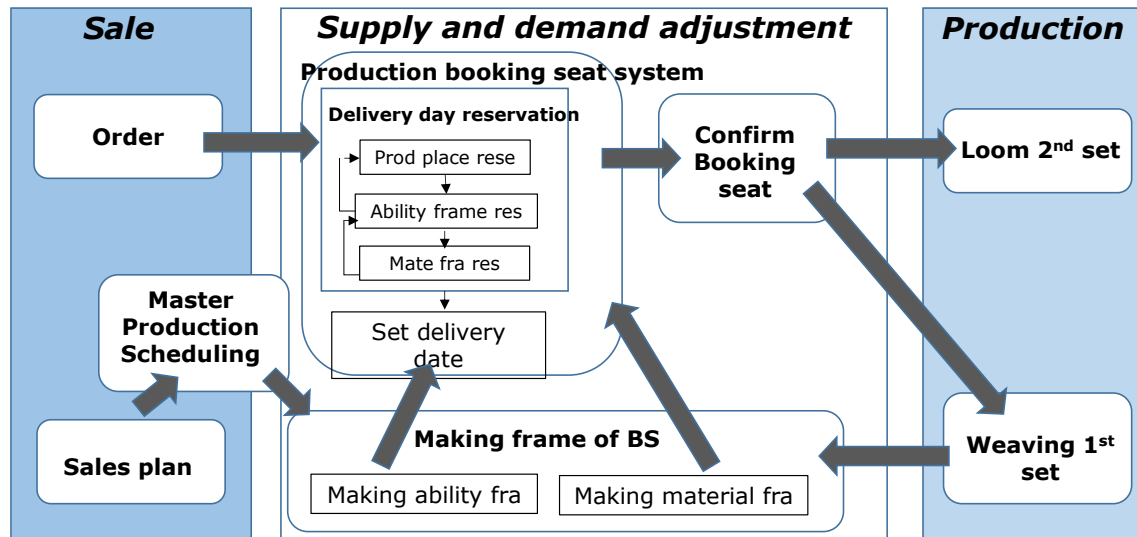
Figure 2: The sales, supply and demand adjustments, and production process of the PW company

Figure 3 illustrates the sales, supply and demand adjustments, and production process using 3D printing technology. Production ability was decided based on the running time for each location and machine. There were no intermediate materials. As a result, the standard production plan was made based on the sales plan. The 3D printer's production can be estimated using the costs of production order time, material consumption, and logistics. Because there is no yield loss with 3D printing technology, it is considered an additional type of production.
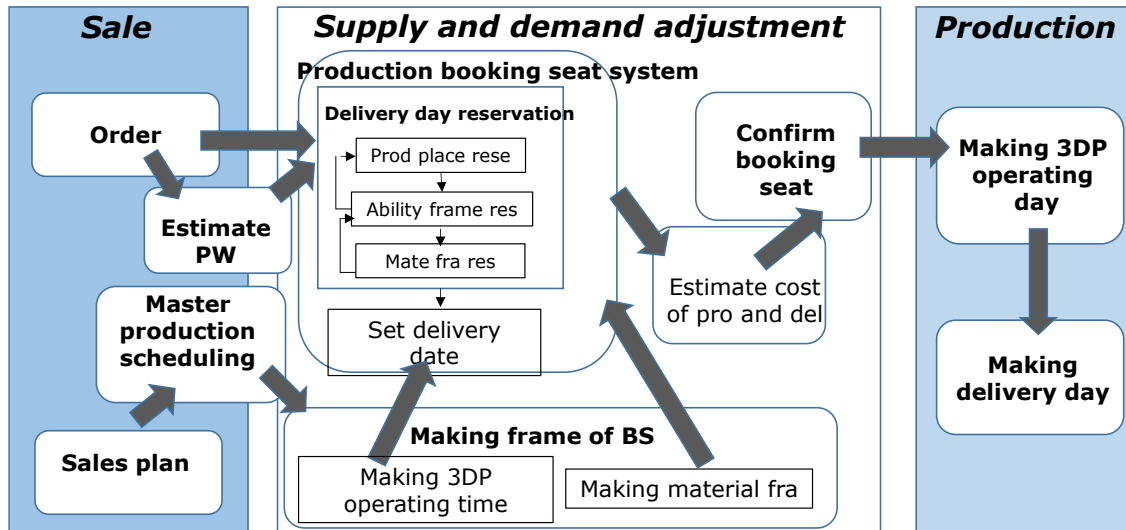
Figure 3: The sales, supply and demand adjustments, and production process using 3D printing technology

The processes were compared using the IDEF0 method (Figure4, Figure 5). Figure 5 shows the three steps to the printing-process: design, modelling, and inspection. The most significant difference between the two processes is the design step, which requires a specific file type (STL file) to create 3D products. The methods for making STL files are 3D CAD (a design software), 3D CG (a design software), and a 3D scanner. This design information sets the modelling, testing, and delivery times. Therefore, it is important that

design information be fully understood to ensure the process is completely correctly (Nakamura, et. al., 2015).
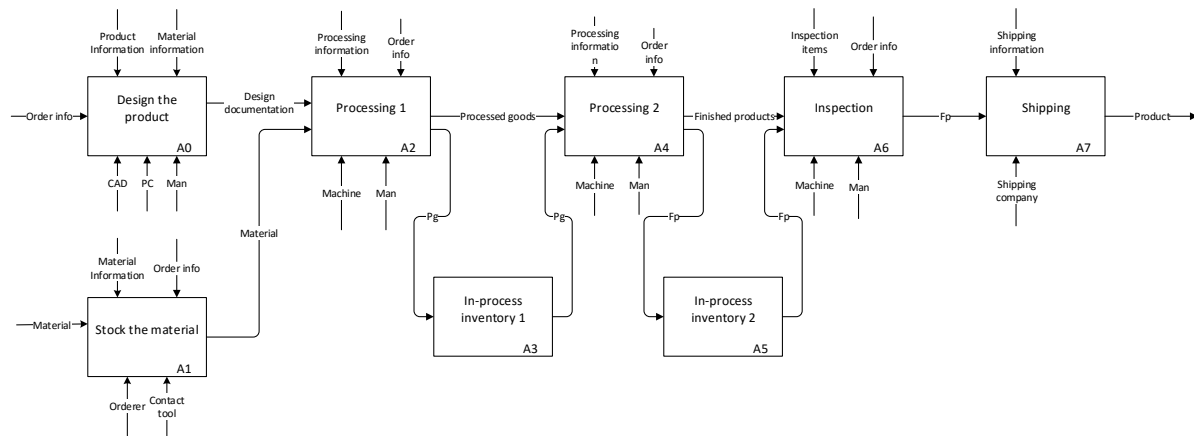
Figure 4: IDEF0 for the PW company's
current production process
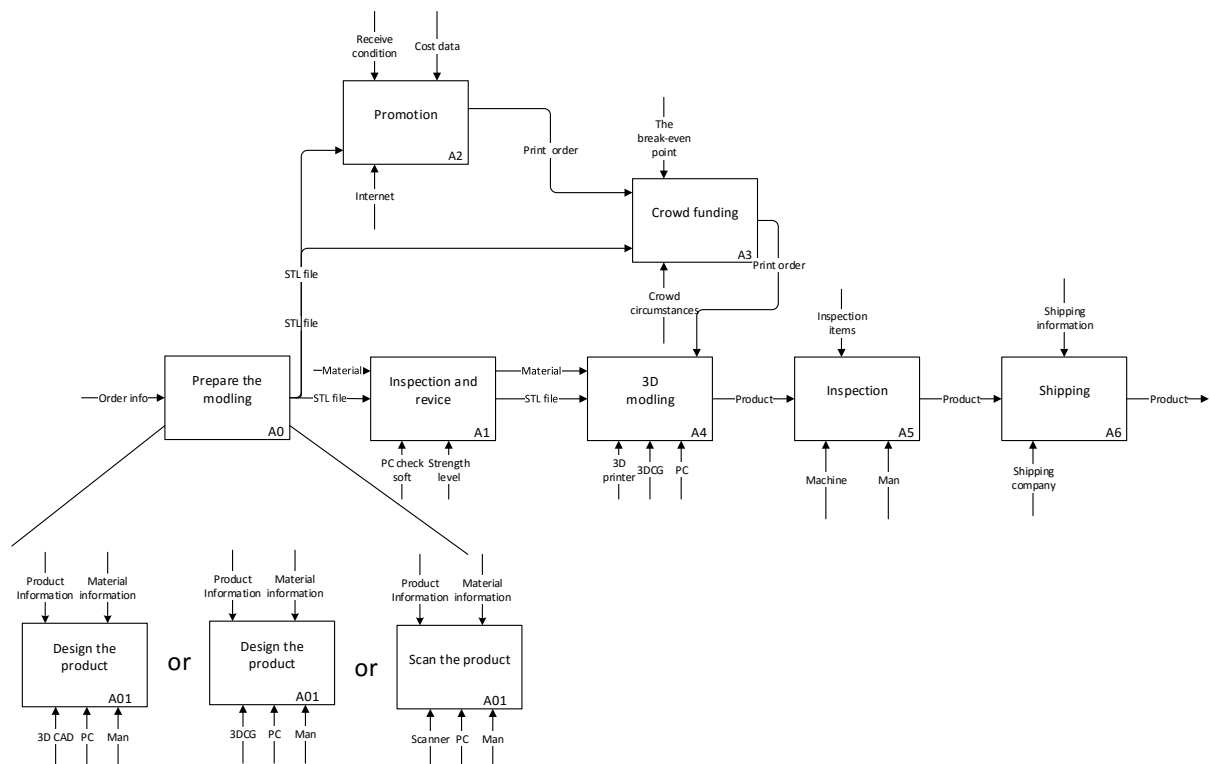
Figure 5: IDEF0 for the production process
using 3D printing

OUTLINE OF THE SIMULATION MODEL
Overview of model prerequisites
Figure 6 depicts the model used for this research. First, the PW company receives orders from customers. After receiving these orders, the production booking seat decides on and sends instructions a 3D printing company. At the same time, management calculates and evaluates raw material costs, process and printing costs, delivery costs, a rate of derivative achievement, and a rate for operation.
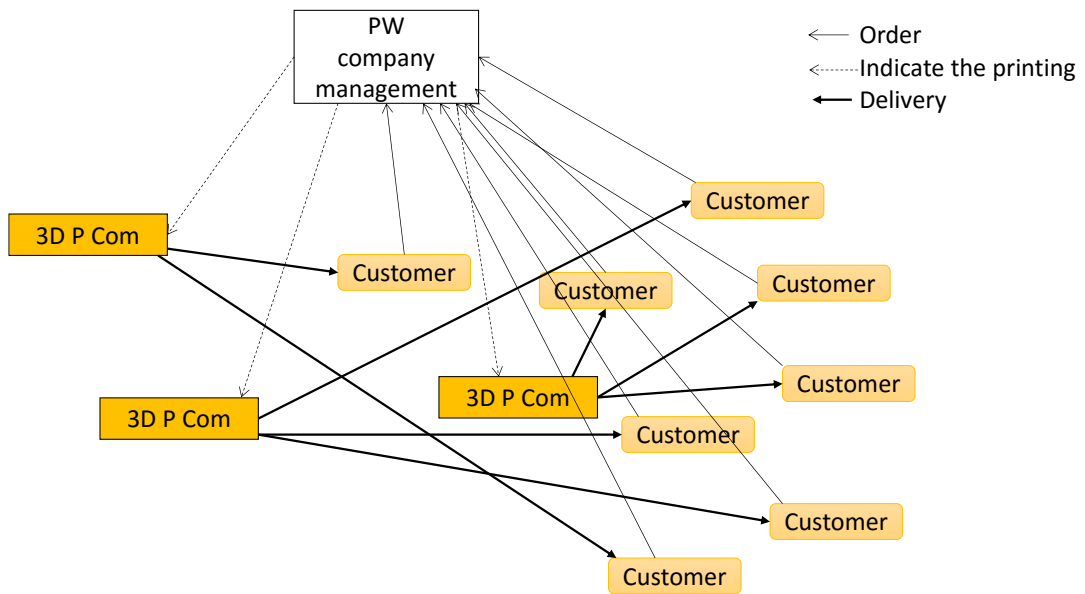
Figure 6: Basic model of the simulation.

The prerequisites are:

· Build-to-order manufacturing only.
· Ability to change depending on the situation.
· Ability to adjust to changing conditions, such as the distance between customers and the 3D printing company and demand decided by the company.
· Company management has one, the 3D printing companies have three, and customers are random.
· The location of the 3D printing company is set in 10 rows and 10 columns (Figure 7).
· The number of orders in one day follows a normal distribution with an average of 2 and a standard deviation of 1.
· Customer ordered product size follows normal distribution.
· Allocation of booking seats fills early schedules and openings (Figure 8).
· The simulation is performed 500 times.
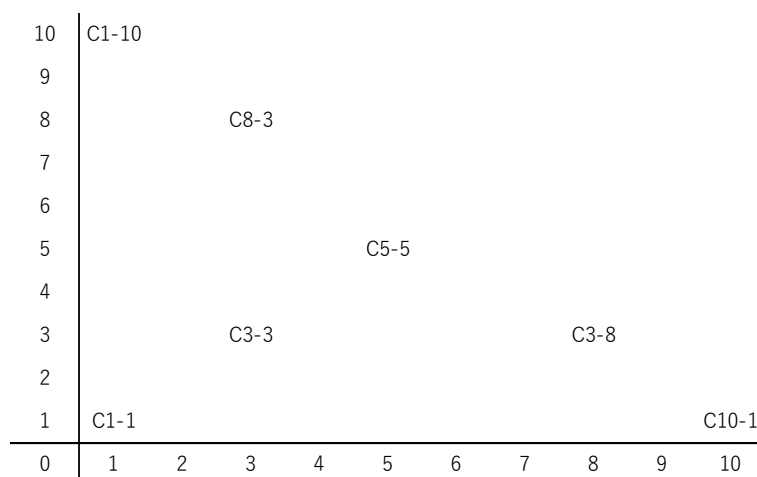
Figure 7: Location of the 3D printing company
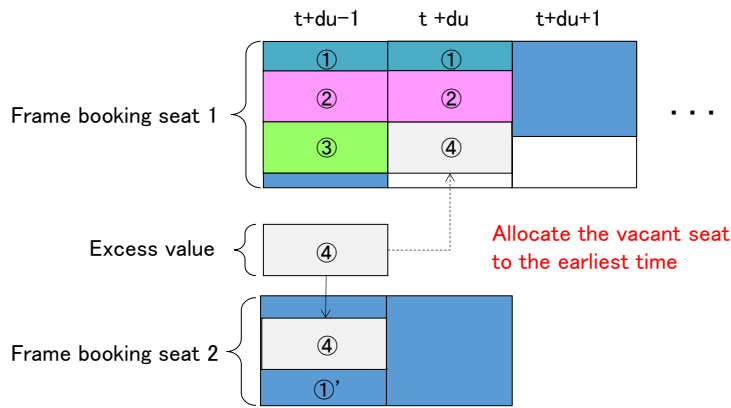
Figure 8: Image of seat allocation

Setting the cost and evaluation functions

The evaluation of cost and time uses a matrix formula because it adjusts the IDEF0 process to a mathematical expression and analyses variations in parameters.

Cost matrix as follows:

$$(C1\ C2\ C3) = \begin{bmatrix} \text{Amount of materials 1} & \text{Processing time 1} & \text{Amount of delivery 1} \\ \text{Amount of materials 2} & \text{Processing time 2} & \text{Amount of delivery 2} \\ \text{Amount of materials 3} & \text{Processing time 3} & \text{Amount of delivery 3} \end{bmatrix}$$

$$\times \begin{bmatrix} \text{Material unit price} & & \\ & \text{Processing unit price} & \\ & & \text{Delivery unit price} \end{bmatrix} \begin{bmatrix} \text{Order volume 1} \\ \text{Order volume 2} \\ \text{Order volume 3} \end{bmatrix}$$

$$(1)$$

Assessment functions of the simulator are from a rate of delivery achievement time and a rate of occupancy. They are as follows:

$$\text{The rate of delivery achievement time} = \frac{\text{Request delivery time from users}}{\text{Term from the order to delivery}} \tag{2}$$

$$\text{The rate of occupancy} = \frac{\text{Time of the seating occupancy}}{\text{3D printer's operating time}} \tag{3}$$

Simulation results and discussion

Table 1 shows the output for the average raw material cost, the average process and printing costs, delivery costs, the rate of derivative achievement, and the rate of operation. The conditions are categorized as three 3D printer companies and two types of 3D printing abilities. The differences in printing capacities include the average process and printing costs and the rate of operation. For the process and printing costs, it is possible to print efficiently by setting the various printers. For the rate of operation, eight values are border, while efficiency is not. As a result, 4 and 5 are more efficient than the other categories.

The most efficient arrangement uses the data envelope analysis (DEA) method (Cooper, 2006). Input values are averaged based on raw material costs, process and printing costs, and derivative costs. Output values are measured using the rate of derivative achievement and the rate of operation. For the assessment values, 1 is efficiency, 2 and 5 have the same ability, and 5 has a different 3D-printing ability. Additionally, shipping costs are better when the location of the printer is centralized, and the rate of derivative achievement

Table 1 : Outputs of the index

3D Ability	Coordinate	Input			Output		Efficiency value
		Average raw material costs	Average process and printing costs	Delivery costs	The rate of derivative achievement	The rate of operation	
Same	① All C5-5	40,380.411	6,260.766	3.567	69.497	7.458	0.914
	② C10-1,C1-1,C1-10	39,730.452	6,121.682	7.813	77.490	7.940	1
	③ C3-8,C3-3,C8-3	39,887.168	6,219.820	4.541	78.376	7.726	0.997
	④ C10-1,C5-5,C1-10	39,925.138	6,201.335	6.183	75.150	8.105	0.983
	⑤ C3-8,C5-5,C8-3	39,734.080	6,161.992	4.317	76.494	8.038	1
Different	① All C5-5	39,928.607	6,047.677	3.580	74.948	5.708	0.991
	② C10-1,C1-1,C1-10	39,968.078	6,018.470	7.646	86.373	6.017	0.989
	③ C3-8,C3-3,C8-3	40,141.064	6,074.963	4.516	88.911	5.970	0.998
	④ C10-1,C5-5,C1-10	40,119.015	6,103.163	5.669	84.462	6.418	0.981
	⑤ C3-8,C5-5,C8-3	40,105.046	6,066.257	4.117	89.282	5.933	1

and the rate of operation are higher when 3D printer capabilities are the same for every situation. However, the resulting efficiency values differ among the three printers. These output values provide strategic guidance for introducing 3D printing technology to manufacturing companies.

CONCLUSION

This study examined problems and considerations the PW company may face while introducing 3D printing technology to their manufacturing process. This study reviewed the delivery time and printer location based on a simulation using the production booking seat system. The output of the simulation considered the cost, rate of derivative achievement, and rate of operation using the DEA method. When analysing the rate of derivative achievement, stock views were added to assess the 3D printer's ability to handle rapid growth. Overall, 3D printing is not only a manufacturing innovation but also an innovation that will facilitate significant changes to SCM. Additional research is required to expand understanding of the benefits of 3D printing using similar simulations that incorporate realistic data and the rules of the production booking seat system.

ACKNOWLEDGMENTS

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FROM SUPPLY TO DEMAND TO DEMAND SUPPLY CHAIN MANAGEMENT: A LITERATURE REVIEW

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ABSTRACT

This paper reviews the literature on supply chain management and contributes a set of findings that capture the state-of-the-art in the field. A total of 194 articles published in the last three decades on supply chain management and related topics have been systematically reviewed according to the year of publication, focus of the study and research method employed. The findings reveal that, to adapt to the ever changing business environment and advancement in technology, design and management of a supply chain has gone through a few major changes in focus ranging from cost cutting to value creation to total integration. Supply chain design has evolved from the product categorization approach, the one-size-fits-all lean or agile solution, to the latest dynamic network alignment model. Similarly, research on managing a supply chain has also undergone a few paradigm shifts with the attention placed mainly on the supply side (supply chain management) at the beginning, then on the demand side (demand chain management), and lately on integration and alignment of all involved business functions (demand supply management). This study may provide reference to researchers who wish to understand the development of research in supply chain management and guideline to practitioners in the supply chain management community for strategy formulation and decision making.

INTRODUCTION

With increasingly market volatility as a result of globalization, economic progress, political and social changes and technological advances, effective supply chain management (SCM) has become increasingly important for companies to adapt to rapid changes in external business environment (Lee 2004; Olavson, Lee & DeNyse 2010). Correspondingly, direction of SCM research has also gradually changed from proposing one-size-fit-all solutions focusing on upstream supply and production to more integrative solutions involving many functions and parties across the entire supply network (Sahin & Robinson 2002; Stavrulaki & Davis 2010).

A review of the SCM literature reveals a trend of changing foci of research in this field from proposing dynamic solutions and strategic frameworks for operational needs to

developing integrative solutions involving multiple processes across various functions. In the 1980s, most of the published journal articles on SCM suggested the leverage of information technology (IT) to enhance supply chain performance. For example, McFarlane (1984) studied the use of computer-based technology in business management to sharpen competitive while Porter and Millar (1985) advocated the use of information as a new approach to generating value. Basically, IT was seen as a vehicle to provide a new perspective of strategic thinking connecting supply and demand. In the 1990s, strategic solutions for integrating the two sides of a supply chain began to emerge. For examples, Fisher (1997) proposed a supply chain model based on product characteristics and classified products as functional and innovative. Naylor, Naim and Berry (1999) combined lean and agile strategies to develop leagile solution taking into consideration market knowledge and positioning of the decoupling point in the different stages of the supply chain process to leverage on postponement. In the 2000s, the idea of process alignment across different management functions was suggested which eventually led to a new research area. Lambert and Cooper (2000) put forward a conceptual framework comprising modules of business processes, components and structures. Subsequently, Rainbird (2004) strengthened the idea by specifying the business processes and components while Jüttner, Christopher and Baker (2007) framed this process into three layers comprising customer buying life cycle, demand, and supply processes. By the 2010s, more sophisticated solutions were proposed in Olavson, Lee and DeNyse's (2010) portfolio supply chain and Gattorna's (2010) dynamic supply chain framework. These solutions stressed not only the alignment between demand and supply processes but also the impacts of external competitive environment and internal corporate culture to achieve an overall strategic fit for the company.

To understand the paradigm shift in SCM, we conducted a systematic literature review on SCM related research in the last three decades using relevant keywords such as "supply chain process integration" and "demand chain management". A total of 194 articles were identified relating to paradigm evolution from supply chain to demand chain to demand supply chain management. Reviewing these articles related to supply chain management, we aim at examining the shifting research focus in the discipline and identifying the key stages of evolution in the main body of the SCM literature in the past thirty years. By examining the changes in the focus of research and research methods used in these studies, we attempt to pinpoint the major changes in the focus of investigation and highlight the latest trend in SCM research. The findings may provide valuable references to researchers who wish to understand the development of research in SCM and identify a niche for further investigation.

For the remaining of the paper, a comprehensive literature review on the shift in SCM research paradigms will be provided. This will be followed by the methodology adopted in this study. Then, findings of the review will be presented and discussed, from which conclusions will be reached to provide researchers with insight for future SCM research.

LITERATURE REVIEW

The study of SCM has evolved significantly in the last few decades. The term "supply chain management" was coined by Oliver and Webber (1982, p. 43) which notified the emergence of the SCM concept from the traditional logistical thinking in the 1970s. Booming solutions from a SCM perspective thrived in the 1990s and continued to the 2000s as the market became increasingly diverse. Definitions of SCM in diverse context

were also developed at a rapid pace. In the early 20th century when assembly line production method was invented, SCM solutions mainly focused on large-scale manufacturing with unit cost reduction. Lean production, originally derived from the Toyota Production System (TPS) (Ōno 1988), was one of the significant advancements in the 1990s promoting the use of barcodes, EDI and shipment marking for cost cutting and accuracy improvement (Abernathy et al. 2000). Waste reduction and time-based concept, such as Just-in-time (JIT) in "flow" operation, depicted the key value of supply chain operation for the industrial market in the 1990s (Liker & Choi 2004).

With continuing power transfer from the upstream suppliers to the downstream distributors, Porter and Millar (1985) put forward the concept of value chain. The notion advocated that value could be captured cross-functionally from the downstream distribution channels rather than the upstream network (Sahin & Robinson 2002). SCM processes were also categorized into primary activities including inbound logistics, operations, outbound logistics, marketing, and sales and service. Procurement, human resource management, technological development and infrastructure were considered as secondary activities. The value chain paradigm basically extended the understanding of SCM from upstream production-oriented cost control to downstream demand-driven value creation.

With the need to better match supply with demand and the emergence of information technology, more integrative solutions taking into consideration the advantage of combining various functions in the network were proposed. Fisher (1997) designed a supply chain model based on product characteristics, such as functional product or innovative product. To widen its application, Christopher, Peck and Towill (2006) modified Fisher's (1997) model by adding metrics of demands and lead time in the framework. Lee (2004, p. 89) presented an integrative solution labelled as triple-A supply chain contending that "only companies that build supply chains that are agile, adaptable, and aligned get ahead of their rivals. All three components are essential; without any one of them, supply chains break down."

Integrative solutions embracing multiple streams, such as marketing management and distribution logistics, soon became a research niche in the development of demand-driven supply chain. SCM solutions, such as lean, agile, leagile, or any combinations of these strategies were widely investigated taking supply chain as an integrative trade-off between efficiency and responsiveness (Naylor, Naim & Berry 1999; Christopher & Towill 2001; Huang, Uppal & Shi 2002). For example, Naylor, Naim and Berry (1999) advocated that the leagile paradigm would require an integrative supply chain view incorporating market knowledge and appropriate positioning of the decoupling point. As such, agile manufacturing would be more suitable to satisfy fluctuating demand whereas lean manufacturing would be more appropriate for production with a level schedule.

Apart from the proliferation of integrative SCM solutions, web-based IT application to achieve end-to-end process integration also became an extensively researched area. For example, Sahin and Robinson (2002) categorized from an operation management perspective the structures of coordination among processes based on level of information sharing and integration of physical flow. Christopher, Lowson and Peck (2004) also designed a framework for achieving agility in a fashion business considering process integration, network-based capability, market sensitive and virtual IT planning the main modules in an agile fashion supply chain. Web-based IT integration solutions, such as vendor managed inventory (VMI) and collaborative, planning, forecasting and

replenishment (CPFR), became popular methods to integrate manufacturers and brand-owners directly to improve efficiency and responsiveness (Cao et al. 2008; Flint 2004).

By the late 2000s, demand chain management (DCM) became an increasingly popular research area to help develop more specific customer-oriented supply solutions. Lambert and Cooper (2000, p. 73) put forward a framework fusing different processes together on the basis of an intricate network of business relationships and management processes. They included customer relationship management, customer service management, demand management, order fulfilment, manufacturing flow management, procurement, product development and commercialization and returns management. Walters and Rainbird (2004) enriched the idea by specifying a "micro" view of individual function process and differentiating it from the "macro" scenario under the DCM paradigm. Jüttner, Christopher and Baker (2007) advanced the concept further by suggesting a three-layered process integration model combining the customer buying life cycle with the demand and supply processes. Specifically integrated process was designed according to day-to-day supply and demand requirements which, in come cases, became a source of dynamics within the firm (Esper et al. 2010; Holmström et al. 2008; Rainbird 2004; Van Goor 2007). Christopher (2012) contended that business transformation from function-oriented to process-driven approach would lead to the creation of cross-functional teams focusing on value creation. This transformation was the main trigger for business to migrate from upstream-focused SCM to downstream-focused DCM. He opined that "companies that are able to respond rapidly to changing customer requirements tend to focus more on managing processes, which are the horizontal, market-facing sequences of activities which create value for customers. They are cross-functional by definition and are best managed through the means of cross-functional teams." (p.7)

As the global business environment became more unpredictable in the 2010s, DCM has further evolved to cope with the volatility. Gattorna (2010) coined the term dynamic supply chain and put forward a portfolio supply chain model which advocated the alignment of supply chain strategy with business strategy as well as the external competitive environment. The model offered a sophisticated framework taking into consideration the "volatile economy" and the changing environment defined by various economic factors, such as oil price, exchange rate, labour rate, tax policy, competitive force, and the maturity of product categories. While more market factors were taken into consideration in formulating solutions, Gattorna (2010, p. 42) stressed the important role of organizational behaviour in the dynamic alignment framework integrating marketing rules and internal supply chain strategies with internal culture and leadership style. In his regard, the emphasis on alignment of organization culture and leadership with external environment and a match of supply chain processes with customer needs had long been advocated by Chorn (1991), Godsell, Harrison, Emberson and Storey (2006), and Chopra and Meindl (2007).

In recent years, alignment of the organizational capabilities with internal and external process operation capabilities has become a newly-defined stream generally referred to as demand and supply chain management (DSCM). Hilletofth (2011, p. 200) defined the paradigm in the study of demand supply chain management as "an approach to achieve the strategic coordination of the demand and supply processes within a particular company and across the demand supply chain in order to provide superior customer value as cost efficiently as possible." In DSCM, "volatile environment" or "structural change" is regarded as a major source of supply chain uncertainty. To mitigate the risk, alignment is again the key. Internally, alignment could be achieved between market

management, supply process and organizational capabilities of a firm. Alignment should also be achieved between internal capabilities with the external market dynamism to achieve strategic fit.

METHODOLOGY

This study used a desktop research methodology to review articles on topics related to supply chain management published in major academic journals in the last three decades from 1984 to 2016. A keyword search in major digital academic journal databases including ScienceDirect, Emerald Insight, Wiley Online Library, and IEEE Xplore was launched. In addition, other sources such as Taylor & Francis Online, Inderscience Online, SpringerOpen, Institute for Operations Research and the Management Sciences, American Marketing Association, Harvard Business Review, Orion, and Supply Chain Management Review were also exploited. The keywords used in the search include "integrative supply chain", "demand and supply management", "value chain management", "demand chain alignment", "marketing and supply chain management", and "supply chain process alignment". As a result, a total of 194 articles (as of 28 April 2016) were gathered (See Table 1). They formed the dataset of this study for analysis.

Table 1: Statistics of articles on supply chain management sourced from literature

Year of Publication	Journal Title	Focus of Study
2016 (4)	Journal of Operations Management (37)	Supply Chain Management (36)
2015 (7)	International Journal of Production Economics (26)	Supply Chain Integration (33)
2014 (5)	Industrial Marketing Management (22)	Supply Chain Design (25)
2013 (3)	International Journal of Physical Distribution and Logistics Management (9)	Demand Chain Management (19)
2012 (13)	European Journal of Operational Research (8)	Value Chain (11)
2011 (12)	Supply Chain Management: An International Journal (8)	Alignment (11)
2010 (12)	Harvard Business Review (6)	Supply Chain Strategy (10)
2009 (12)	The International Journal of Logistics Management (6)	Information Systems on Supply Chain (9)
2008 (16)	Journal of Business Logistics (5)	Information Technology on Supply Chain (9)
2007 (7)	European Journal of Purchasing and Supply Management (4)	Customer Relationship Management (6)
2006 (13)	Industrial Management and Data Systems (4)	Supply Chain Collaboration (6)
2005 (14)	International Journal of Operations and Production Management (4)	Supply Chain Flexibility (5)
2004 (17)	Omega (4)	Supply Chain Alliance (4)
2003 (4)	Computers and Chemical Engineering (3)	Supplier Relationship Management (3)
2002 (12)	International Journal of Logistics Management (3)	Demand Supply Chain Management (2)
2001 (7)	European Management Journal (2)	Supply Chain Coordination (3)
2000 (13)	IBM Systems Journal (2)	Supply Chain Complexity (1)
1999 (5)	International Journal of Agile Management Systems (2)	Total Quality Management (1)
1998 (3)	International Journal of Production Research (2)	
1997 (6)	Journal of Systems and Information Technology (2)	
1996 (1)	Applied Soft Computing (1)	
1994 (1)	Business Horizons (1)	
1993 (2)	Computers & Industrial Engineering (1)	
1991 (2)	Decision Support Systems (1)	
1985 (2)	Others (26)	
1984 (1)		

The 194 articles were then reviewed and categorized in four major periods where there were major shifts in paradigm such as publication of articles the led to new research direction. Within each period, analysis was made based on the journal in which the article was published, country of the affiliation of the first author, number of authors, focus of the study, and research method used. The use of these classifications would help reveal the following:

(1) major fields supply chain management research was affiliated with;
(2) geographic location of major effort in supply chain management research;
(3) evolving focus of supply chain management research throughout the years; and
(4) changes in research methods used in supply chain management studies.

FINDINGS

Figure 1 shows the distribution of 194 journal articles related to supply chain management (SCM) published in various academic journals between 1984 and 2015. Four periods, namely 1984-1996, 1997-2003, 2004-2009, 2010-2016, can be identified based on major changes in research direction in the field. For example, the numbers of articles published within each of the periods are 9, 50, 79, and 56 respectively. Tables 2, 3, 4 and 5 show for each period the major journals in which the articles were published, the geographic locations of the studies (based on country of the affiliation of the first author), the foci of the research effort, and the primary methods of investigation.

Figure 1: Distribution of articles related to SCM published between 1984 and 2016
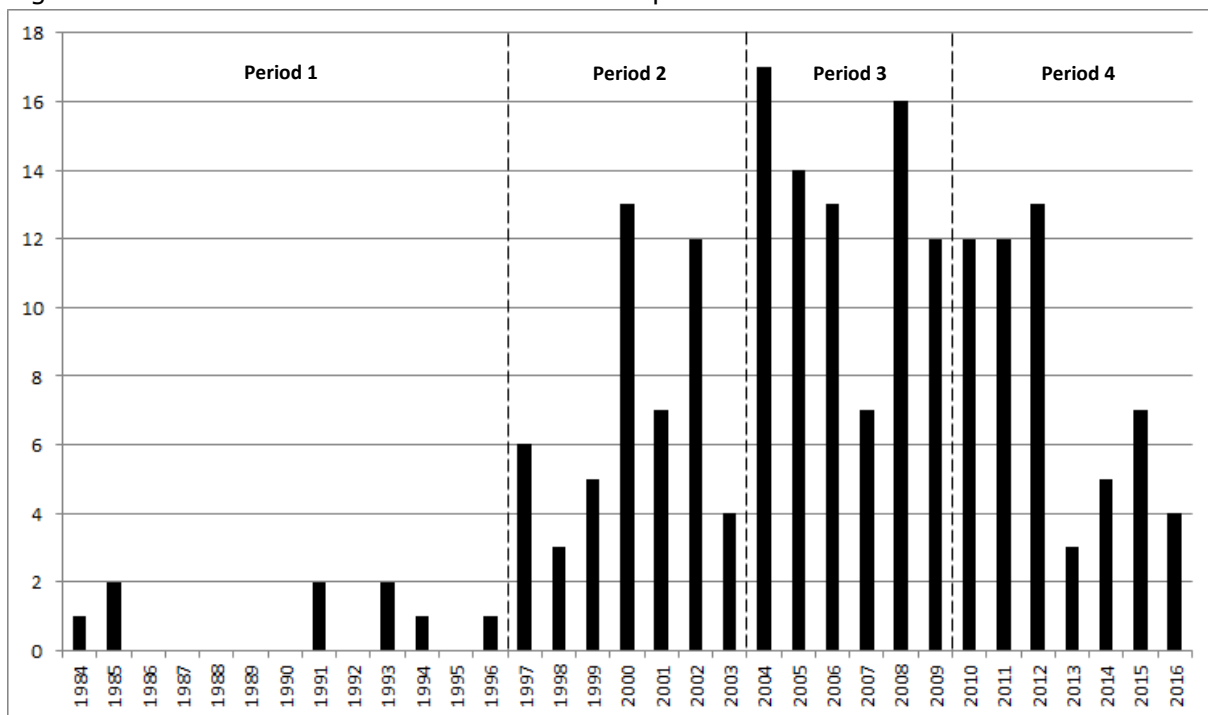
Table 2: Major journals in which the SCM related articles were published

Period 1 (1984-1996)	Period 2 (1997-2003)	Period 3 (2004-2009)	Period 4 (2010-2016)
Harvard Business Review (2)	Journal of Operations Management (12)	Journal of Operations Management (17)	International Journal of Production Economics (11)
IBM Systems Journal (2)	International Journal of Physical Distribution & Logistics Management (5)	Industrial Marketing Management (13)	Journal of Operations Management (8)

| 5 articles in 5 other journals | 33 articles in 8 other journals | International Journal of Production Economics (11) 38 articles in 26 other journals | 27 articles in 19 other journals |

Table 3:   Geographical locations of the SCM related studies reviewed

Period 1 (1984-1996)	Period 2 (1997-2003)	Period 3 (2004-2009)	Period 4 (2010-2016)
United States of America (5)	United States of America (26)	United States of America (39)	Europe (18)
Australasia (3)	United Kingdom (15)	United Kingdom (13)	United States of America (15)
United Kingdom (1)	Europe (7)	Europe (13)	Asia (11)
	Asia (1)	Asia (7)	United Kingdom (15)
	Australasia (1)	Australasia (4)	Australasia (4)
		South America (2)	Canada (2)
		Middle East (1)	Middle East (1)

Table 4:   Major foci of the SCM related studies reviewed

Period 1 (1984-1996)	Period 2 (1997-2003)	Period 3 (2004-2009)	Period 4 (2010-2016)
Alignment (related to IT) (3)	Supply chain management (issues) (12)	Supply chain management (18)	Supply chain Integration (22)
Information systems in supply chain (2)	Supply chain design (efficiency and responsiveness) (10)	Supply chain integration (seamless operation) (10)	Alignment (6)
Customer relationship management (2)	Demand chain management (focus shifted to demand side) (8)	Supply chain design (9)	Supply chain Design (6)
2 articles with 2 other foci	20 articles with 6 other foci	Value chain (things that add value, customer driven) (9)	Supply chain management (5)
		Demand chain management (8) 25 articles with 4 other foci	17 articles with 5 other foci

Table 5:   Primary research methods used in the SCM related studies reviewed

Period 1 (1984-1996)	Period 2 (1997-2003)	Period 3 (2004-2009)	Period 4 (2010-2016)
Empirical analysis (3)	Case study (18)	Case Study (23)	Empirical analysis (20)
Questionnaire survey (2)	Literature review (14)	Empirical analysis (20)	Case Study (11)
Case study (2)	Empirical analysis (7)	Literature review (19)	Modelling (11)
Illustrative examples (1)	Questionnaire survey (5)	Modelling (7)	Literature review (8)
Literature review (1)	Modelling (4)	Questionnaire survey (7)	Survey (5)
	Interview (1)	Interview (2)	Simulation (1)
	Simulation (1)	Simulation (1)	

As revealed in the tables, SCM studies in the last three decades have shifted from being part of the more general business research to a very specific discipline focusing on total integration and close alignment internally and externally. Major journals where SCM studies were published have also changed from the business management field, e.g., Harvard Business Review, to operations management and production economics, e.g., International Journal of Production Economics. Research foci have moved from general SCM issues to supply chain integration and tailored supply chain design based on internal and external alignment. Research methods have also geared from qualitative case study towards quantitative empirical analysis suggesting that the research has transcended from theoretical discussion to practical implementation. These findings align with the observation from the literature review that the paradigm of SCM research has gradually shifted from upstream cost reduction to downstream value creation to the current integrated and aligned cross-functional dynamic supply chain design.

CONCLUSIONS

This study has reviewed 194 articles of research on SCM published from 1984 to 2016. The objective is to report the changes in research focus and paradigm in this field in the last three decades. As the literature reveals, the paradigm of SCM research has shifted from SCM in the 1980s-1990s (focusing on upstream supply management and cost reduction) to DCM in the 1990s-2000s (focusing on downstream demand management and distribution efficiency) to DSCM from 2010 onwards (focusing on total integration and alignment between functions for value creation). Primary research method has also changed from using case study to conducting empirical analysis. In other words, SCM research has moved from a field of general management study addressing issues from a theoretical perspective using qualitative investigation approach to a specific discipline emphasizing on practical integrative design and alignment for optimization leveraging quantitative techniques and analysis. Although the findings are only based on the review of 194 articles which is an arguably small dataset compared to the total number of supply chain related studies published in all academic journals and industry publications, they may still offer some insights to SCM researchers trying to find a niche for further investigation and to inspire practitioners striving to develop integrative supply chain solutions for their businesses.

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A HOLISTIC PERSPECTIVE ON SUSTAINABLE PROCUREMENT IMPLEMENTATION

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ABSTRACT

The capability and capacity to implement a sustainable approach to procurement is increasingly becoming an order qualifier in product related globalised businesses. This research aims to identify key factors influencing successful supply network wide implementation of a sustainable approach to procurement. Building on a systems thinking approach, the study develops a conceptual model for sustainable procurement implementation. The drivers and barriers to sustainable procurement are identified based on a literature review and secondary data collected on 85 global firms' sustainability practices. The research identifies corporate environmental awareness and the commitment of top management as the key drivers for implementing sustainable procurement practices within supply network. The conceptual model identifies three broad categories of drivers along with barriers for the potential adaptation.

INTRODUCTION

The growth of the world economy due to the globalization of trade, is commonly seen to have caused a substantial increase in CO_2 emission. This so called '*greenhouse gas effect*' is a major contributor to global warming and climate change. Faced with these environmental challenges practitioners and researchers are looking to integrate sustainability in their business activities (Walker et al., 2008; Sarkis et al., 2011). This growing interest in sustainable business practice is evident in the increase in the number of published articles on sustainable supply chain management (Walker et al., 2012). Yet to-date this growing body of work on sustainable business practices follows a Western or developed economy view of what are good practices for sustainability; with wide variations in sustainable practices being observed in less developed areas (Steurer and Konrad, 2009) across the globe. Research is needed on the factors affecting the adoption of environmental procurement to spread good practices globally (Tian et al., 2014).

Extant research has identified drivers and barriers to incorporating environmental concerns within a business, but most of that analysis has been undertaken at the level of the supply-chain or network level rather than drilling down to focus just on the procurement function itself. Sustainable procurement is currently seen as strategic function (Weele, 2014) but extant research either reports either at the level of a specific country or specific organisation, limiting generalizability. Therefore, further investigation into factors affecting the implementation for sustainable procurement is essential to extend best practices globally. The aim of this research is to identify the key factors influencing the successful implementation of sustainable procurement. The objective of the research is to develop a conceptual model for sustainable procurement implementation based on the identification of key factors driving sustainability within a procurement function.

The paper is organised as follows. The next section reviews the literature for drivers and barriers for sustainable procurement practices. The research methodology briefly presents the method used for data collection and analysis. The following section presents findings including the conceptual framework generated as part of this study. By applying the

principle of systems thinking, the relationship of different variables is presented through causal loop diagramming. The paper closes with conclusions, limitations and areas for future research.

LITERATURE REVIEW
Sustainable Supply Chain Management

Growing environmental and social problems have raised the awareness of sustainability among firms as well as government (Govindan et al., 2014). Initiatives by Governments such as ISO14001 certification and establishing the environmental regulation/legislation is evident in some parts of the world (Zhu and Sarkis, 2004). The Government's actions could be one of the important triggers to encouraging the implementation of environmental management (Tian et al., 2014). Another trigger comes from stakeholder groups, since they strongly influence the corporate strategies of the firm (Vachon and Klassen, 2008). Sustainable Supply Chain Management (SSCM) emerges as an organisational approach to instil environmental awareness in the traditional supply chain management (Sarkis et al., 2011). The scope of SSCM varies from sustainable procurement to environmental conscious customer (Zhu and Sarkis, 2004). Earlier, Srivastava (2007) scrutinised the SSCM literature and argued that the scope of SSCM encompasses from product design processes through the end customers, as well as end-of-life product management. The boundary of SSCM is rather wide and in order to achieve the successful implementation, the focus needs to be on the strategic functions (such as procurement, manufacturing) of supply chain management.

Challenges for sustainable procurement practices
Drivers

The major influencing drivers for promoting sustainability practice could be grouped under two categories as internal and external (Walker et al., 2008). We follow similar classification approach to review drivers and barriers to the sustainable procurement practices. Different sectors adopt sustainable procurement practices, however the internal

List of drivers	References
Internal	
Top management commitment	Drumwright (1994); Carter et al. (1998); Wycherley (1999); Walker et al. (2012)
Cost reduction	Handfield et al. (1997); Carter et al. (1998); Carter and Dresner (2001); Zhu et al. (2005); Large and Gimenez Thomsen (2011); Walker et al. (2012)
Improving firm performance	Carter et al. (2000); Rao and Holt (2005); Nidumolu et al. (2009)
Skilful policy entrepreneurs	Cousins et al. (2004); Giunipero et al. (2012); McMurray et al. (2014);
External	
Gaining competitive advantage	Carter and Jennings (2004); Rao and Holt (2005); Lawson et al. (2009); Giunipero et al. (2012); McMurray et al. (2014)
Legislative and regulatory compliance	Min and Galle (2001); Handfield et al. (2002); Carter and Jennings (2004); Zhu et al. (2005); Walker et al. (2008)
Potential for receiving publicity	Carter and Jennings (2004); Cousins et al. (2008); Walker et al. (2008); Appolloni et al. (2014)
Pressure by customers and investors	Giunipero et al. (2012); Genovese et al. (2013)
Public pressure	Handfield et al. (2002); Zhu et al. (2005); Cousins et al. (2008); Giunipero et al. (2012)

Table 1: Drivers for sustainable procurement practices

driving efforts are much similar. It is identified that personal commitment of top-management is positively related with an introduction of environmental policy (Walker and Brammer, 2009). Top management support is essential for driving the environmental program, as it requires strong resource support for the deployment (Carter and Jennings, 2004; Vachon, 2007). Skill of policy entrepreneur, in other words the middle management significantly contribute to the organizations achievement (McMurray et al., 2014; Giunipero et al., 2012). Other organisational factors influencing sustainable procurement implementation can be associated with leadership, policy, organisation strategy and finance (McMurray et al., 2014). Another important internal driving force is a desire to gain cost reduction advantages (Large and Gimenez, 2011; Walker et al., 2012).

One of the important external driving forces is a compliance with the international environmental standard and regulations, such as ISO14001, WEEE and RoHS (Zhu et al., 2005). Government pressure appears to be associated with the management decisions related to the adoption of the green procurement practice (Carter and Jennings, 2004; Walker et al., 2008). It has an argument that the compliance with regulation/legislation may not positively reflect on organization's environmental procurement performance. However, with the government regulation acquiescence, firms gain benefits from governmental incentives in some countries. For example, UK promoted the environmental program by provide a premium tariff and tax benefits for suppliers or manufacturer who invest or innovate the use of renewable energy and minimise resources consumption (European commission, 2012; UK Environmental Law Association, 2014).

Key motivator and facilitator for environmental responsible business is customer pressure (Carter and Jennings, 2004). The end-customer's demand for green design and manufacturing can be seen as a 'reactive driver' of sustainable procurement (Giunipero et al., 2012). Offering sustainable products is a 'proactive action' which can possibly lead in gaining a competitive advantage in the market (Giunipero et al., 2012). Enhancing financial performance, improving working conditions and better labour standards for health and safety positively strengthens firm's ability to compete against competitors (McMurray et al., 2014). On the contrary, if firms do not consider environmental procurement practices, it may face public resistance improving their performance or a reputation (Appolloni et al., 2014). The public movement towards greater environmental responsibility appears to be one of other key external drivers escalating firm's pressure on the adoption of environmental practice (Zhu et al., 2005; Giunipero et al., 2012). All the identified internal and external barriers are presented in Table 1.

List of barriers	References
Costs	Wycherley (1999); Roa and Holt (2005); Beske et al. (2008); Large and Gimenez Thomsen (2011); Giunipero et al. (2012)
Industrial specific barriers	Chen (2005); Zhu and Sarkis (2006)
Inexperienced in the practice	Min and Galle (2001); Carter and Jennings (2004); Bowen et al. (2011)
Poor supplier commitment	Cousins et al. (2004); Walker et al. (2008); Sarkis et al. (2011); Giunipero et al. (2012); Hollos et al. (2012)
Techonological investment	Carter and Jennings (2004); Vachon (2007); Genovese et al. (2013)
Unclear standards	Chen (2005); Zhu and Sarkis (2007); Min and Galle (2001); Sarkis and Dhavale (2015); Walker and Brammer (2009)

Table 2: Barriers for sustainable procurement implementation

Barriers

One of the major barriers to implementing a sustainable approach to procurement is higher cost. Investment cost is complex, as it demands collaboration from all the related internal and external stakeholders. Regulation is another major driver toward the environmental efforts. Interestingly it could be both a driver as well as a barrier for implementation

success (Zhu and Sarkis, 2007). The lack of clear standards and direction from government regulation/policy on sustainability can also significantly delay the program. To reach the goal of implementing sustainable procurement, companies in general start tracking their own carbon footprint. Where both buyers and suppliers are unwilling to share or exchange footprint information- a major barrier remains. Another crucial barrier emphasized by several studies is a lack of the right technology (Walker et al., 2008; Sarkis et al., 2011). Table 2 shows additional barriers along with the associated references identified through the literature review.

RESEARCH METHODOLOGY
The exploratory study attempts to bring research insights by combing literature survey with secondary data on sustainability practices. A Systems Thinking (ST) approach is adopted in the study to capture a holistic picture of the problem. The ST approach helps in understanding the complex interdependencies between variables necessary for robust decision-making. The method helps in understanding the structure and behaviour of a system as a whole (Hoejmose and Adrien-Kirby, 2012). One of the key benefits of ST is its ability to effectively break down the problem for the holistic view (Sillitto, 2014). Systems thinking is a useful approach for preliminary observation and analysis, before applying system dynamics modelling to capture precise reflection of a real system (Sterman, 2001).

Secondary data on 83 firms was collected for the study in the form of annual reports. Parts of these reports discuss the sustainability practices and policies adopted by the individual firm. For example, Amazon's annual report presents actions such as reducing packaging waste, green building and so forth for eco-friendly business (Amazon.com Inc., 2015). In the sample, the majority of firms are engaging with sustainable procurement. The number of academic papers published within the field of sustainable procurement has been growing since 2005, and is increasing year on year (Appolloni et al., 2014). The sustainable procurement content of the sample of company report data supports this trend; there is a steady increase in the number of publications during 2008-2010, with a steep rise from 2011 onward. It is evident that there is rising interest both in academia and industry.

SYSTEMS THINKING
Causal loop diagram (CLD) is used as a tool for developing systems thinking. Using a CLD tool, the researchers' plotted all the drivers and barriers to understand their inter-dependence. Figure 1 shows the CLD for sustainable procurement implementation. The feedback loops represent the effects (+/-) on each other. Through the analysis it was evident that three variables strongly influence sustainable procurement implementation; corporate environmental awareness policy, policy entrepreneur and green procurement strategy variables were strongly influencing different internal as well as external drivers.
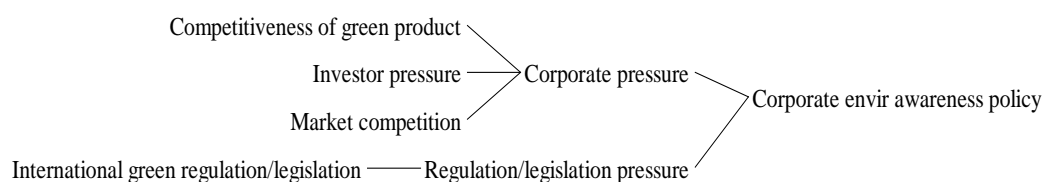
Figure 2: Example of causal loop tree diagram

Corporate environmental awareness policy is the key factor derived from the CLD. This factor is triggered by regulatory compliance and pressure from the outside company such as from customers, investors and society. The second driver is policy entrepreneur or middle management level, seeing the role and responsible of a policy entrepreneur would support the achievement in the implementation. The final key driver is green procurement strategy; this strategy is motivated by the decision making from executive management and regulation requirement in standard material specification. Figure 2 shows the relationship map between influencing variables. An iterative process of creating similar causal loop tree diagrams supported the development of the conceptual model.

Figure 1: Causal loop diagram for sustainable procurement implementation

FINDINGS AND CONCLUSIONS

Based on a review of the academic literature and analysis of firm generated data, the research identifies the drivers and barriers affecting the implementation of green environmental practices. Additional drivers were identified from the secondary data. Target setting, training on environmental awareness, green product design, product life cycle assessment and Audit/Supplier evaluation are identified through the study.

The research has drawn out the key factors that potentially influence adoption of sustainable procurement practices. A conceptual model of the drivers for sustainable procurement has been developed (Figure 3). This study suggests three main drivers affect implementation, namely corporate environmental policy, policy entrepreneur and sustainable procurement strategy. The length of an arrow represents the power of each driver and the area that it influences. For example, policy entrepreneur is influencing the sustainable procurement strategy while at the same time both factors are under the force of corporate environmental policy driving the integrated environmental practice within the purchasing function. However, in order to achieve the objective, the companies cannot overlook the barriers that cause delays and ineffective implementation (identified above as cost, regulation and supplier commitment).
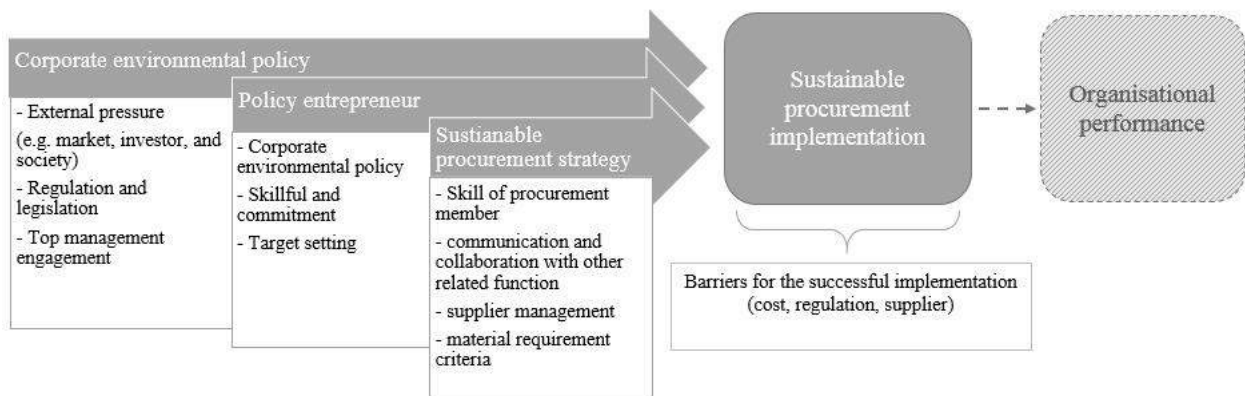
Figure 3: A conceptual model for improving the sustainable procurement practice

The research analysed secondary data from 83 leading supply-chain organisations to identify the factors that support implementing sustainable procurement. The research successfully provides a holistic and systematic approach to implementing sustainable procurement across supply networks. A systems thinking approach extracted the key activities as well as contributing to addressing the limitations of current models. This combination of systems thinking and secondary data analysis contributes to the holistic capture of the structure of the entire sustainable procurement system. Nevertheless, the research has some limitations in terms of the data and methodology. Even though the information came from the reliable sources, organizations may not publish up-to-date or detailed information. The Causal loop diagram developed in this study assumes that there are no time delays between causal links. In addition, the CLDs did not provide the researchers' with concrete results, but does represent the provisional system structure of the relationship between variables. The study provides exploratory perspective on social, environmental and economic issues within the procurement function. The next stage of the research will utilize the information to develop a stock and flow diagram for a simulation study. This study also strongly suggests that unsuccessful sustainability implementation creates a negative feedback for the firm, impacting its brand reputation and image; and reinforcing the need to understand implementation. The research is expected to support practitioners in understanding the barriers, challenges and opportunities in sustainable procurement.

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Note: Additional references shown in Table 1 and 2 are not included in this list due to page restrictions.

THE ROLE OF TECHNOLOGY IN OUTSOURCING PRACTICES IN NIGERIAN OIL AND GAS INDUSTRY

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Abstract

Purpose - The purpose of this research is to assess the current state of outsourcing practices in Nigerian oil and gas industry and examine the impacts of technology on firm's geographical scope of outsourcing operations.

Design/Methodology/Approach – A mixed method approach involving a combination of questionnaire and semi-structure interview. The data collected provides a cross-sectional study of 200 oil and gas companies with senior level managers and supply chain experts as the respondents. We have asked the respondents to provide their own perception on how technological capabilities have impacted their organisational outsourcing practices and performance.

Finding - The research revealed that there are many beneficiary role of technology in outsourcing practices in terms of driving new business concepts and performance, such as business process re-engineering, organisational restructuring, benchmarking, alliance and lean management.

Originality/Value – This paper is different from other previous studies in outsourcing industries that focused on discrete manufacturing whereas the oil and gas sector is process oriented and offer a different operational environment for outsourcing practices. There is also limited literature that explained the impacts of technology on the outsourcing practices in a developing economy.

Practical/theoretical applications – The results could be used by outsourcing organisations as a decision support enabler in processing the value of their intellectual assets in making strategic and tactical decision and sharing problems effectively. The outcome could also support organisation's general knowledge from both internal and external source, uncover relationships between the tangible and intangible, the tacit and explicit.

1. INDTRODUCTION

In an increasingly competitive global market-place, companies are looking at new ways to improve their business operations in order to remain profitable. The influence of technology in outsourcing practices is crucial to both large and small companies in a developing economy, as these companies need to involve their suppliers closer to products and process innovation. This has particularly, in recent years, increased the search for oil and gas fields which has resulted in great technological advances in exploration, development and production segments (Bruno don Santos, 2009). But, this exploration is costly, highly technical, less efficient and likely to cause higher ecological damages. More so, the need to improve the efficiency of existing field, the costs of refurbishing aging infrastructure, fees related to constantly changing government regulations, geopolitical instability, volatility of oil price, and terrorism activities are staggering (Batoul Modarress, 2016).

This conditions stimulate investors to shift the quest for fossil fuel to unconventional reserves. According to the Organisation of Petroleum Exporting Country's Director of Research Division, Dr Omar Abdul-Hamid, OPEC expects demand for crude oil to hit an average of 111million barrels per day by 2040. He explained that new capacities from unconventional sources are case in point. ''Demand growth mainly comes from emerging economies and developing countries, particularly Asian, and from OPEC members state. Their demand more than compensates for shrinking use in highly developed countries. Developed countries are reducing their oil consumption due to increasing fuel efficiency. Demand for oil will be in transportation and petrochemicals'', (OPEC, 2015).

Nigerian is ranked seventh among the oil and gas nations in the world and number one in Africa. Oil and gas expert believed that Nigerian could even earn more from full utilization of gas resources with sound investment policy. Nigeria currently, has four refineries (Port Harcourt 1 and 11, Warri and Kaduna) with a total installed capacity of 450,000 barrels per day (bpd); Petrochemical industry at Eleme and the Nigerian Liquefied Natural Gas (NLNG) Project.

In spite of this strategic position, Nigerian prime opportunities appears to be dwindling. This is more in the face of evolving global economic trends; low crude oil prices, the bourgeoning cost of deep-water operations, the emergence and the appeal of alternative energy sources. However, the availability of oil and gas resources does not automatically lead to economic growth but can provide the requisite stimulus for economic growth if mechanisms for harnessing the resources are effectively established (Musa Jega, 200). For example, natural gas has other uses not commonly known like fertilizers manufacturing, polyethylene for the manufacture of plastics, insecticides, and other pesticides, pharmaceuticals as well as additives in the manufacture of many products like cell-phone parts, automobile parts, aeronautics, cosmetics, and electrical appliances. The following sections of this paper will include the literature review, discussion and validation of these propositions. The paper ends with conclusions drawn from the study.

2. LITERATURE REVIEW

Although the concept of outsourcing was used by manufacturing executives in the late 1970s (Corbett, 2004), it was only a decade later that the term was officially introduced. Yet, another decade later it was already referred to by Harvard Business Review as one of the great management ideas of the past century (Sibbet, 1997).

Outsourcing practice has increasingly become an important strategy that can significantly assist organisations to leverage their skills and resources to achieve greater competiveness (Quinn and Hilmer, 1994; Welson, 1996). As these developments are constantly evolving, current academic research seems to be lagging behind in the most recent developments of this complex phenomenon. The task for researchers is therefore to follow in the wake of these development (Jussi and Eriksson, 2009). Since the birth of the practice, several research streams have taken their interest in the phenomenon of outsourcing. Markell et al., (2005) have identified three streams in literature, which relate to the strategy of outsourcing. These three, however, have their own specific characteristics: strategic management literature, supply chain literature and international business (IB) literature.

Several researchers have also analysed the drivers of outsourcing, both from a theoretical perspective (Trunick, 1989; Quinn and Hilmer, 1994; Razzaque and Sheng, 1998; Lankford and Parsa, 1999; Kakabadse and Kakabadse, 2000; Jennings, 2002; Lynch, 2004) and from a practical point of view using case studies and surveys as empirical data. The authors based their analysis within the developed countries, such as US, UK, Australia, and New Zealand (Corbett. 1998; Fan, 2000; Bolumole, 2001; McIvor, 2003; Beaumont

and Sohal, 2004). The results showed that many drivers are unique to specific geography and industries and explained some common factors that motivate organisational outsourcing practices such as cost structure, collaborative partnership, and market forces. The authors overlooked other major drivers of outsourcing, including technological capabilities as listed in table 1, which perhaps is the key driver in outsourcing decisions. The researchers also excluded developing economies which is a major gap that this study investigated and validated in the discussion sections.

Outsourcing is viewed as the process of establishing and managing a contractual relationship with external supplier for the provision of capacity that has previously been provided in-house (Momme, 2002). Others viewed it a potential benefit of disadvantage and risk confronting with transaction cost (Lacity and Willcocks, 1995). Batoul Modarress, (2016), also claimed that all these perspective are all focused on outsourcing process in discrete manufacturing and not in oil and gas oriented industries. This paper shared the author's argument but employed different approached as regards methodology and empirical data used in the analysis. For example, the author focused on collection of replies through interview and secondary data as empirical materials. But this paper used mixed method involving primary data from questionnaire and semi-structure interview as empirical data. More so, Modarress, (2016), addresses the driver of outsourcing from the shareholder's perspective of cost reductions, while this paper addressed it from the technology development perspective. More so, the researcher claimed to adopt transactional cost as organisational theory while this research deployed the theory of resource base view (RBV) of comparative advantage.

Drivers of outsourcing Practices	Codes
Desire for technology development	**DTD**
The desire for cost reduction	**DCR**
The desire for risk sharing and uncertainty	**RSU**
The desire to increase flexibility	**TIF**
The desire to increase market share	**DTIMS**
The need to improve organisational performance	**NIOP**
The need for information sharing and communications	**NISC**
Ability to focus on core competence	**AFC**

Table 1. List of outsourcing drivers

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In addition, this research focused on the technological capabilities as the key element of driver in outsourcing practices within the context of developing oil and gas economies. The results of this research in the next sections have validated this argument.

2.1 **Impacts of technology**

Today companies compete not only on the basis of product, service, and operational superiority, but also to enhanced management of their corporate memory and intellectual assets. They are beginning to realize their edge lies in how they manage the efficient flow

and transfer of knowledge across the organisations. They see technology as a panacea for all knowledge management (Christy Silver, 2006).

According to International Energy Agency's chief economist, Faith Birol, the global investment in upstream oil production in 2015 has decline by almost 20 percent to settle at $100 billion. Some of the key challenges that industry face includes: the right equipment to be applied in a particular oil field/well discovery, appropriate production systems and structures, the availability of technological base to carry out the project economically. In some cases, new technologies needed to develop to extract the resources (Bruno Santos, 2009).

In June 2013, the UK Government commissioned a report, led by Aberdeen oil tycoon Sir Ian Wood. One of the key area identified by the wood report is technology development. He emphasised that commercial pressures dictate that industry wants quick, smarter and sustainable methods of getting fuel safely out of the ground. The researcher therefore, has explored this gap and used the above similar approach in the context of Nigerian situation and has made an interesting revelation as shown in the discussion sections.

Most studies have focused on technological development in oil and gas upstream and downstream supply chain management. Sea (1993) was probably the first to address the supply chain management in the context of an oil company. The author developed a linear programming network model for planning the logistics of a downstream oil company (Sergio et al., 2000). The main weakness of this theories was that it failed to address the activities within the offshore upstream planning of the oil fields. Nevertheless, Van den Heever, (2004) investigated this weakness and addressed the design and planning of offshore oilfield infrastructure focusing on business rules.

3. CONCEPTUAL MODEL AND THEORY

The conceptual model explained the relationship between the technology and outsourcing and the impacts on performance.

Fig 1.

Relationship between

Outsourcing Model, performance

and   Technology

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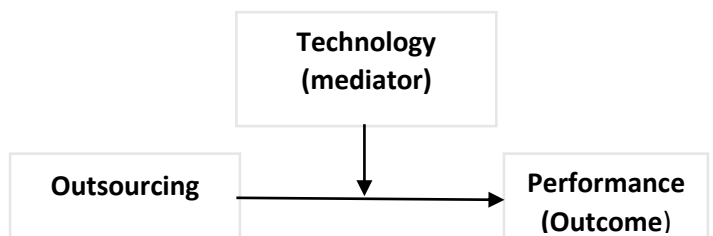
For example, in a survey covering over 700 organisations of UK, USA, and continental Europe spanning diverse sectors like Financial service, Telecom, Pharmaceuticals, etc., it was found that cost was losing out to the other prominent drivers, which is the desire to access new technology, capability and best practices. Another example was the experience of Nike and Reebok, which focus on design and marketing of footwear, their core-competence, while outsourcing manufacturing activities (Sankalp Pratap, 2014). Therefore, what is new is the relationship between the technology and outsourcing in driving performance. The researcher has used two propositions to address this new concept and the research objectives of this study.

The theory used in this paper to examine the impacts of technology in Nigerian oil and gas industry is resource-based view (RBV) model of competitive advantage which suggest that competitive advantage may be sustained by harnessing resources that are available, rare, imperfectly limited, and valuable (Barney, 1991). Firms resources have been defined as

all assets, capability, organisational processes, attributes, information, and knowledge controlled by enterprise that enable the firm to conceive and implement strategies with goal to improve its efficiency and effectiveness (competitiveness) (Barney, 199; Daft, 1983). In the context of Nigeria as one of the developing oil economies, the comparative advantage is its abundant crude oil and gas deposit.

4. RESEARCH METHODOLOGY

Problem statement and data collection

To examine the impacts of technology in outsourcing practice in Nigerian oil and gas industry, the researcher adopted a mixed method research, a combination of questionnaire and semi-structure interview. The data collected provides cross-sectional study of 200 oil and gas companies with operations managers, senior managers and supply chain experts as the respondents. We have asked the respondents to provide their perceptions on how technological capabilities have impacted and drive their organisational outsourcing practices and performance. The researcher collected 100 samples and valid 94 samples were analysed showing a 50% representative of the probability sample size of 200 (Mark Saunders and Philip Lewis, 2012). The sampled companies are a combinations of small, medium and large enterprises and the respondents selected for interviews include senior level managers. Interview with managers were performed by following a set of semi-structured questions. The answers were recoded, transcribed, validated with the respondents and consequently analysed. Two questions were advanced from the literature and conceptual model, with special emphasis on the Nigerian oil and gas industry clusters.

Q1. To what extent does technological development the major drivers of outsourcing practice and performance in Nigerian oil and gas industry?

Q2. Do you agree that technological capabilities influence your organisation's outsourcing decision?

5. RESULTS AND ANALYSIS

Ninety-four questionnaires (94) were analysed out of 100 questionnaires collected showing 50% representation of the 200 sample size.
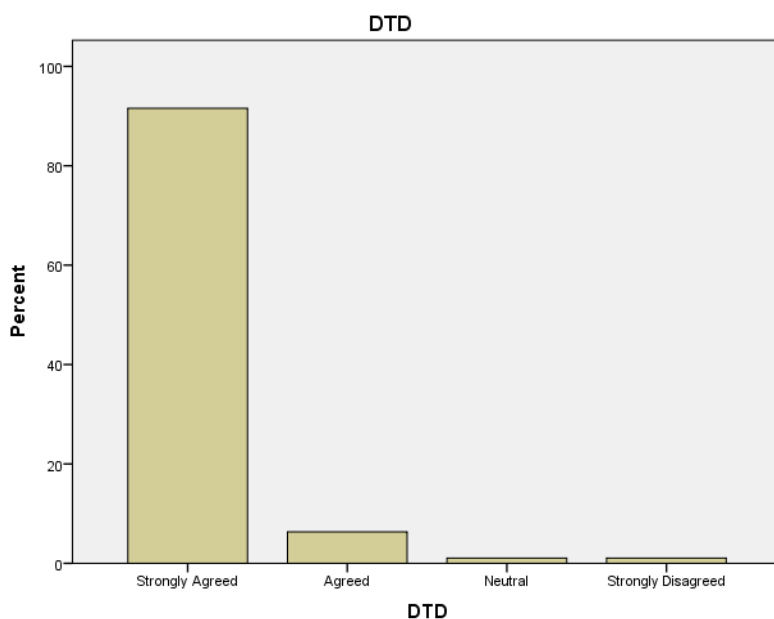
Figure 2.

Survey respondents

from oil companies on technological development

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Key: DTD – desire for technological development

The Participants were asked to rank all the outsourcing drivers in terms of strongly agree, agree, neutral, disagree and strongly disagreed as outline in the table 1. The drivers include: the desire for cost reduction, the ability to focus on core competency, to increase flexibility, the need to improve organisational performance, the desire to increase market share, the need for information sharing and communication, the desire for technological development and the desire for risk sharing.

 In answering question Q1; An overwhelming majority of the respondents (91.6%) support and strongly agreed (see figure 3) while less than 10% of the respondents agreed, neutral and strongly disagreed respectively. Also when compared technological development with its rival, cost reduction, eighty-eight per cent (88.4%) of the respondents strongly agreed while less than 10% agreed with no response on the neutral, disagree and strongly agreed. The table 2 explained in detail the statistical analysis of the of how respondents respond to the list of outsourcing drivers that influence their operations. The mean and median value of the two rival drivers: desire for cost reduction (1,12, 1.00) and desire for technological development (1.13, 1.00) respectively. The results showing a marginal increase in mean value of the respondents' desire for technological development against the desire for cost reduction.

The figure 4 bar chart and figure 5 pie chart represent the outcome of the second question(Q2) to the respondents. Majority of respondents rated in figure 5 strongly agreed (91.6%), Agreed (6.3%), Neutral (1.1%), and strongly disagreed (3.2%) responded respectively. In figure 4 the most respondents rated strongly agreed (37.2%), agreed (34.0%), Neutral (14.9%), disagreed (10.6%), and strongly agreed (3.2%)

Statistics

		DCR	AFC	TIF	NIOP	DTIMS	NISC	DTD	RSU	
N	Valid	95	95	95	95	95	95	95	95	
	Missing	0	0	0	0	0	0	0	0	
Mean		1.12	1.91	1.82	1.93	2.04	1.23	1.13	1.88	**Table 2. Survey statistical analysis of the drivers**
Std. Error of Mean		.033	.081	.075	.081	.095	.072	.052	.087	
Median		1.00	2.00	2.00	2.00	2.00	1.00	1.00	2.00	
Std. Deviation		.322	.787	.729	.789	.922	.706	.510	.849	
Variance		.103	.619	.531	.622	.849	.499	.260	.720	
Range		1	3	4	2	4	4	4	4	
Minimum		1	1	1	1	1	1	1	1	
Maximum		2	4	5	3	5	5	5	5	
Sum		106	181	173	183	194	117	107	179	

Fig. 3

Fig 4.

Technology

DTD
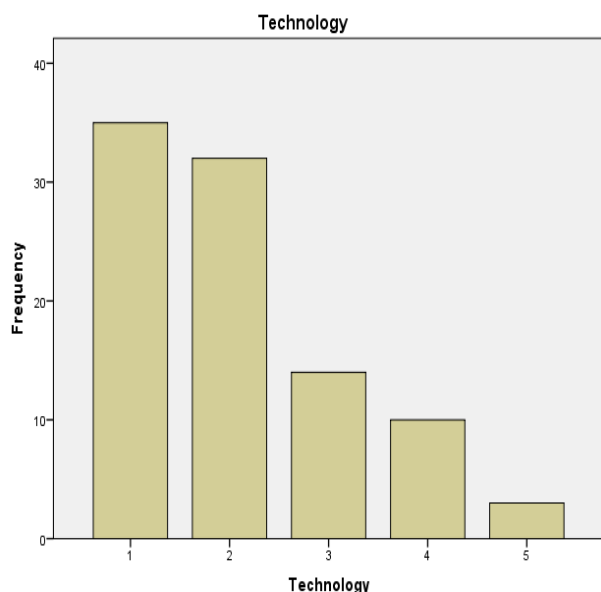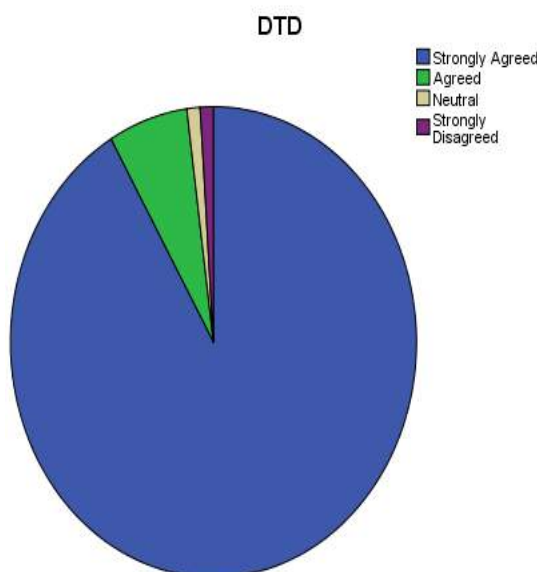
This discussion follows a major agreement among the senior level manager resulting from small, medium and large enterprise in their outsourcing operations and the role technology is playing. When looking at the outsourcing strategies of a firms from large, medium to small enterprise, technological capability stands out as the key driver among other comparable drivers in this study (see table 1). The larger multinational seems to be in the lead, (see table 2,3,4 and 5) even though, there is seemingly general agreement across board that technological capabilities are now the new normal in driving outsourcing activities over other drivers especially cost reduction. It also important to note that less than 5% of the respondent's sampled companies disagreed or strongly disagreed that technology drives their outsourcing operations. What the results implies is that over 90 per cent of the companies sampled believed that technology greatly influences their organisation's outsourcing decisions. The study also shows that there are overwhelmingly evidence of great relationship between outsourcing and technology. This has also validated the conceptual model proposition that technology could play the role of an enabler in driving outsourcing to better organisation performance and effectiveness. This awareness is key now that there is a strong demand from the industry for improving its performance towards a path to reaching an even higher success rate (Sara Haji-Kazemi, 2013).

What this finding also means is that companies within the oil and gas clusters can form outsourcing collaboration or alliance among the larger firms and this will offer the smaller companies the opportunity to adapt and imitate the technological capabilities of the Multinationals. Therefore, indigenous firms that acquire these technological capabilities or home-grown innovation can also leverage them in attracting contracts through outsourcing operations.

9. Conclusion

The different combinations of ownership and location seem to have a substantial effect on the companies' outsourcing strategies. Developing economies appears to outsource more internally while the developed economy outsourcing more externally. One of the reasons for this disparity lies on the technological knowledge capability and ability of firms

to deliver the required service. Therefore, oil and gas industry needs to find a way to share expertise so that the important core knowledge is not lost but fostered internally and externally and adapted to embrace new evolving industry challenges across supply chain.

Nigeria has been producing oil since 1958. The oil majors operate most of the oil and gas field either in joint ventures or under PSCs with the national oil company, NNPC. This study indicates that technological capabilities and skills alone are not sufficient enough to establish an efficient and sound operating national oil company. There is a need also to put the right incentives in place for utilizing the capacity and skills in an optimal way, giving the national objectives for the industry. There is probably case for the government intervention to strengthen the local content acts in order to lower local industries' barriers to entry. The national government could regulate this activity and also careful not to impose regulations that excessively fragment the supply chain. The government should also encourage MNOCs to remain committed to pioneering feats in local content development.

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Section 3: Collaboration and relationships in supply chains

EXAMINING SUPPLIER-SIDE QUALITY MANAGEMENT IN THE CHINESE AUTOMOBILE MARKET

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Abstract

Purpose of this paper:
Since 2009, China has become the world's largest automobile producer and market. As the assembler is normally in charge of assembling and stamping works, the supply of components becomes a fundamental process of ensuring desirable quality. Supplier-Side Quality Management (SSQM) practices vary, among others, by business structure and supply chain position (Dellana and Kros, 2014). However, the dynamics of SSQM have mainly been empirically researched on buyers and suppliers that are typically not related in some forms of an identifiable direct exchange (Ambrose et al., 2010). In order to fill this gap, we aimed to compare two dyadic relationships: one Chinese Self-Owned Brand (CSB) (and one of its suppliers) with one Chinese-Japanese Joint Venture (CJJV) (and one of its suppliers) by analysing their SSQM practices and performances. This comparative study aims to answer two research questions: 1) How do SSQM practices differ? 2) Why do such differences occur?

Design/methodology/approach:
In order to answer our research questions, case study was employed (Yin, 2013). Data was collected from semi-structured interviews, company documents, and observations to enhance data triangulation. An interview protocol was developed from the review of relevant literature, and a systematic data analysis process was employed, on both the within and the cross case levels.

Findings:
Our research elaborates on the differences between operations capability and quality culture aspect in supply chain relationships in the Chinese automobile market. The comparison also reveals the diverse operational and strategic SSQM practices in supplier selection, supplier support, supplier communication, and supplier involvement. Based on these findings, a comprehensive framework is developed to assist in better understanding SSQM in China.

Value:
This comparative study empirically investigates the SSQM of buyer and supplier in the same relationship, and contributes to academic understanding of relevant factors in the Chinese automobile industry. It also provides insights into the expectations and perceptions of relationship partners. Moreover, this research should help managers in recognising best practices in SSQM and in identifying improvement directions.

Research limitations/implications (if applicable):
This research focused on two dyadic relationships (i.e. CSB-Supplier; CJJV-Supplier); therefore, more relationships with diverse characteristics should be included into future

research. Furthermore, to test the generalizability of the results, other methodological approaches such as a large survey could also be conducted.

Practical implications (if applicable):
This paper provides empirical evidence explaining how and why CSB differs from CJJV in SSQM to quality and supply chain managers. Moreover, firms need to recognise their capability and quality culture and act accordingly.

1. INTRODUCTION

A series of high-profile automobile recalls, such as Fiat Chrysler Automobiles recalled 275,614 Dodge Journey vehicles due to the leaking water tank (J.D. Power, 2015), has attracted worldwide attention to the importance of Quality Management (QM) in the automobile Supply Chain (SC). The recall of 58,477 Model 550s of Roewe Motor, in which the oil return pipe cracks easily (Sina, 2014), has also revealed that quality problems in the SC can create tremendous implications for customer confidence and brand identity in China as well. These recalls share one common characteristic: the involved automakers do not produce the problematic component. It means the quality problem of the automobile is mainly attributed to Supplier-side Quality Management (SSQM). Moreover, according to "Made in China 2025", the manufacturing industry development strategy of the Chinese government, pursuing excellent Chinese automobile quality is significantly affected by the local suppliers' capability. How to apply joint quality improvement, conduct mutual learning, and enhance the efficiency of SC synergy are the core topics in the Chinese automobile market (Lu et al., 2014).

While automobile production and sales volumes in China keep breaking world records, the market share of Chinese Self-owned Brands (CSBs) started to show a decline from 2013 (FT, 2014). At the same time, Joint Ventures (JVs) make enormous contributions to the rapid development of the industry. Moreover, the Initial Quality Score (IQS) evaluation, which is determined by problems reported per 100 vehicles (with a lower number of problems representing higher quality), indicates automobile brands whose quality is above the industry average level in the Chinese market (J.D. Power, 2014). Among these listed brands, seven are Chinese-Japanese Joint Ventures (CJJVs). CJJVs are jointly founded by Chinese and Japanese automakers (the Japanese capital cannot exceed 50% of the brand ownership) (Lu et al., 2014). On the other hand, only three CSBs exceeded the industry average level. This small number indicates that the extent of quality improvement in CSBs is still lagging behind others, especially compared to CJJVs. However, there is limited research on CSBs, the role of which turns out to be incredibly important in the global automobile industry (Lu et al., 2014). Furthermore, the dynamics of SSQM have mainly been empirically researched on buyers and suppliers that are typically not related in some forms of an identifiable direct exchange (Ambrose et al., 2010). Such a research approach does not allow for direct comparisons within the same SC settings and cannot accurately reflect the SSQM application in both buyers and suppliers. In order to fill these two gaps, we aimed to develop understanding on SSQM by means of a comparison of two dyadic relationships: a CSB-Supplier dyad and a CJJV-Supplier dyad. In the context of the Chinese automobile industry, our study aims to answer two research questions: RQ1) How do SSQM practices differ? RQ2) Why do such differences occur? The remainder of this paper is organised as follows. Section two provides a detailed literature review and section three presents the research method employed. The within-case and cross-case analyses are reported in section four. This is followed by the findings and discussion, and the conclusions.

2. LITERATURE REVIEW

Past SSQM research concentrated more on developed countries and overlooked emerging economies (Flynn et al., 2013). Since China became the largest automobile producer and market in 2009, the limited Chinese automobile market research renders SSQM understanding insufficient. While previous studies discussed quality issues and buyer-

supplier relationships in the Chinese automobile industry, they did not choose CSBs as the research target. For example, Kim et al. (2011) argued that the relationship between foreign suppliers and foreign automakers in China varies due to the choice of suppliers' headquarters, the foreign automakers' strategy, and the environment of the Chinese automobile industry. Moreover, the existing empirical studies of the buyer-supplier relationship mainly focused on one participating player (Ambrose et al., 2010). For research that studied both buyers and suppliers, the buyer-supplier dyads are mainly mismatched (Ambrose et al., 2010). The findings based on the mismatched dyads can't accurately reflect the real buyer-supplier relationship, and the summarised characteristics of SSQM practices may mislead academics and practitioners.

There are more than 5,000 types of components in an automobile (Womack et al., 2007). As the automaker is usually in charge of assembling and stamping works (Lu et al., 2014), the supply of components becomes an indispensable process of ensuring desirable quality. Suppliers need to provide quality materials and participate in the product design process. Successful buyer-seller relationships encourage suppliers to be involved earlier in the buyers' quality improvement and product design (Hu et al., 2014). Effective supplier relationship management benefits the organisations in obtaining strategic resources and capabilities, thus increasing their competitive advantage (Foster, 2008). Moreover, long-term relationships with suppliers ensure companies' commitment to quality and improves SC performance (Huo et al., 2014). Furthermore, collaboration with the supplier in new product design and quality improvement programmes is conducive to achieving higher product quality and financial performance (Hu et al., 2014; Hu et al., 2015). Therefore, this research addresses supplier selection, supplier cooperation, and supplier relationship development to describe SSQM practice.

Using high-quality components results in deficiency reduction. This has a positive impact on internal controls over other variables, such as machinery and personnel (Huo et al., 2014). Thus, suppliers should be selected according to their quality practices following a systematic procedure (Hu et al., 2015; Jayaram et al., 2010). A comprehensive supplier evaluation system can also ensure the supplier maintains the desired level of quality (Noshad and Awasthi, 2015). Moreover, manufacturers cannot keep producing high-quality products without active suppliers' cooperation. Companies purchase both product parts and capabilities from their suppliers; therefore, supplier cooperation practices should rely on mutual benefits rather than arm length relationships (Kuei et al., 2011). The frequent and timely communications about quality assist with reduction of quality disputes and coordination of quality goals (Huo et al., 2014). The systematic approach to information sharing and energetic supplier involvement are core supplier cooperation practices (Hu et al., 2014). Furthermore, efficient supplier cooperation relies on long-term supplier development practices, which reinforce communication and eliminate obstacles between buyers and suppliers. Supplier relationship development practices refer to organisations' effort to improve suppliers' capability for long-term mutual benefit (Foster, 2008). Moreover, buyers should cooperate with appropriate suppliers who are able and willing to share information and participate in buyers' quality programmes (Hu et al., 2014). Buyers should then increase reliance on the suppliers and try to develop closer relationships with them through providing appropriate training and financial support (Noshad and Awasthi, 2015). Therefore, supplier development is measured by the mutual understanding of quality expectation and the channels of strengthening suppliers' quality capability.

Companies with diverse ownership, structure, and capability should apply customised quality practices to maximise performance (Zhang et al., 2012). In China, CJJVs control more and better resources than CSBs in the fields of machinery and workforce (DRC, 2015). CJJVs not only apply more mature quality systems within their companies but also have more experience in supporting and learning from suppliers (Lu et al., 2014). Advanced quality systems assist CJJVs in designing quality plans and selecting potential suppliers; more skilful staff help CJJVs to communicate and coordinate with suppliers

more efficiently (Lu et al., 2014). Moreover, Li et al. (2003) and Chen and Tan (2013) summarised that JVs have more successful QM than Chinese domestic companies due to their employees' better understanding of quality control and continuous improvement philosophy. However, no past research has systematically investigated SSQM by comparing CSB-Supplier and JV-Supplier dyads. Hence, it is necessary to study the influence of ownership on SSQM in the Chinese automobile market. Based on our research objectives and the literature review, this research was guided by two research questions: RQ1) How do SSQM practices differ? RQ2) Why do such differences occur?

3. METHODOLOGY

The two research questions are designed to clarify the SSQM conditions and the corresponding root causes; hence, it is suitable to conduct case study research to explore contextual aspects and relationships (Yin, 2013). Case study is a helpful approach when researchers seek to answer 'how' and 'why' type questions (Yin, 2013). The cases of this study were selected based on three criteria: 1) the automaker is a major player in the Chinese automobile industry; 2) the ownership of the automaker is either CSB or CJJV; 3) the automaker can provide access to one of its suppliers. As a result, one CSB-Supplier dyad and one CJJV-Supplier dyad were selected. Data triangulation was implemented by conducting semi-structured interviews, reading company documents (i.e. annual reports, internal SSQM memos), and observing the manufacturing process (i.e. site visiting) to enhance data reliability and validity. Two interview protocols (Automaker Version and Supplier Version) that consist of 15 interview questions were developed from the literature to ensure a smooth and rigorous environment for the interview, and for collecting rich data. Two managers in each company, who supervise SC and quality works, were interviewed. Hence, eight interviews were conducted in our study. Company and interviewee names were anonymised due to confidentiality agreements. The interviews were audio recorded, and the average duration was around 50 minutes. After collecting the necessary data, the data analysis process of Miles and Huberman (1994) (i.e. data reduction, data display, and conclusion drawing) was employed. The within-case analysis was conducted to categorise the SSQM practices for each dyad. The cross-case analysis was then applied to compare the differences between these two dyads and identify, compare, and contrast the factors that affect SSQM.

4. CASE ANALYSIS
4.1. Within-Case Analysis
4.1.1. CSB-Supplier Dyad

CA is famous for making durable and long lasting models. In 2015, it sold 950 thousand vehicles and had the second largest market share among all CSBs. For the SSQM, CA requires suppliers to obtain ISO/TS16949 certification. Moreover, for the different components, CA categorises suppliers into different groups. LQC (Quality Manager, CA) claimed: "*For each component, we classify the involved suppliers into four levels based on their capability of product development, quality improvement, order fulfilment, and cost control*". In addition, CA established Variability Reduction Teams (VRTs) for different components to improve quality. The VRTs are composed by the employees from the involved companies. VRTs hold weekly telephone meetings to discuss quality issues. Besides, to better supervise suppliers, CA developed a customised Supplier Relationship Management (SRM) system with the help of Oracle Corporation. LXQ (SC Manager, CA) stated: "*Our SRM systematically records, supervises, and analyses the quality and production data of intra-system and extra-system suppliers. This system helps us to accurately evaluate, select, and assist our suppliers*". Furthermore, CA also holds an annual supplier conference to reward the suppliers that contribute most in the field of quality development, synergy enhancement, and product design.

CAS supplies rubber products to CA for more than five years. It is located in Hebei and employs more than 400 workers. For CA's supplier selection, XST (General Manager, CAS) stated: "*The current requirements and selection standards of CA are stricter than the past criteria. The stricter selection standards not only benefit CA but also help us to improve the quality. However, on the other hand, CA's standards increase both the*

technical and financial burden to our company". XSZ (Quality Manager, CAS) further claimed: *"Due to the large number of CA's models, the design of components, the quality requirements, and production schedules differ tremendously. What is worse, sometimes CA's requirements and evaluation are incomprehensible and not clear"*. For supplier cooperation, although CA built VRTs and implemented SRM, XSZ still thought that cooperation cannot bring expected returns. He stated: *"CA's quality staff barely came to our company to help us. We mainly communicated through QQ (Chinese chat software), but the discussed content focused more on the production plan"*. For supplier relationship development, CA aims to jointly develop with suppliers through providing financial and technical support, but XSZ indicated: *"We never received financial assistance from CA but feel stressed due to CA's cost control"*. XST then summarised: *"In general, our relationship with CA is closer than five years ago. But we still think CA does not treat us as importantly as we treat it. It mainly requires us to complete the tasks and fulfil the commitment. I think we are in a hierarchical relationship"*.

4.1.2. CJJV-Supplier Dyad

The sales of DN reached 1.04 million in 2015 and it was ranked first among all CJJVs. DN implements a "PQVE" policy to guide SSQM, in which "P" represents profit, "Q" represents quality, "V" represents volume, and "E" represents efficient. For the supplier selection, DN requires all the suppliers to have ISO/TS16949 certification as a minimum requirement. The company evaluates suppliers' quality monthly by testing the 5M1E (Man, Machine, Material, Method, Measure, and Environment). For supplier cooperation, DN jointly sets up the quality target with suppliers and then breaks it down to component level for corresponding suppliers. Moreover, the company implements a Quality Control Data Distribution System (QCDDS) to promote communication with suppliers. QCDDS can carefully record the defect quantity, the responsible factory, located region, and solution. Furthermore, DN applies Gemba Kaizen (GK) in supplier cooperation as well. GK means continuous improvement at the production spot. XHG (Quality Manager, DN) explained: *"GK activity means that we send technical staff to suppliers' sites to help them analyse, summarise, and improve quality. We will show suppliers our style of continuous improvement and teach them how to do it"*. The cost of GK is jointly covered by DN and involved suppliers. For supplier relationship development, DN also selectively invests in some suppliers to help them upgrade machinery and technology. It implements an "Encourage Policy" to build healthy relationships with suppliers. XHG further claimed: *"We not only support suppliers by providing quality training and financial investment. We also encourage suppliers to compete with each other to help them to keep the continuous improvement spirit. Hence, we (DN and suppliers) can achieve the win-win result"*. DN also holds an annual supplier conference, in which a Quality Forum is arranged.

DNS produces plastic door handles for DN. It is located in Jiangsu and employs around 350 workers. For DN's supplier selection, LHW (Sales Manager, DNS) stated: *"The supplier evaluation process and standards of DN are transparent and consistent. Even though the selection standard becomes stricter, we can comprehensively prepare the test based on the criteria provided by DN"*. For DN's supplier cooperation, MXH (Quality Manager, DNS) positively commented on the GK activity. He indicated: *"At first, we didn't want to do GK due to the huge amount of cost (around 50 thousand GBP). But we had no other choice in order to sign the contract with DN. Surprisingly, the results shocked us. We saved around 300 thousand GBP in the end"*. Hence, supplier cooperation was not only beneficial to DN but also created huge value for DNS. For DN's supplier relationship development, LHW argued DN not only provides support but also brings crisis awareness to suppliers. LHW explained: *"I think DN applies the so-called 'Catfish Effect' to us. DN keeps seeking potential suppliers that produce the same components as us. This makes us keep working on improving product and service…… DN also provides technical and financial assistance"*. MXH then summarised: *"We work as a partner of DN. DN not only assigns tasks to us but also offers profitable returns. DN not only invites us to participate in its product design and quality improvement but also provides a blueprint when our capability can't meet the requirement"*.

4.2. Cross-Case Analysis

Based on the SSQM condition of each dyad obtained from the within-case analysis, the cross-case analysis was then conducted. Data was reduced further to derive commonalities and differences between these two dyads. Our data revealed that each automaker implemented SSQM in its particular way. The suppliers also treated automakers' SSQM differently and reacted in their own distinctive way. We found that both CSB and CJJV were implementing more and more rigorous supplier selection standards. They designed and applied various cooperation activities to involve suppliers in their quality improvement work. Moreover, in order to strengthen the buyer-supplier relationship, they also set up support plans to assist suppliers in improving product and service. However, the suppliers treat and react differently to these SSQM practices. Although CAS admitted that the SSQM practices of CA can improve quality for both CAS and CA, it still complained about the negative impact and deficiency of those practices. On the other hand, DNS was more welcoming to DN's SSQM practices and treated these practices as major sources of performance improvement. Through continually comparing the data of these two dyads, two major factors that cause the differences are clarified.

4.2.1. Automaker's Capability

During the field work, we found clear gaps in the fields of quality training, employees' capability, and execution of quality improvement plan between CA and DN. In CA, the quality training for staff is provided when they join the company. Only selected managers will be sent to Shanghai or Beijing to participate in advanced QM sessions. Moreover, LQC (Quality Manager, CA) complained: "*How can we build a functional Failure Mode and Effects Analysis (FMEA) database by only three young staff without the knowledge to identify the occurrence and severity of quality problems?*". LXQ (SC Manager, CA) further added: "*Although we apply the five tools of ISO/TS16949 in the company, our staff cannot skilfully handle Advanced Product Quality Planning (APQP) and the Production Part Approval Process (PPAP)*". APQP and PPAP are the core parts of involving suppliers in automakers' product design and quality improvement (Lu et al., 2014). The insufficient capability of conducting APQP and PPAP directly causes the fluctuation of quality requirements, production plans, and product designs in CA. This then largely increases the burden of CAS in the field of quality assurance and production stabilisation.

On the other hand, DN only hires staff with at least a bachelor degree. To the different levels of employees, DN not only provides induction quality training but also arranges weekly quality training sessions. XHG (Quality Manager, DN) further stated that: "*We send our quality managers to Japan to visit and work with our Japanese parent company. This training channel significantly improves their understanding of quality and how to use tools to supervise quality work*". The comprehensive quality training and high employee capability ensure the smooth execution of GK activity and the successful application of QCDDS. Hence, the quality department staff of DN can provide quality guidance when DNS can't meet the quality requirements. Moreover, owing to the resources of the Japanese parent company, DN has sufficient ability in product design and quality planning. Thus, DN can provide clear and stable criteria to evaluate DNS. This can decrease the variation of DNS' production; in return, the quality of DN's vehicles can be stabilised due to the consistent components produced by DNS.

4.2.2. Suppliers' Status

In the CSB-Supplier dyad, CAS acts as the subordinate of CA. This means CA orders CAS to meet its fast changing quality and production requirement but offers insufficient support and returns. Based on the within-case analysis, CAS didn't receive enough quality guidance and financial assistances from CA but kept cutting the cost to meet CA's price requirements. This indicates that CAS shows more commitment to improving quality in this dyad. This kind of SSQM approach blocks the communication between CA and CAS and decreases the efficiency of SC synergy, which in turn generates more

complaints from both CA and CAS. Hence, the lower status of CAS in the CSB-Supplier dyad negatively influences SSQM.

However, in the CJJV-Supplier dyad, DN treats DNS as a partner. This means DN and DNS share the same quality improvement goals, make mutual agreeable inputs into quality improvement, and receive the deserved returns. For example, the GK activity in this dyad needs financial and technical investment from both DN and DNS. In return, DN can receive components with better quality and DNS can make more profit. Moreover, DN applies the so-called 'Catfish Effect' in developing a strong partnership with suppliers. For instance, instead of merely providing support to DNS, DN also motivates DNS to compete with potential suppliers to continuously improve quality. With the better product and service, DNS did not act as a follower of DN but played a significant partner role in ensuring DN's quality. DNS is more welcoming to the SSQM practice of DN and can provide more valuable input. Therefore, the more equal status of DNS in the CJJV-Supplier dyad positively affects SSQM.

5. DISCUSSION

Based on the within-case analysis, RQ1 was answered. Although CSB and CJJV are implementing stricter supplier selection standards, conducting more supplier cooperative activities, and strengthening the supplier relationship, the involved suppliers react differently to automakers' SSQM practices. In general, the CJJV-Supplier dyad obtains a more successful SSQM than the CSB-Supplier dyad. DNS is more welcoming to SSQM practices and prefers to actively participate in the automakers' quality improvement work. According to the cross-case analysis, RQ2 was answered. The different automakers' capability and the supplier status in a dyad together determine the execution of SSQM and the reaction by the supplier. By summarising the results of these two research questions, an SSQM framework for the Chinese automobile market was developed, which is presented in Figure 1 below. The six internal black rectangles, namely selection criteria, supplier evaluation, quality information sharing, supplier involvement, mutual understanding of quality goal, and strengthening supplier's quality, indicate the SSQM aspects that reveal differences between CSB-Supplier and CJJV-Supplier dyads. The two external grey rectangles, namely automaker's capability and supplier's status, represent the root causes of different SSQM in the Chinese automobile market.
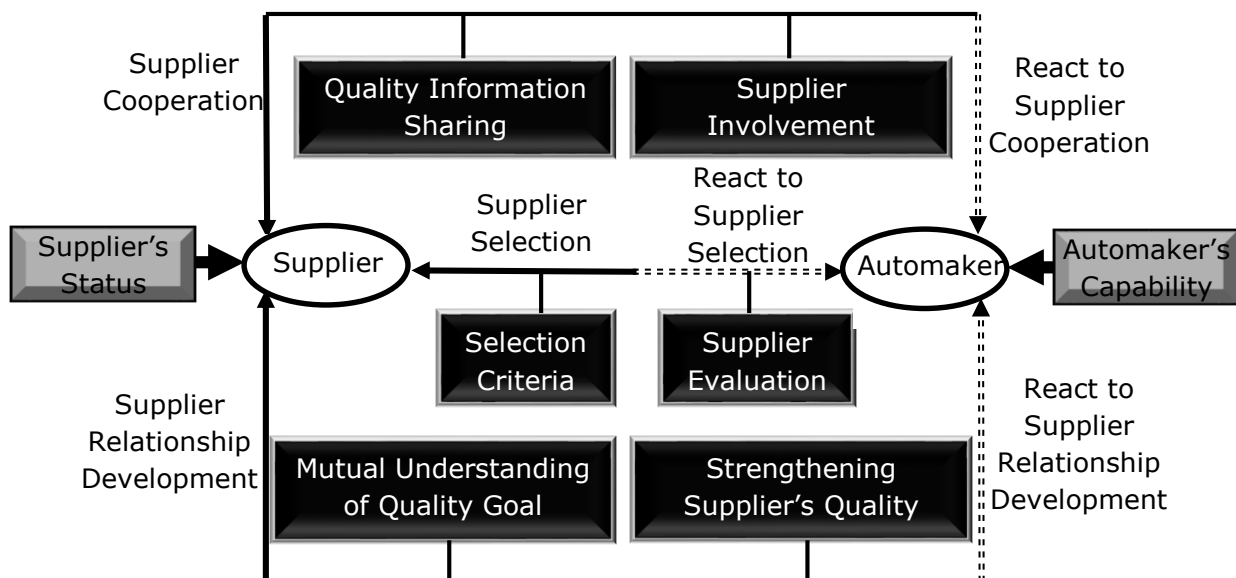
Figure 1: SSQM Framework for the Chinese Automobile Market

The finding of the different SSQM conditions between a CJJV-Supplier dyad and a CSB-Supplier dyad is consistent with Li et al. (2003), who identified that JV conducts better QM practices than other types of companies in China. However, it is contrary to Zu et al. (2011), who suggested that the ownership doesn't bring any influence on quality work for Chinese companies. Zu et al. (2011) argued that Chinese companies have made

substantial efforts in upgrading advanced techniques and accepting modern management practices. However, adopting advanced quality technologies and practices doesn't equal excellent execution. Moreover, compared to CJJV, the insufficient capability in CSB can significantly block SSQM application (Hu et al., 2015). The summarised two impeding factors of SSQM confirm the work of Chen and Tan (2013), which clarified that JVs conduct more successful quality work than Chinese local companies due to controlling work better and having more resources. In addition, the insufficient SSQM in the CSB-Supplier dyad supports the work of Soltani et al. (2011), who suggested that the cooperation with high-quality, capable suppliers, can't always benefit the SC.

6. CONCLUSION

This study identifies two SSQM literature gaps, clarifies the different SSQM approaches in the Chinese market, identifies two major impeding factors of SSQM implementation, and proposes an SSQM framework. The findings contribute to the ongoing SSQM research by comparing two dyads with different ownership. This comparative study answers the call for ownership and behaviour research in SC quality proposed by Foster (2008), Flynn et al. (2013), and Huo et al. (2014). As one of the first to point out the different SSQM between the CSB-Supplier dyad and the CJJV-Supplier dyad beyond the company-wide perspective, our study can add value to current SSQM literature. Moreover, our work provides empirical evidence to reflect real differences of SSQM in the CBS-Supplier dyad and CJJV-Supplier dyad by including both the buyer and the supplier of the dyad in the research. We conclude that, despite the difficulty of gaining access to dyadic populations, further research on perceptual differences involving matched-pair data is necessary.

This study provides several insights that CSBs should pay much more attention to efficiently applying SSQM. Although CSBs continuously adopt advanced quality theory and up-to-date quality tools, they cannot professionally involve suppliers in SSQM and motivate them to provide more input. Based on our study, CSBs should enhance their capability through hiring more skilful and professional staff and providing well-designed quality training to employees. This can assist CSBs to guide and cooperate with suppliers more efficiently. Moreover, CSBs should treat suppliers as partners but not followers. The suitable status of suppliers in SCs can promote SSQM. Through jointly designing quality tasks, making mutual agreeable input, covering reasonable investments, and offering deserved returns, CSBs can encourage suppliers to adopt SSQM and then devote themselves to quality improvements in SCs.

It is significant to evaluate the findings and contributions of our research with the limitations. The generalisation of this case study may be questioned due to the small sample size and the contextual environment. However, this study still provides valuable insights for academics and practitioners on how to apply SSQM in the Chinese automobile market. This limitation paves the way for future study. First, more companies with diverse characteristics should be investigated. For example, American and German automakers should be involved in future work. Second, other methodological approaches, such as a large-scale survey, should be conducted to test the findings of this study.

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HOW SUPPLIER SELECTION CRITERIA AFFECTS BUSINESS PERFORMANCE? A STUDY OF UK AUTOMOTIVE SECTOR

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Abstract
Purpose of this paper:
According to KPMG international (2015), global sales of automobiles are forecasted to reach 73.9 million vehicles and expected to hit 100 million units in the next two years. This shows that automotive sector has a tremendous growth potential and UK automotive sector is no different. However, in recent years the growing environmental awareness has become a major concern for automotive sector as they are faced with pressure of reducing carbon emissions as well as the costs. Suppliers play a significant role in achieving environmental goals set by organisations. Under these circumstances it is worth exploring the criteria that are used in assessing suppliers including the green aspects and how that affects the business performance.

Design/methodology/approach:

This research adopts a mixed method research approach. In order to collect the quantitative data a survey questionnaire was constructed and sent to automotive businesses listed in the FAME database. In order to triangulate the findings of this study, survey was complemented with in-depth interviews. Around 100 automotive manufacturers were invited for the survey however only 38 usable responses were received. In total seven semi-structured interviews were also conducted with people from different backgrounds and work experiences in the automotive sector.

Findings:

Literature identified delivery, cost, quality and technology as the supplier assessment criteria commonly used in assessing suppliers in automotive industries. Yet the issue of culture and green supply chain practices (GSP) were also widely concerned in several studies. The data analysis showed that delivery, quality, cost, technology, culture are correlated with exception of green supply chain practices. GSP was only found to be correlated with technology and cultural criteria. Semi-structured interviews suggest delivery and quality as the most important criteria when assessing supplier because of their greater impact toward business performance and reputation. Findings from all respondents also showed that most automotive manufacturers have already adopted

environmental competency in their criteria. However, interviewees mentioned that this criterion does not take a major role in assessment compared with other criteria. The results also indicate that all factors studied do affect the business performance of automotive organisations.

Value:

This study contributes to the limited literature focused on assessing supplier selection criteria and business performance linkage in the UK automotive organisations. In addition, most studies on supplier selection and business performance ignore the green practices as important criteria which this study aims to address.

Research limitations/implications:

The study is based on the findings from a limited survey responses and semi-structured interviews. Having larger sample population would certainly improve the validity of the findings. The perspective of SMEs and large businesses with regard to each supplier selection criterion may be different hence the future research in this domain would also provide some valuable contributions.

Practical implications:

The survey responses indicate green supply practices as one of the important criteria in supplier selection. This suggests that automotive manufacturers should realize the importance of green practices while selecting their suppliers. This will help them to meet their own green goals while simultaneously meeting the government environmental regulations.

INTRODUCTION

According to KPMG international (2015), global sales of automobiles are forecasted to reach 73.9 million vehicles and expected to hit 100 million units in the next two years. This shows that global automotive sector has a tremendous growth potential and UK automotive sector is no different. However, in recent years the growing environmental awareness has become a major concern for automotive sector as they are faced with pressure of reducing carbon emissions as well as the costs (Zhu, Sarkis and Lai, 2007; Holt and Ghobadian, 2009). As Zhu, Sarkis and Lai (2007) stated that the green supply chain management is a new approach to assist the firms to develop 'win-win' strategies to obtain profit and market share by reducing the environmental risks and become more ecological friendly. The reduction of carbon dioxide emissions is taken more seriously while the cost pressure on organisations may increase the risk of quality problems. With the changing regulatory requirements and shifting technological landscape, it is crucial for automotive industries to seek a balance to survive in this competitive market.

Suppliers play a significant role in achieving environmental goals set by organisations. The change in trend is directly affecting the procurement primarily due to necessities of a purchasing team to ensure that the cost control is well managed. Thus, the supplier selection processes should be taken into consideration (Svensson, 2004). The purchasing is an important activity as most automobile companies rely on a number of suppliers for vital components of their products. In most industries, cost of purchased materials and parts can take up to 70% of the final cost (Ghodsypour and O'Brien, 1998). Hence, the purchasing team has to assess suppliers wisely to minimize the cost of the product to increase the margin for earning more revenues. A poor decision making in selecting right supplier may lead to severe problems (de Boer, Labro and Morlacchi, 2001). Under these circumstances it is worth exploring the criteria that are used in assessing suppliers including the green aspects and how that affects the business performance (Kannan and Tan, 2002).

The purpose of this research therefore is to investigate how the supplier selection impacts on organizational performance in an automotive industry. Previous studies have been performed on both supplier assessment and business performance from different aspects. However, a fewer number of studies have used cultural alignment and green supply chain practices in supplier assessment criteria. This research specifically focuses on investigating the impact of supplier selection on the organisational performance in the automotive industry. The next section reviews the literature around this area.

LITERATURE REVIEW
In a competitive global environment manufacturing sector plays a major role in many economies. Supplier selection has emerged as one of the critical factors to the success of organization, and in particular, organizational performance. Organizational performance is an indicator showing how well the business has done. Several researchers have therefore focused on the framework for supplier assessment and performance measurement on different aspects; some studied on the differences between countries, some focused on specific industry for instance automobile (Gnanasekaran, Velappan and Ayappan, 2010), electronics (Pearson and Ellram, 2015), software (Stewart, 1995), telecommunications (Önüt, Kara and Işik, 2009) and healthcare (Lambert, Adams and Emmelhainz, 1997). Since the automotive industry plays a key role as a major exporter in several countries, this study will focus on automobile's supplier assessment and business performance.

Purchasing and Supplier Assessment
In most organizations, the purchasing or procurement department exists as a backbone of the operations where the significance of the department is relatively high in manufacturing, retail and other industrial organizations. Purchasing has played a critical role in cost saving and operates cash-associated jobs as more than half of the sales turnover is often spent on purchased materials and service. Ghodsypour and O'Brien (1998) have stated that the cost of materials and components can take up to 70% of product in some cases. In general, the jobs of purchasing are (1) Maintaining the quality of organization's product, (2) Preventing cash tie-up in inventory, and (3) Procuring materials; might include bidding when associated with supplier assessment. Van Weele (2009) highlights that healthy relationship with suppliers can improve the financial position in short term and the competitive strategy in long term.

There are several ways to choose suppliers and the assessment has changed throughout the time. The buying firm can either get single source or multiple sources of suppliers. Both sources have benefits and drawbacks and it depends on the type of purchasing. Potentiality having reliable suppliers is a key to successful purchasing (Pooler and Pooler, 1997). The role of supplier assessment has been increasingly gaining attention of researchers which is evident from the research publications (Gunasekaran, Patel and McGaughey, 2004; Kannan and Tan, 2002). A number of organizations have increased the level of out-sourcing and rely on the supply chain as a competitive strategy (Choi and Hartley, 1996). Several approaches to assess suppliers have been followed over years including offline competitive bids, reverse auctions, and direct negotiation. However, before assessing suppliers, a company should decide whether to use single source or multiple sources (Chopra and Meindl, 2013). After the lists of interesting suppliers have defined, request for quotation approach applies to get the price from each supplier. Request for quotation (RFQ) approach is used when the price is not published and only certain supplier are invited to quote in the aspect of how they could meet the requirements and state the cost of supply (Pooler and Pooler, 1997).

Factors in Supplier Assessment
There are many factors that affect the decision such as brand reputation, quality, and availability in addition to cost. Therefore, the decision should be made carefully among alternatives to select suppliers. There are a number of criteria beside price that generally is used in assessment such as reliability, financial factors, technology, delivery,

availability, quality, sustainability, and service. In recent studies, green purchasing is normally included in the supplier selection criteria due to the increasing awareness of people in environmental competency (e.g. Humphreys, Wong and Chan, 2003; Zhu and Sarkis, 2004). A number of studies have defined that quality is perceived to be the most important criteria for managers. Contrarily, in practical approach, researchers have examined that cost and delivery becomes the most impactful factor for the managers when the decision is made (Kannan and Tan, 2003). Nonetheless, some studies have argued that cost is the least important factor (Choi and Hartley, 1996). Furthermore, technology also takes part in supplier selection criteria because components that are not the core competencies of the firm usually shift to supplier with appropriate technology (Vonderembse and Tracey, 1999). Several factors have been determined following both quantitative and qualitative criteria. Quantitative criteria refer to price, quality, and delivery whereas qualitative refers to service, management compatibility, flexibility which are the criteria difficult to quantify and requires the expert to assess the judgment (Bhutta and Huq, 2002). Nevertheless, it is difficult for managers to maximize all dimensions' performance (Verma and Pullman, 1998). The assessments have come with trade-offs where the firm has to balance tangible and intangible factors. Therefore, managers have to weigh the emphasis of individual factors to construct the best strategy for business.

Environmental challenges have increasingly concerned businesses at the global scale including transportation, storage, and the disposal of material waste. Since sustainable purchasing has become one of the important activity in logistic and supply chain activities (Grant, Trautrims and Wong, 2013), therefore sustainable purchasing and procurement play an essential role in the organisation in reducing environmental footprints which can start from sourcing supplier, until collaborating with suppliers, and also include lifecycle assessment. However, applying environmental factor into purchasing decision comes with trade-offs, as this area is relatively new where little theory exist (Handfield et al., 2002). In order to reduce the environmental impacts, the firms have to contribute to their suppliers to enhance the environmental performance (Jabbour and Jabbour, 2009). There is an interrelationship between environmental factors, cost and quality (Grant, Trautrims and Wong, 2013). Cost performance can be improved by the improvement of quality whereas quality performance assists the environmental performance. Good quality performance can facilitate reduced material wastes from rework and carbon footprint. However, cost reduction is a major consideration in procurement. Buyers may prefer to go with the lowest price and not willing to pay more for sustainable products as well as implementation of sustainable practices (Grant, Trautrims and Wong, 2013).

The exploration on supplier assessment has been widely observed in different approaches and scenarios in different countries. Kannan and Tan (2003) have examined the attitudes on supplier selection of US and European managers and the impact on performance, whereas the supplier selection practices in US automotive industry at different levels have been compared by Choi and Hartley (1996). Yet numerous articles have focused purely on the impact of green supply chain management towards industry (Kumar et al., 2015; Zhu, Sarkis and Lai, 2007). Furthermore, culture becomes more essential for businesses since many organisations are engaged in overseas purchasing. The alignment of culture between organisations can impact the decision made on supplier selection. Cost, delivery, quality and technology are generally included as the supplier assessment criteria. Cost directly relates to the purchasing job where cost savings is the main aim. Other factors can influence cost criterion such as delivery, technology, and quality. On time delivery becomes more important, while late delivery will impact the cost of production (Vonderembse and Tracey, 1999). Quality is also perceived to be the most important criteria by researchers (Verma and Pullman, 1998) because the poor quality of components results in rework which will impact the cost of production and delivery that may require shorter lead time to prevent the production line to stop. Moreover, technology is also important in assessment criteria as a great number of components are made by suppliers (Vonderembse and Tracey, 1999). The firm should ensure that

technology is appropriate to enhance the capacity and the manufacturing process. Moreover, technology also plays an important role in implementing green supply chain practices.

From above discussions, it could be seen that all criteria are somehow related and have an impact on each other. Therefore, this research will investigate how supplier selection criteria have an impact among themselves and toward business performance. This research is intended to include culture and green supply chain practices altogether with delivery, quality, cost, and technology since not so many studies have included green supply chain practices and culture into the assessment criteria. Hence, this research gap leads to the conceptual framework (See Figure 1) and hypotheses formulation.
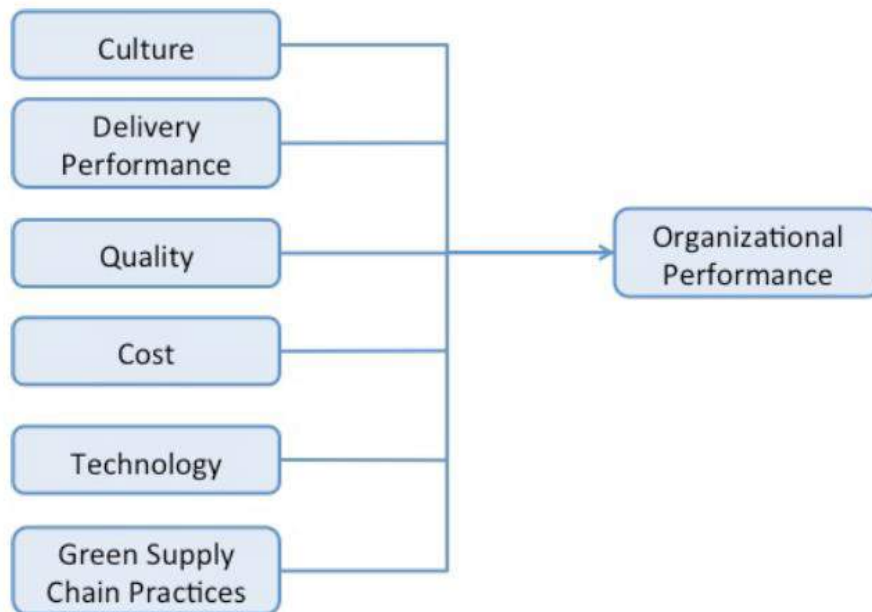
Figure 1: Research Framework

Hypotheses

Seven hypotheses are set to be investigated;

Hypothesis 1: On time delivery has a positive influence on business performance
Hypothesis 2: Quality has a positive influence on business performance
Hypothesis 3: Cost has a positive influence on business performance
Hypothesis 4: Technology has a positive influence on business performance
Hypothesis 5: Culture has a positive influence on business performance
Hypothesis 6: Green supply chain practices have a positive influence on business performance
Hypothesis 7: All dimensions of supplier selection criteria interlink with each other

METHODOLOGY

This research adopts a mixed method research approach, i.e., a combination of quantitative and qualitative method. Cross-sectional research was chosen for this subject because the study only obtained the data at a single point in time. In order to collect the quantitative data a survey questionnaire was constructed. A number of supplier assessment criteria were identified through the literature and questionnaire was prepared accordingly. Business performance questions reflected the degree of impact toward each criterion. Respondents were asked to complete the survey using five-points rating scale (1 = strongly disagree, 5 = strongly agree). The web-based questionnaire created using Qualtrics software was sent to the automotive businesses listed in the FAME database.

Around 100 automotive manufacturers were invited for the survey however only 38 usable responses were received. Although the number of responses are small but the response rate (38%) is good compared to many published studies.

In order to triangulate the findings of this study, survey questionnaire was complemented with seven in-depth interviews with people from different backgrounds and work experiences in the automotive sector. Six interviewees were directly involved in the purchasing area while another one indirectly works in purchasing but partially involves in supplier selection process. Two one-to-one interviews and five telephonic interviews were conducted from seven automobile companies.

To ensure that the quality of research is consistent and accurate, reliability and validity must be met (Bryman and Bell, 2011). Triangulation was applied between questionnaire and interview to achieve reliability. The finding from literature reviews, survey and interviews were merged to ensure that the data collection is consistent. The quantitative data was securely collected on the web-based tools where qualitative data was confidentially recorded in a quiet environment and all personal data were kept anonymous. The validity of data was assured by using all materials and information related to the research topic. All criteria used in the questions were directly obtained from reliable source, i.e., literature and company manuals. Pilot test was done to prevent any error in the questionnaire before it was distributed to all respondents (Bryman and Bell, 2011). In the aspect of interview, they were conducted with professionals directly and indirectly related to purchasing department.

FINDINGS
The survey questionnaire was sent to around 100 automobile manufacturing companies which resulted in 38 valid responses. Descriptive analysis shows that most respondents (39%) were from the large organisations (between 1000-5000 employees), whereas around 34% were from organisations less than 1000 employees. About 50% of the respondents were senior managers, followed by assistant managers (34%) and general employee (16%). When asked about how many suppliers normally they deal with, most of them (37%) mentioned between 100-500 suppliers, followed by 51-100 suppliers (21%), less than 50 suppliers (18%), 501-1000 suppliers (13%) and more than 1000 suppliers (11%). This shows that most automobile manufacturers deal with a significant number of suppliers that supply several small to large components.

Variables that we focus in this study comprise of delivery, quality, cost, technology, culture, green supply chain practices (GSP), and business performance (BP). Hence respondents were asked their opinion about these specific criteria. Majority of respondents agree that on time delivery is important when assessing suppliers whereas reliable transportation is also relatively important. Respondents moderately agreed on other factors such as the location of supplier should be geographically compatible, delivery takes short lead time and the firm has ability to respond to unexpected demand. Respondents strongly agree that the quality of supply should always meet requirements. Meanwhile respondents acknowledge that supplier who has certificate to guarantee the quality is important as well. Respondents highly agree that the competitive price of materials, parts, and service is more desirable and likely to win the bidding. The ability of supplier to reduce material cost and delivery cost is agreed by respondents as winning criteria while respondents slightly agree on the low labour cost. Respondents admit that the willingness of supplier to continually improve product and process is desirable while plenty amount of expertise is of less concern. Respondents somewhat agree that ability of the firm to set up for new products at short period of time is important and the order entry and invoice system of supplier is easy to use is another aspect that can win bids. When asked about the culture, respondents moderately agree that cultural match between firms is essential and supplier's work ethics should align with buying firm. Moreover findings show that political stability of the supplier's country is barely important in the opinion of respondents. In contrast, respondents slightly disagree that the firm

should have excellent government support to their business. However, respondents tend to agree that honest communication between firms is important.

When asked about the green supply chain practices, respondents relatively agree that the parts or products should be designed to be environmental friendly. However, respondents also point out that the supplier with green image and willing to spend on environmental cost on improving system is less important, which was very interesting finding. This shows that automobile companies are not driven by image of the organisation rather actual practices followed by suppliers draw more attention. In addition, respondents somewhat agree on supplier that has high environmental competencies and has capability to generate low level of pollutant effects. Finally, respondents were asked to rate the impact of each supplier selection criteria towards business performance. They strongly agree that on time delivery and satisfactory quality has a positive impact on the business performance together with cost control. Respondents moderately agreed that cultural alignment and being eco-friendly has a positive impact towards business performance. In order to test the proposed hypotheses, we run the correlation analysis on the survey data. The outcome of the analysis is shown in Table 1 (see below).

Table 1: Correlations

	Delivery	Quality	Cost	Technology	Culture	GSP	BP
Delivery	1						
Quality	.574**	1					
Cost	.643**	.581**	1				
Technology	.480**	.476**	.559**	1			
Culture	.401**	.411*	.476**	.489**	1		
GSP	.133	.006	.0249	.361*	.522**	1	
BP	.371*	.401**	.459**	.311**	.648**	.312*	1
** Correlations significant at the 0.01 level (1-tailed)							
* Correlations significant at the 0.05 level (1-tailed)							

As shown in Table 1, delivery is strongly correlated with cost while moderately correlated with quality, technology, and culture criterion. Delivery does not correlate with green supply chain practices at all. However, delivery is moderately correlated with business performance. Thus, delivery has high impact on cost while the influence on quality, technology, culture and business performance is somewhat affected. Hypothesis 1 (H1) is proved to be valid because delivery was found to be positively correlated (.371*) with business performance. This was also verified through the interviews. Most interviewees absolutely agreed that delivery highly impacts business performance because the firm will not keep high inventory to prevent the cash tie up. One of the interviewees mentioned that '*delivery is one of the three key requirements of supplier*'.

The correlation shows that quality moderately impacts delivery, cost, technology, culture, and business performance, whereas no correlation was evident with green supply chain practices. Quality was also found to be positively correlated (.401**) with business performance and thus validating Hypothesis 2 (H2). All interviewees agreed that quality plays an important role when assessing suppliers because poor quality of supply often results in rework which increases the cost of supply and delivery time.

Cost was found to have moderate relationship with quality, technology, culture, and business performance. Similar to delivery and quality, no correlation was evident with green supply chain practices. Hence, Hypothesis 3 (H3) was also found to be valid. One of the interviewees asserted this linkage by stating that '*cost highly impacts the business performance because the selling price is set up first from the customer's preference surveys and even before the design is set. So we have to ensure that the purchasing team can lower the cost to get desirable margin*'.

Technology was found to be moderately correlated with all criteria while the business performance was weakly but positively correlated (.311**). Therefore, correlations also supported Hypothesis 4 (H4) since technology was found to have a positive impact on business performance. In support of this finding one of the interviewees claimed that 'Technology is one of our prime criteria for selecting suppliers. Suppliers need to come up with improvements on process and product through their technology and engineering'.

According to the correlation analysis, culture moderately correlates with all criteria. This implies that culture somewhat impacts delivery, quality, cost, technology and green supply chain practices. Yet the influence of culture towards business performance is relatively strong. Culture showed to have a positive impact (.648**) on business performance which proves that Hypothesis 5 (H5) is valid. One of the interviewees stated that 'difference in time zone and culture makes the communication between firms becomes slower and often difficult. Likewise the language also affects our businesses'.

Green supply chain practices was only found to be correlated with technology and culture at a moderate level, while the rest do not correlate with green supply chain practices. Moreover, green supply chain practices slightly affect the business performance since green supply chain practices has a weak relationship. Nevertheless, Hypothesis 6 is proved to be valid because green supply chain practices has a positive impact (.312**) on business performance. One of the interviewees highlighted the importance of GSP in supplier selection by stating that 'GSP partially impacts the selection because good environmental management comes with higher cost. If the bidding prices between suppliers are very close, the environmental competency may take a role'.

It is evident from the correlation analysis that most criteria are correlated with each other as well as are correlated with the business performance with the exception of green supply chain practices that does not impact business performance. Thus, correlation provides support to all our hypotheses (H1-H6) except hypothesis 7 (H7). Correlation shows that delivery, quality, cost, technology, culture, and green supply chain practices have a positive impact on business performance.

CONCLUSIONS
The findings obtained from a quantitative and qualitative approach reveal that the criteria presented in the research framework have an impact on the business performance. The survey findings give a rough idea on respondents' viewpoint towards the significance of the particular criterion while the interviews findings explicate how these criteria are important in the business. All hypotheses were tested by using bivariate correlation to observe the relationship among all factors. The correlation proved that hypothesis 1 to 6 (H1-H6) are valid while hypothesis seven (H7) is invalid because green supply chain practices did not correlate with delivery, quality, and cost factor. However, this suggests that more evidence is required before any generalisation can be made, given the role green supply chain practices does plays in supplier selection. Future research should there aim to obtain more empirical data to further investigate this and validate these findings. The study can also be expanded across different sectors and different countries. In addition, future studies should apply other robust statistical analyses such as multiple regressions, path analysis and structural equation modelling.

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THE IMPACT OF OWNERSHIP TYPE ON THE INTERRELATIONSHIPS BETWEEN BUSINESS PROCESS MANAGEMENT, SUPPLY CHAIN COLLABORATION, COLLABORATIVE ADVANTAGE AND ORGANISATIONAL PERFORMANCE

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ABSTRACT
The purpose of this study is to empirically explore the interrelationships between Business Process Management (BPM), Supply Chain Collaboration (SCC), collaborative advantage and organisational performance, and how they are attributed to the types of company ownership. Using a large scale survey questionnaire, data was collected from 204 medium and large manufacturing companies operating in Thailand. The respondents' firms were categorised into three groups based on ownership, namely Thai-owned, Joint Ventures (JVs) and foreign-owned firm. The Partial Least Squares approach to Structural Equation Modelling with multi-group analysis (PLS-MGA) was employed to analyse the results. The results suggested that ownership types partially moderate the interrelationship between BPM, SCC, collaborative advantage and organisational performance. Moreover, the results show that JVs and foreign-owned firms were found to have a higher level of BPM practices and achieve better organisational performance, while Thai-owned firms have insignificant results regarding the relationship between BPM and organisational performance. In addition, JVs show a higher level of significance on the relationship between BPM and SCC compared with foreign-owned and Thai-owned companies. The results provide insights into how to improve intra- and inter-organisational practices (BPM and SCC), especially with regards to the different types of ownership, to improve firms' performance and to maximise value.

INTRODUCTION
To ensure that a company achieves competitive advantage and enhanced performance levels, the link between a firm and its Supply Chain (SC) members is considered as one of the main enablers (Pradabwong et al., 2015). A growing number of literature has examined the relationship between ownership types and firm performance (e.g., Lefort and Urzua, 2008; Jiang et al., 2013). Firms with different types of ownerships have different operations strategies, which would have an impact on the organisational performance and goals. The previous stage of our research confirmed that there are positive relationships between Business Process Management (BPM), Supply Chain Collaboration (SCC), collaborative advantage and organisational performance. This study is a step further, as it is based on evidence that different types of ownership impact on organisational performance (Rahman et al., 2010; Zhao et al., 2011; Chen and Tan, 2013). This paper aims to examine how the type of ownership relates to the interrelationships between BPM, SCC, collaborative advantage and organisational performance. We divided ownership into three categories namely, Thai-owned, Joint Ventures (JVs) and foreign-owned companies. The results of this study contribute to extending the knowledge on BPM and SCC practices, and the benefits achieved in terms of collaborative advantage and organisational performance. Moreover, this research

offers evidence of the role of the contextual factors, namely types of ownership in BPM and SCC practices. The results of this study also have managerial implications, especially for organisations wishing to improve their collaborative advantage and organisational performance along with BPM and SCC practices.

LITERATURE REVIEW

The base-line model

The base-line model explored the interrelationships between BPM, SCC, collaborative advantage and organisational performance. BPM and SCC were identified as second-order constructs, as both approaches are higher in abstractions and incorporate a number of first-order constructs (Pradabwong et al., 2013). To cover the entire scope of the two main approaches of this study, the key constructs (first-order constructs) of BPM and SCC were identified based on an extensive review of the literature that considered the relevant number of citations. As a result, the main elements of BPM identified are: strategic alignment, information technology (IT), process orientation and improvement, and people involvement. The four main elements of SCC identified are: information sharing and communication, sharing common goals, joint activities, and incentive alignment. A Multi-dimensional approach was employed, and items were developed to explain each construct.

The research framework and hypotheses were developed and empirically tested based on the Partial Least Squares approach to Structural Equation Modelling (PLS-SEM) with a large-scale survey data collection (204 usable questionnaires) from manufacturing firms operating in Thailand. The results show that: (a) items are reliable and valid to explain each construct; (b) there is a direct positive relationship between BPM and SCC, BPM and organisational performance, SCC and organisational performance, SCC and collaborative advantage, and collaborative advantage and organisational performance; (c) regarding the mediating effect, the relationship between BPM and organisational performance is partially mediated by SCC, and the impact of SCC on organisational performance is partially mediated by collaborative advantage (Pradabwong et al., 2013). This study is a step further because it discusses the contextual factor of ownership types to determine whether they moderate the interrelationships under investigation.

Specific reliable and valid items were used to explain each construct (Pradabwong et al., 2013). BPM is characterised as having four main constructs): (1) IT which can be explained by three reliable and valid items: data sharing, IT integration, the use of IT to support supplier performance measures; (2) Process Orientation and Improvement which are explained by 5 items: process and value stream mapping techniques, effective business process improvement approach, KPIs, understanding about business process, learning new skills continuously; (3) People involvement is described by five items: top management responsible in solving problems, and communication with employees, employees involved in planning, decision making, and opportunities to fix problems; and (4) Strategic Alignment can be described by four items: strategies being developed based on customer needs, sufficient methods of measurement and clear tracking of performance, strategic planning has taken to functions/areas, process measures has been developed based on strategy. Regarding SCC, four main constructs and their items were identified: (1) Sharing common goals which is explained by six items: agreement on the goals of the SC, collaboration targets, the improvements that benefit the SC, tactical goals and objectives, working towards the goals of the SC, collaborative plan; (2) Incentive alignment is described by four items and these are the sharing of costs, risks,

benefits, commensurate with investment and risk; (3) Information Sharing and Communication are explained by four items: providing advanced information about any change, the sharing of information that benefits each other, looking for new and relevant knowledge together, identifying customer needs; and (4) Joint activities are described by five items, namely resolving forecast exceptions, optimising availability levels, inventory requirements, resolutions on order exceptions and working out solutions on quality problems. Moreover, five items which are time to market for new product development, product variety, product innovation, quality, and meeting customer requirements are used to explain collaborative advantage. Organisational performance covers both financial and non-financial performance and four items have been developed and were tested for reliability and validity; these items are: sales growth, return on investment, overall competitive position, and core competencies and capabilities. This study is a step further, as it uses this base-line model to empirically test whether firm ownership would have an impact on those relationships.

Impact of ownership
Ownership refers to control, governance and directional power of a firm and this refers to the person or entity who owns the firm (Zhao et al., 2011; Chen and Tan, 2013). It has significant implications for organisational control, risk sharing, resource allocation, bargaining power and managerial decision making (Zhao and Lou, 2002). Several studies have stated that different types of ownership influence organisational performance for a number of reasons (Douma et al., 2006; Delios et al., 2008). Firstly, diverse types of ownership with differences in identity, concentration and resource contributions among owners result in differences of incentives management and managerial control (Douma et al., 2006; Delios et al., 2008). Secondly, different types of ownership have been associated to different goals, which influence firm performance (Douma et al., 2006; Chen and Tan, 2013). Hence, organisational decisions and policies are created based on the different goals of owners. For instance, financial investors would be more interested in short-term, rather than long-term returns on their investments. Contrary, private ownership has a strong interest in profit maximisation, having sufficient control and maintaining firm management to achieve their goals even with poor resource levels (Delios et al., 2008). Lastly, different types of ownership have different organisational structures, cultures and business processes (Chen and Tan, 2013). For example, several Japanese and American companies operate in Thailand, and they tend to have different management cultures. Therefore, management practices such as human resource management, leadership, culture and teamwork may differ in different ownership types.

Thailand is ASEAN's largest producer and exporter of electronic appliances and the second largest producer and exporter of automotive products (The office of Industrial Economics, 2016). The electronics and automotive industries are the main drivers of Thailand's industrial economy (The office of Industrial Economics, 2016). As Claessens et al. (2000) indicated, in East Asian countries, the control is based on pyramid structures and cross-holding among firms. Japanese firms are commonly widely held, whereas Thai firms are primarily owned and controlled by individuals, families and related partners (Claessens et al., 2000). Due to these characteristics, the agency costs are more likely to increase to mitigate agency problems (Thanatawee, 2012). Thai culture has been, typically, associated to focusing on quality of life rather than on performance, and on relationship between people rather than on money; therefore, different from other cultures, such as the Japanese one, which is more concerned with performance and security (Hofstede, 1980).

Foreign-owned companies have a more individualistic culture and take a global perspective (Zhao et al., 2011). This offers greater human resource advantages, such as possessing higher skills and having more experienced managers (Beaumont et al., 2002, Chen and Tan, 2013). Further, they may display relatively more advanced information system and technologies (Zhao et al., 2011). JVs are firms shared by two or more cross-border partners holding equity (Acquaah, 2005). Firms that are jointly owned are viewed as the most efficient type for reducing costs and risks, accessing valuable resources and capabilities, such as technology and knowledge that will allow them to be effective in domestic and international markets (Acquaah, 2005). Kampstra et al. (2006) indicated that leadership is the most important quality for SC members; therefore, JVs with powerful joint leadership adds value to a SC.

Several empirical studies have found evidence of the relationship between types of ownership and quality management practices. For instance, Delios et al. (2008) focused on measuring and classifying the implications of the ownership structure and diversification strategy, specifically for companies that operate in China. Rahman et al. (2010) focused on Thai manufacturing companies and demonstrated that types of ownership, namely Thai-owned, foreign-owned and JVs, have a significant impact on the relationship between lean practices and operational performance. Chen and Tan (2013) explored the impact of organisational ownership structure on the implementation of just-in-time and production operations performance. They focused on firms that operated in China and grouped firms into three types, namely foreign-owned, JVs and state-owned firms. The study by Zhao et al. (2011) examined the relationships between internal integration and relationship commitment on external integration. It examined research models for companies with different ownership: Chinese and foreign-owned companies. Their results revealed that Chinese companies have a strong collectivism culture and relationship commitment, which has a significant impact on external integration with suppliers and customers. While, foreign-owned are characterised by a more individualistic culture and more reliance on technology capabilities, and it shows that there is no significant relationship between relationship commitment and external collaboration. However, previous studies have paid little attention on the impact of contextual factors on intra- and inter-organisational practices, especially the impact of ownership types on BPM and SCC practices. Theoretically, as discussed in the previous paragraphs, firms with different types of ownership have different goals, cultures and operational strategies. Therefore, these may impact those relationships under investigation. Hence, our hypothesis was developed as:

H: The interrelationships between BPM, SCC, collaborative advantage and organisational performance are moderated by ownership types.

METHODOLOGY
A questionnaire was developed and a five point Likert scale was used as the main response format. The questionnaire included multi choices for the question of company ownership (100% Thai-owned, JVs, and 100% foreign-owned). The initial questionnaire was pre-tested by academics and practitioners to get feedback and improve it. Subsequently, it was subject to a pilot phase, before the large scale survey was conducted. Both online and postal surveys were used for the large-scale survey data collection phase from both medium and large manufacturing firms in Thailand that have been certified to ISO 9000. A total of 1,363 questionnaires were sent, resulting in 204 useable replies – a response rate of 14.97%. The questionnaires included 58 Thai-owned companies (28.40%), 70 JVs (34.30%) and 75 foreign-owned companies (36.80%) with

1 missing the relevant information (0.50%). The vast majority of the respondents were large firms with more than 200 employees (73%). After the data collection phase, the non-response bias was assessed via a chi-square test (Wiengarten et al., 2010), revealing that the data was free from non-response bias.

ANALYSIS AND FINDINGS

The hypothesis testing was performed by means of the PLS-SEM multi-group analysis (PLS-MGA) method. The minimum sample size requirement for this study was calculated at 30 observations. Therefore, each sample group (Thai-owned, JVs, and foreign-owned) was well above the minimum sample size requirement regarding the 10 times rule for the use of PLS-SEM analysis (Henseler et al., 2009; Hair et al., 2014). This study used constructs and items that were developed and tested for measurement model reliability and validity from the earlier phase of this study (Pradabwong et al., 2013). Therefore, both first-order and second-order constructs were reliable and valid based on these criteria of indicator reliability, internal consistency reliability, convergent validity and discriminant validity (Henseler et al., 2009; Hair et al., 2014).

Regarding PLS-MGA results, the models were run separately via SmartPLS version 3. The contribution of R^2 demonstrated the importance of each construct and its relative contribution to the overall value of R^2 (Wilson, 2010). Table 1 presents a complete list of all the submodels' endogenous constructs R^2, with values ranging between 0.243 and 0.708. For foreign-owned firms, it explains 70.8% of the variance in organisational performance, which is considered to have substantial power. Most of the R^2 values show moderate explanatory power ($0.33 < R^2 < 0.67$), excluding R^2 of SCC and collaborative advantage in the sample group of Thai-owned firms ($R^2 = 0.247$ and 0.243 respectively), which indicates small explanatory power ($0.19 < R^2 < 0.33$).

Table 1: Results of the R^2 values relating to type of ownership

R^2	Thai-owned	Joint Venture	Foreign-owned
SCC	0.247	0.547	0.360
Collaborative advantage	0.243	0.503	0.489
Organisational performance	0.532	0.538	0.708

To find out the path coefficients and standard errors, bootstrapping (5,000 iterations) was used with the number of cases being equal to the number of samples in each subgroup (Hair et al., 2014). Then, the Levene's test was applied to measure the equality of standard errors across the sample groups. The PLS-MGA results are presented to evaluate path coefficients across two data groups (Hair et al., 2014). The results are provided in Tables 2 and 3 which compares the types of ownership: Thai-owned vs. JVs, Thai-owned vs. foreign-owned, and JVs vs. foreign-owned respectively. The PLS-MGA results show that the moderating effects of ownership types are partially supported on the interrelationships between BPM, SCC, collaborative advantage and organisational performance.

Regarding the relationship between BPM→OP, the path coefficient for Thai-owned firms is insignificant (path coefficient = 0.137, t = 1.285) at the level of 0.05 (See Table 2). The path coefficients for both JVs (path coefficient = 0.457, t = 3.315) and foreign-owned companies (path coefficient = 0.207, t = 2.124) are significant, whereas for JVs are much higher. For the association of BPM→SCC, all three path coefficients are significant (path coefficients are 0.497, 0.740, and 0.600 respectively for Thai-owned, JVs, and foreign-owned firms). JVs show a higher level of significance compared with foreign-owned and Thai-owned companies. For the relationship of CA→OP, the path coefficient for JVs firms is insignificant (path coefficient = 0.024, t = 0.163) at the level of 0.05, while the path coefficients for Thai-owned (path coefficient = 0.510, t = 4.958) and foreign-owned companies (path coefficient = 0.300, t = 3.112) are significant.

Table 2: Results of PLS-SEM relating to ownership

Direct	Thai-owned				Joint Ventures				Foreign-owned			
	$P^{(1)}$	t-state (1)	p-value	se($p^{(1)}$)	$P^{(2)}$	t-state (2)	p-value	se($p^{(2)}$)	$P^{(3)}$	t-state$^{(3)}$	p-value	se($p^{(3)}$)
BPM→OP	0.137	1.285	0.199	0.107	0.457	3.315	0.001	0.138	0.207	2.124	0.034	0.097
BPM→SCC	0.497	4.241	0.000	0.117	0.740	12.496	0.000	0.059	0.600	5.465	0.000	0.110
CA→ OP	0.510	4.958	0.000	0.103	0.024	0.163	0.870	0.144	0.300	3.112	0.002	0.096
SCC→CA	0.493	5.301	0.000	0.093	0.709	12.002	0.000	0.059	0.700	11.371	0.000	0.062
SCC→ OP	0.229	1.674	0.094	0.137	0.311	2.116	0.034	0.147	0.456	4.333	0.000	0.105
n	58				70				75			

* Considered the results of t-value under unequal standard errors assumed. [(a)]p<0.10, [(b)]p < 0.05, [(c)]p < 0.01

Table 3: PLS-MGA results

Direct relationship	Thai-owned vs. Joint Ventures					Thai-owned vs. Foreign-owned					Joint Ventures Vs. Foreign-owned				
	$\|p^{(1)}-p^{(2)}\|$	Test for equality of SE	t-value	df	p-value	$\|p^{(1)}-p^{(3)}\|$	Test for equality of SE	t-value	df	p-value	$\|p^{(2)}-p^{(3)}\|$	Test for equality of SE	t-value	df	p-value
BPM→OP	0.320	0.996	1.847*	121	0.067[a]	0.070	0.598	0.486	131	0.627	0.250	0.004	1.493*	124	0.138
BPM→SCC	0.243	0.000	1.870*	83	0.065[a]	0.103	0.705	0.641	131	0.523	0.140	1.000	1.129*	111	0.261
CA→ OP	0.486	0.999	2.766*	118	0.007[c]	0.210	0.680	1.492	131	0.138	0.276	0.001	1.606*	120	0.111
SCC→CA	0.216	0.002	1.977*	97	0.051[a]	0.207	0.013	1.867*	101	0.065[a]	0.003	0.761	0.106	143	0.916
SCC→ OP	0.082	0.901	0.405	126	0.686	0.227	0.136	1.349	131	0.180	0.145	0.006	0.808*	125	0.420

SE: Standard errors, * Considered the results of t-value under unequal standard errors assumed. [(a)]p<0.10, [(b)]p < 0.05, [(c)]p < 0.01

For the relationship of SCC→CA, all path coefficients are significant for the three groups. The path coefficients for JVs (path coefficient = 0.709, t = 12.002) and foreign-owned firms (path coefficient = 0.700, t = 11.371) are similar, while the path coefficient for Thai-owned firms (path coefficient = 0.493, t = 5.301) is much lower. For the relationship of SCC→OP, all three path coefficients are significant; however, interestingly it is higher for foreign-owned firms (0.456), and lower for JVs (0.311) and Thai-owned forms (0.229). Overall, the results show that the interrelationships between BPM, SCC, collaborative advantage and organisational performance are partially moderated by the ownership types. Therefore, the hypothesis is partially supported.

DISCUSSIONS AND CONCLUSIONS

This study is based on evidence suggesting that there are positive relationships between BPM, SCC, collaborative advantage and organisational performance (Pradabwong et al., 2013). Therefore, this study makes further progress, as we bring forward new insights on the impact of ownership type on the intra- and inter-organisational practices, and their benefits. We found that ownership types partially moderate the interrelationship between BPM, SCC, collaborative advantage and organisational performance. For JVs and foreign firms, BPM has a significant positive relationship on organisational performance – we did not find similar evidence for Thai-owned firms. Furthermore, for all three ownership types considered in our research, there is a significant positive relationship between BPM and SCC. More specifically, considering the relationship between BPM and SCC, in JVs it exhibits a higher level of significance than in foreign-owned and Thai-owned firms. Our findings are consistent with the studies by Acquaah (2005) and Kampstra et al. (2006) who indicated that JVs are the most capable types of firms (e.g., for sharing resources and capabilities), in which powerful joint leaderships can be created.

The findings from our study also provide some guidelines for managers and ownership of companies to achieve a better level of organisational performance. In particular, managers should be aware of the multidimensionality in the nature of BPM, and the importance of the four main constructs, namely strategic alignment, IT, process orientation and improvement, and people involvement, especially as these four elements capture the core BPM practices. This should be particularly helpful for Thai-owned companies due to their managerial characteristics and the cultural aspects, as they are primarily owned and controlled by families and individuals (Claessens et al., 2000). Thai-owned companies should firstly concentrate on understanding those four main BPM elements and put them in practice. Then, they should benchmark and learn from JVs and foreign-owned firms regarding how to work collaboratively with their SC partners and improve organisational performance based on effective BPM implementation. Activities such as training on process improvement techniques (e.g., TQM and lean), active communication with employees and jointly solving process improvement issues are examples that Thai-owned firms should learn from JVs and foreign-owned companies.

This study makes significant contributions towards the understanding of the interrelationship between BPM, SCC, collaborative advantage and organisational performance with organisational ownerships. To summarise, future research and company management should be aware that the type of ownership will impact on how BPM and SCC practices enhance the level of organisational performance. Effort on improving BPM practices will result in higher organisational performance for JVs and foreign-owned firms. For all three ownership types considered the relationship between BPM and SCC is significant, and higher for JVs. Further research could take the form of case studies regarding different ownership types to gain a deeper understanding of the large scale survey results.

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EXAMINING THE ROLE OF GUANXI NETWORK IN SUSTAINABLE SUPPLY CHAIN MANAGEMENT

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ABSTRACT
Purpose of this paper:
Interpersonal relationships, such as guanxi, have been identified as having an important role in supply chain management (SCM). They have been studied to enhance economic performance of a wide range of supply chains (Lee and Humphreys, 2006). However, to sustain economic outcomes, environmental and social corporate responsibility have become emerging topics. Even though researchers have started to examine guanxi as a mediator for green supply chain initiatives (Luo et al., 2014), it is pertinent to consider the impacts of guanxi on the three pillars of sustainability in the context of SCM. Therefore, the aim of this study is to address this research gap by evaluating the relationships between guanxi and sustainable supply chain management (SSCM) with empirical data.

Design/methodology/approach:
By adopting social network theory, a conceptual framework was built in AMOS and the questionnaire was designed to examine the relationships between guanxi with buyers and sellers, and the impacts on supply chain capitals, SSCM and SSCP. Then the online questionnaire was designed accordingly and was sent out to practitioners doing business related to SCM. Finally, 590 responses have been collected achieving a 23% response rate. After checking the data validity and duplication, 477 usable questionnaires were analyzed with structural equation modeling using AMOS, to evaluate a set of covariance relationships between the variables.

Findings:
The research shows that guanxi networks positively increase financial, human and social capitals, which in turn encourages supply chain practices and improved SSCP. The size of the network also appears to have an impact.

Value:
The main contribution to knowledge that our research offers is a thorough evaluation of the relationships between guanxi and SSCM, simultaneously considering economic, environmental and social responsibilities. It also helps to understand SSCM empirically from a social system perspective.

Research limitations/implications:
Because guanxi is socially constructed, to more deeply understand their underlying mechanisms, further qualitative studies are encouraged. Further, the sample shows a geographical focus of the responses in the south of China yet different regions could emphasize various levels of guanxi.

Practical implications:
The study reveals different levels of involvements with guanxi and social network in different industries, firm sizes and firm types. Therefore, accordingly, companies can invest in building and maintaining guanxi networks which influence their SSCP, in order to gain maximum benefits for SSCM from these networks.

INTRODUCTION
Serious sustainability issues caused by supply chain management (SCM) have been identified, for example, Steinz et al. (2015) highlighted a significant increase in carbon

dioxide emissions and pollution of the water, soil, and air during the rapid economic growth of China. However, to achieve sustainable supply chain management (SSCM), it is believed that we need collaborative efforts rather than focusing on an individual company. It is further argued that such collaboration be with both internal and external stakeholders (Pagell and Wu, 2009).

Good practitioners sometime fail to understand the social structures behind collaboration and consequently fail to anticipate its consequences for business performance (Kilduff and Krackhardt, 2008). The notion of network embeddedness, including the relations with family, friends, and acquaintances, influences human behaviours and economic activities (Granovetter, 1973). Managing global supply chains seem to be far more complex than an extension of traditional supply chain functions. They require understandings and capabilities to handle institutional environments and the social structure where related companies position. In China, guanxi is embedded in every social relationship; it influences mind-sets and social behaviours without people realizing it. Guanxi also ties into operational strategies for power generation and trust cultivation. In particular, it has been found that there are two main strategies for buyers to influence suppliers: either through power or through the creation of trust between organizations (Abramson & Ai, 1997). Guanxi ties with key actors are seen as an essential strategy for gaining cooperation (Steinz et al., 2015).

Some researchers have tried to investigate the impact of guanxi on social and environmental responsibilities in the supply chain (Michailova and Worm, 2003; Wang and Wood, 2013). Interestingly, it appears that the focus of guanxi on social equity outweighs environmental quality. The studies mainly emphasize perspectives of employee equality and satisfaction and harmony with the local community because guanxi is a notion of investigating human relationships and relationship quality rather than being directly linked to environmental factors. However, some empirical studies claim that guanxi between buyers and sellers could mediate green supply chain collaboration implementation (Luo et al., 2014, Cai & Yang, 2014) or stimulate firms to upgrade technology to deal with resource waste (Hills & Man, 1998) and pollution (Wang & Woods, 2013). By adopting social network theory (SNT), guanxi networks arguably generate the necessary capitals for spreading SSCM in networks (Gao et al., 2014). However, it remains uncertain to what degree guanxi could generate capitals to enhance SSCM practices. This paper intends to test this understanding, grounded in SNT.

This paper presents three major contributions to knowledge. First, it links knowledge creation to the study of SSCM and expands the discussion to informal relationships. Second, it presents evidence with large empirical sample size to test the hypothesized relationships between guanxi and SSCM to facilitate the knowledge of current arguments in the field. To our best knowledge, this is the first paper that explores the impact of guanxi social network on SSCM by taking into account economic, environmental, and social responsibilities. Third, it tests the relationships between informal and formal network, that is, the influence of guanxi networks to supply chain networks.

RESEARCH CONSTRUCTS
Network economics in guanxi networks
The impact of the extension of a micro individuals' friendship network is the diffusion and spread of diverse phenomena, information, and opportunity within the constructed social networks (Granovetter, 1978; Christakis & Fowler., 2007). According to Burt (1992), the spread of a social network generates essential capitals including financial capital (e.g., cash, investments, and lines of credit), human capital (i.e., a combination of natural abilities and required skills), and social capital (i.e., through friends and general contacts to receive opportunities to use financial and human capital). These capitals are regarded as the assurance for sustainable development (Rennings & Wiggering, 1997; Reynolds et al., 2010) and can be cultivated through different network models.

The purpose of maintaining good guanxi is to sustain the relationships and satisfy the involvements with mutual trust and reciprocity (Renqing). Depending on the level of guanxi between players and their position in the social structure, strong ties enhance the network influence with a high degree of psychological commitments between players, featuring strong ganqing (emotional closeness) and xinren (trust). While the structure of guanxi networks are far more multifaceted and people are not always linked with strong ties. More often, one person knows another because of their mutual connections, such as friend's friend or third parties. However, it is not the purpose of this study to analyse the network structure, but to understand integration of supply chain capitals from network spread. Studies broadly agree that guanxi networks improve the relationship quality between buyers and suppliers, between firms and employees, and among employees to reduce conflicts (Chen et al., 2011) and increase collaborative behaviour (Cheng, 2011).

In good guanxi relationships, transaction costs can be reduced by having a more balanced distribution of power between customers and suppliers (Cui et al., 2013; Nie et al., 2011; Yang & Wang, 2011) and reducing opportunistic diversification from suppliers (Yen & Barnes, 2011). Therefore, a guanxi network is claimed to serve as managerial ties (Kong, 2011) to reduce risks, increase long-term strategic benefits and to build collaboration relationships with suppliers (Cai et al., 2010). Trustworthy information and opportunities would be shared and diffused among guanxi players to obtain further business opportunities (Cai & Yang, 2014). In addition, high-quality production and superior services are ensured from employees and suppliers (Chen & Wu, 2011), stemming from the expectation of obtaining mutual help when needed. When people embrace similarities and expertise, guanxi members tend to share professional knowledge and expertise when working on similar duties (Hom & Xiao, 2011). This helps improve human capital through knowledge transfer in order to promote and diffuse advanced knowledge, concepts, and feasible skills for the long-term mutual benefits within players. This also results in more efficient usage of natural capital.

The importance of building capital has been highlighted in a sustainable development context (Daly, 1996). The origins in economics claim that sustainability is the maintenance or increase of the total stock of various types of capital for future generations (Zaccai, 2002), to increase the structure of capabilities for an individual or a society to adapt to a variety of external constraints (Lehtonen, 2004). Therefore, capital is seen as the operational tool to assure sustainable development programs. Considering social network as a whole system and various types of capital that guanxi networks generate and diffuse, we then establish the theoretical framework in Figure 1 and argue that:

H₁: Guanxi networks positively embeds network economics with supply chain capitals integration.
H₂: Supply chain capitals integration enhances sustainable SCM.
H₃: Improved sustainable SCM positively increase performance in SSCM.

Even though sustainable SCM has been widely recognised in developed areas, in emerging markets such as China, it is still uncommon. Large numbers of companies have limited knowledge about sustainable SCM and inadequate skills to perform it. Without the mediator of integrating supply chain capitals, companies have less motivation to invest in SSCM. Furthermore, in traditional operational models, the guanxi social network plays the role of getting 'arm's length' help for maximizing economic benefits. Unfortunately, promoting sustainability is expensive in short term, such as purchasing green materials, dealing with pollution and wastewater, and providing a good working environment for employees. Therefore, embracing strong social network position and building guanxi with different stakeholders, including government institutions, communities and customers, companies may decide not to invest on sustainability if they escape negative social justice. Therefore, we argue:

H₄A: Without the mediator of supply chain capitals and other institutional forces, guanxi networks can negatively impact on sustainable practices in SCM. H₄B: Without the mediator of supply chain capitals and other institutional forces, guanxi networks can negatively impact on performance of SSCM.
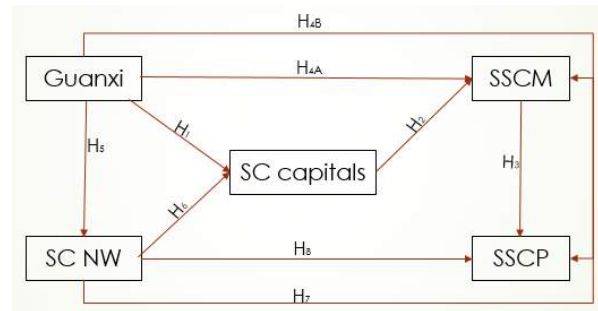
Figure 1: Proposal model for the role of guanxi in developing SSCM

Social networks influences the size of supply chain networks
In organization study one of the most persistent debate is the interaction between formal and informal structures in organizations (Boden and Molotch, 1994). Unarguably, not a single organization is operated without human involvement. Thus, 'organizations are operating in an informal mode virtually all the time' to some extend (Boden and Molotch, 1994, p.29). Any supply chain is comprised by various organizations regardless their roles and positions in the value chain, either as a customer or as a supplier. Consequently, it can be argued that supply chains are operating in an informal mode where human actors do matter. Further, social networks are a set of nodes (individuals) linked by particular connections. Given that individuals shape the network where they are in, it is very difficult to separate supply chain networks with social networks. Consciously or unconsciously, humans tends to associate with people who resemble themselves, this is so called 'love of being alike' (Christakis and Fowler, 2009), or homogeneity in social network (Nohria, 1992). Therefore, it is assumed that the structure of social network (i.e. strong links or weak links) could influence the structure of supply chain networks. In particular, good guanxi networks are beneficial for network extension in supply chain networks, which enriches supply chain capitals. Thus:

H₅: High level of guanxi network positively increase the supply chain network size.
H₆: Supply chain network size positively impacts on supply chain capitals integration.
H₇: Supply chain network size positively impacts on sustainable SCM.
H₈: Supply chain network size positively impacts on performance of SSCM.

METHODOLOGY
Sampling and data collection
Based on the conceptual framework and research constructs, an online survey was designed (using the website http://www.lediaocha.com). The introduction to the survey clearly stated that potential respondents were people whose work role related to supply chain and operation activities. The study was not limited to defined firm type, firm size nor industry. Respondents were then asked to indicate answers for each question, using a 5-point Likert scale (1=strongly disagree, 5=strongly agree). The survey was piloted by various researchers and 10 practitioners for content validity and translation correctness (the final version was in Mandarin). Where necessary, questions were reworded to improve clarity. The revised survey was then published online and the link sent to practitioners and their social networks. Two rounds of reminders were also sent.

In total, 2565 people clicked on the survey front page. However, only 590 completed the whole survey, giving a 23% response rate. Having checked the quality and validity of each submission, including serving IP, usage of time to finish and sequences of responding to questions, the number of usable surveys reduced to 476.

Measures
Measurements in the literature were adapted and applied to assess the core constructs in the study. In this research, all the questions were measured by 5-point Likert scale. Four items measured guanxi (Yen et al., 2012) while, three semantic items were adopted from Zhao et al., (2011), Shou et al., (2011) and Cheng et al. (2012) to measure financial capitals. Three items were adopted from Zhao et al., (2011) and Cheng (2011) to measure social capitals and another three items were conveyed to measure human capitals (Chen, 2009-18; Kam et al., 2011-48; Li and Lin, 2006-59). Initiatives regarding to environmental and social responsibilities are adopted from Zhu and Sarkis (2004) and Awaysheh and Klassen (2010). Finally, items measuring performance of SSCM could be located in the studies from Awaysheh and Klassen (2010) and Marshall et al. (2015). Guanxi has been criticised for linkage of unethical practice, therefore, a related item (on the issue of bribery) was added to the survey.

To investigate the possibility of nonresponse bias in the data, a set of t-tests were used to examine statistically significant differences in the responses between the early and late waves of responses with 100 surveys in each group, roughly representing 20% of the sample size individually (Armstrong & Overton, 1977). Results show with nonresponse bias.

Demography of the sample
Approximately 80% of the respondents identified themselves as company managers (Junior manager, middle manager and senior manager), whereas only 9.2% of the sample representing general staff. Domestic and national owned companies were mostly distributed with 72% of total. In other words, 28% of the respondents worked in non-Chinese companies. In terms of industry, this sample shows a wide variety of industrial sectors. Many were in the manufacturing sector, including electronics (50.5%), food (18.3%), apparel (19%), and automotive (16.5%). The service sector includes banking and finance, logistics providers, warehousing, healthcare, software and IT companies.

Validity and Reliability
For assessing validity, researchers usually consider content validity and construct validity. To assess content validity, the measurement items were developed from different published empirical studies and the expert judges (supervision group and other related academic staff) were used to ensure the scale items have covered full content of constructs. To achieve construct validity, researchers suggest that confirmatory factor analysis (CFA) is the powerful tool to access both of convergent validity and divergent validity (O'Leary-Keylly and Vokurka, 1998).

Overall, all factor loadings in the model were very strong, which means that the measured constructed were well explained by the research questions. Convergent validity was achieved with AVE values mostly were over than 0.5 for measured constructs, apart from supply chain network (0.487). Divergent validity in the measured model was achieved because each MSV value is smaller than the related AVE value, and same with ASV value shown in Table 2.

	CR	AVE	MSV	ASV	NW	Guanxi	SCcapitals	SSCP	SSC
NW	0.829	0.709	0.099	0.070	0.842				
Guanxi	0.804	0.508	0.212	0.128	0.251	0.713			
SCcapitals	0.924	0.801	0.510	0.258	0.251	0.460	0.895		
SSCP	0.839	0.636	0.320	0.184	0.230	0.341	0.498	0.797	
SSC	0.858	0.755	0.510	0.263	0.315	0.349	0.714	0.566	0.869

Table 2: Validity and reliability results

Reliability and unidimensionality

After running the reliability statistics test (Coefficient alpha) in SPSS, the result shows a 0.907 value to indicate a high reliable of measured items for the model. Besides, AVE and composite reliability value which takes into account of the homogeneity and internal consistency of the measured construct (Koufteros, 1999) were also taken into account to measure reliability. Given that in Table 2, CR values in each construct were from 0.82 to 0.92, the conclusion drawn is that the measured model achieved reliability sufficiently.

A recognised way of assessing unidimensionality is to conduct CFA and assess the overall model fit through goodness-of-fit indices, along with other diagnose tools including standardized residuals and modification indices (Koufteros, 1999). The fit indices indicate that the measurement model achieved a good fit with the data ($X^2/df=1.954$; GFI=.900; CFA=.943; TLI=.936; RMSEA=.045; PCLOSE=.969). In modification indices, the items can be explained theoretically and controlled in the model.

ANALYSIS AND RESULTS

In SEM, the structural model is to analyse the theoretical (unobserved) constructs and to test five research hypotheses. SEM estimates were generated using AMOS with the maximum likelihood estimate method. The goodness of fit for our model are R^2 =807.344 with a degree of freedom=414, RMSEA=0.045, NFI=0.891, IFI=0.944, TLI=0.936, CFI=0.943, GFI=0.900, AGFI=0.880, PGFI=0.751. These indices shows a good model fit and are better than the commonly acceptable goodness of fit model (Shah and Goldstein, 2006).

The results of hypotheses tests 1-8 using SEM are shown in Figure 3 and Table 3. All standardized coefficients, apart from H_{4A} and H_{4B}, are indicated to be significant at the 0.05 level, suggesting supports for them. Guanxi social networks have a positive influence on supply chain capitals integration, so does to supply chain networks. Impacted from guanxi social networks, supply chain networks also have a positive influence on supply chain capitals integration. In the mediators of supply chain networks and supply chain capitals, guanxi social networks positively impact on sustainable supply chain practices and finally improve performance in SSCM.
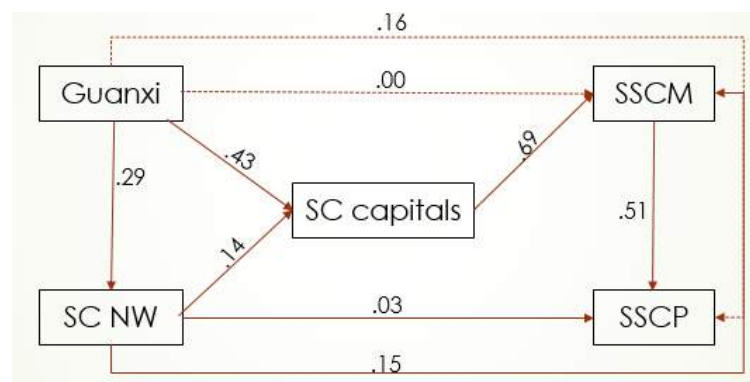
Figure 3: Estimated structural equation model

Hypot-hesis	Hypothesized relationship	Unstandardized coefficient	Standardized coefficient	t-value	Supported?
H_1	Guanxi networks- supply chain capitals	0.32	0.43	6.52	Yes
H_2	SC capitals-sustainable supply chain practices	0.92	0.69	8.55	Yes
H_3	Sustainable SCM-performance in SSCM	0.30	0.51	6.98	Yes
H_{4A}	Guanxi-SSCM	0.00	0.00	-0.90	No
H_{4B}	Guanxi-SSCP	0.09	0.16	2.71	No
H_5	Guanxi-supply chain network	0.24	0.25	3.87	Yes
H_6	Network-SC capitals	0.11	0.14	2.46	Yes
H_7	Network-SSCM	0.16	0.15	2.92	Yes
H_8	Network-SSCP	0.02	0.03	0.66	Yes

Table 3: Results of SEM

DISCUSSION

This study focused on examining the casual relationships between guanxi social network and SSCM practices and performance with the mediators of supply chain capitals integration and supply chain network size. Using data from a sample of people dealing with supply chain issues in China, we demonstrate five major findings. While most of these relate to SSCM, insights into guanxi more generally are also gained.

First, it has remained challenging to understand the relationship between guanxi and trust, even though researchers have previously tried to measure guanxi by ganqing, renqing and xinren (Yen et al., 2012). In theory, we failed to show xinren (trust) could exist without the conditions of ganqing and renqing, but neither has the statistical result has given a strong loading factor of xinren to guanxi (0.48). Therefore, we argue that trust is embedded in ganqing and/or renqing. It is based on xinren when people exchange ganqing or renqing; while without ganqing nor renqing, it is not possible for people to decide whether or not the other party is trustworthy.

Second, the results show that strong personal relationships with key buyers and suppliers enhance the integration of social, financial and human capitals. Guanxi between players create social capitals by driving long-term buyer and supplier relationships and reducing the power asymmetry. Buyers and suppliers work together for sustaining mutual benefits, which directly reflect on economic performance contributions by improving product quality and reducing investment in inventory. Previous research has shown that strong guanxi relationships enhance human capitals in terms of improving working and learning capability technological supports in logistics and supply chain processes (Chung et al., 2015).

This study has supported the previous research on the positive link between economic and environmental responsibilities (Zhu and Sarkis, 2004). Enhanced integration of supply chain capitals in guanxi networks lead to environmentally responsible practices. Long-term orientation in relationships between buyers and suppliers increases cooperation, and upgrades technology to meet environmental objects. Environmental audits are provided in the internal management to ensure standards have been met. For social responsibility, good guanxi networks lead to companies taking into account employees' benefits by paying worker a living wage and regulating over-time wage, providing a healthy and safe working environment and regulating recruitment policies with no child labour and forced labour. These initiatives have created positive impacts on performance of SSCM (with mean=3.2 to 3.6, standard deviation= 0.59 to 0.65).

In economic performance, integration of financial and human capitals essentially increase the efficiency and effectiveness of operation costs and training costs. Improved environmental performance concerns with reducing the consumption of hazardous and toxic materials, reducing water waste and avoiding environmental accidents with fines. These performances result from the increase in human and social capitals in guanxi networks, to transfer knowledge and advanced technology of greening the supply chains. To increase social performance, good guanxi networks encourage companies to reduce the health and safety hazards in workplace and promote volunteers at local charities and governance ethical practices in supply chains, such as no gift giving and bribery between company representatives and partner companies.

Finally, the study examines the influence of individual social networks on supply chain networks in terms of network extension. It shows that good guanxi networks positively extend the supply chain network size. Every company or even supply chain is constituted with individual humans. Therefore, personal preference and selection directly influences the structure of the institutional network (Kilduff and Tsai, 2003). Guanxi networks provide the opportunities to access a bigger pool of personnel who could become suppliers or customers potentially. The stronger the links between guanxi partners, the more likely people will to share information and resources in the structured networks, including brokering the networks by introducing one to the other. By spreading the supply chain network sizes, companies could enhance the integration of supply chain capitals and SSCM practices, aligned with improvement of performance in SSCM. However, the degree of influences from guanxi is not tremendous because formal institutional strategies and practices are more comprehensive than only concerning the impact of guanxi networks.

CONCLUSIONS AND FUTURE RESEARCH

This study has examined the influences of guanxi networks on SSCM practices and performances with the mediators of supply chain capitals and supply chain network sizes. We can draw the conclusion that the stronger guanxi networks are between buyers and suppliers, the more capitals supply chain integrates and the bigger sizes of supply chain networks, which results in better practices and performance of SSCM.

Future research will draw on the depth of this framework by understanding the 'why' and 'how' questions. In specific, in which role do the institutional forces play, such as national and international regulations in the proposed framework and how do different stakeholders, such as customers matter. Second, how do social networks and supply chain networks interact in practices. We expect growing interest in the simultaneous exploration of informal and formal influences on SSCM, particular from the network perspectives.

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USING SENSORS TO SUPPLEMENT PARTNER TRUST IN COLLABORATIVE TRANSPORT

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Abstract

Partner trust is a critical requirement in collaboration for resource sharing. It is a soft, and partly a social driven construct a trustor entity applies to develop a degree of expectation in the trustee object. Specific to collaborative transportation logistics, partner trust is needed to facilitate the sharing of idle spaces in vehicles. This need is further driven by collaborative environment –Cyber-Physical Systems (CPS) within limited physical interactions, short-lived cooperation, dynamic actors, and likely strangers. Since traditional physical cues of trust and reputation are inefficient to apply in CPS collaborative environments, a supplement of human-in-loops CPS is prominent. With rich sensed information, it requires mapping the analogy reputation and trust in traditional society into a networked society. Motivated by this need, this research proposes an approach to build partner trust in vehicle sharing. It applies human-in-loops CPS as soft sensor: social networks and online communities. This approach facilitates trusting processes in the absence of physical interactions.

Introduction

The lacking trust among collaborating partners in supply networks is constituted by uncertainties inherent in many factors. These factors range from "collaborative processes, namely: information sharing, incentive schemes, decision synchronization" (Simaputeng & Sridharan, 2005), to opportunism as well as nature of supporting environments. Adding to aforementioned factors, supply networks are featured with many new and dynamic actors, who enter and leave the community. Meanwhile, digitally-mediated collaboration repudiates usage of traditional physical cues of trust and reputation in individuals and organizations. Above all, hard-trust (computational security) primitives (Confidentiality, Integrity, Availability –CIA) are less appropriate to handling arising uncertainties and vulnerabilities. This inappropriateness rests in a primary purpose for which CIA mechanisms were designed for. The CIA mechanisms are designed to protect computer and network resources against malicious agents. Contrary to this purpose, partner trust in

collaboration has a purpose to confidently assure that counterpart partners behave in manners expected. Rendering this confidence by applying only "CIA mechanisms on data or information" [Robinson et al, 2011] is insufficient. Collaborating partners require soft trust, being reliability, confidence and assurance (Robinson et al. 2011) in entities they interact and deal with. They need to trust people, organizations, data and information sources, personal assistants and processes. For example, if information providers act deceitfully by providing false or misleading information, CIA mechanisms are unable to protect against this type of threat (Joesang et al)a. The major concern is: how to establish required soft-trust (user trust) in absence of physical cues of trust. This concern becomes ever imperative in this era where physical processes are seamlessly getting linked to virtual world, through Cyber–Physical Systems (CPS). Therefore, this study examines how to apply data and information sensed in social media to help supplement trust in partners. Initially, the IoT concepts are employed to improve partners trust, and accordingly, suggests an implementation framework, the main focus of this article is on collaboration for vehicle sharing.

Methodology

The main objective of the study is two-folded, thus also the methodological approach is based on combination of the research methods:
A structured literature was carried out. The keywords used in finding the literatures are derived from previous research related to trust in collaborative networks, including those in supply chain and logistics, CPS and IoT. The databases used in this work originate from catalogs from a German University and online databases which identified relevant in these fields such as Science Direct, IEEE etc. The second part of the work is based on action based research. The work with the framework had a different methodical approach. Design Science was the overall scientific approach in this work. More specific, action research was applied.

Partner Trust and Vehicle Sharing: Benefits from Cyber-Physical Systems

Vehicle sharing employ collaborative business model, with vehicle owners –partners selling or renting idle spaces to offer dynamic and affordable services to needy customers. Of recent, vehicle sharing is elevated by innovations in Information and Communication Technologies (ICTs): Cyber-Physical Systems (CPS) and cloud computing. With particular to CPS, physical processes –transportation are linked to cyber –computational and communication to better improve logistics functions. These improvements are parallel to new organization of the world, created by a shift of traditional society to networked society in the influence of ICTs. Referring to transportation logistics, many supports exist, ranging from electronic markets places, Intelligent Transportation Systems (ITS) as well as intelligent and mobile sensors devices. Together with these potentials, vehicle sharing is however challenged with a lack of partner trust (Graham 2011; Hu et al. 2011).
This lack of partner trust is constituted by many factors, including "collaborative processes –information sharing, incentive schemes and decision synchronization" (Simatupang and Sridharan 2005), and environments. In environment context, partnering entities –people and organizations interact seamlessly, mainly in cloud under CPS support. There are many new and dynamic actors, entering and leaving the community, such that establishing trustworthiness is challenging. Moreover, networked society repudiates usage of traditional physical cues of trust and reputation in humans and organizations.
Towards connectedness of everything, physical objects sense, communicate and respond via global internet. This connectedness enhance further the mobility of people and goods under CPS support. CPS is promoted by three converging trends: (1) smart embedded systems, mobile services and ubiquitous computing; (2) internet-based business

processes, and; (3) social networks and communities (Acatech 2011). The vision of physical internet –CPS is to move, store, produce, supply and use physical objects, globally, in a manner that is economically, environmentally and socially efficient and sustainable (Alice 2014). Towards shared economy, ride sharing as well as vehicle truck sharing benefit are supported with CPS innovations. Today, transport services by Uber, Lyft and bla bla car apply CPS and cloud platforms in mobile applications to allow travelers rent time and space in car (Mulligan 2014). Expectedly, sharing of empty vehicle trucks will apply similar arrangements. Nevertheless, CPS innovations offer worthy contribution to partner trust in vehicle sharing. The usage of mobile sensors –smartphones, electronic market places, and social networks and communities are prominent to establishing trust.

Many devices and objects now have computers embedded in them, which interact with the physical world using sensors and actuators, exchange information with one another e.g. mobile devices –smartphones (Acatech 2011). The mobile smartphone are Wi-Fi device sensors, exchanging physical information to cyber. They are relatively improved in processing speed, storage and analytics; equipped with Global Positioning System (GPS), thus, communicating location-based real-time information. Smartphones can be installed with transport apps to help planning vehicle sharing and dissemination of road information. In the context of partner trust, smartphones help establishing true attributes of the partner: identity –through registered SIM-cards, and real location –through GPS. Additionally, high resolution camera in smartphones can now scans QR code to read stored URLs or any other information. This technology is useful in signing transportation contract as well as tracking sharing partners.

The second benefit from CPS arises in the provision Information Technology (IT) services for electronic market places, and Intelligent Transport Systems (ITS). Similar to online trading in e-commerce, combination of CPS and cloud computing contributes establishing electronic market places for vehicle sharing. Transport applications outsourced to cloud platforms provide robust and affordable services to a sharing community. The Uber and Lyft –ride sharing companies, and bla bla car –a simple and direct carpool, are examples of these applications. To meet needs of Small and Medium-Sized (SMEs) companies, and large ones, similar applications are useful.

The third benefit relate to human-in-loop CPS, particularly social networks and online communities (Pal 2015). People –physical objects are considered as soft sensors through cues they tweet. Human expressions: emotional feelings, opinions, activities and experiences generate rich content, out of which specific information needs are derived (refer figure 1). These social-networks connect services increase access to and enrich user data in the social web (Ko et al. 2010)
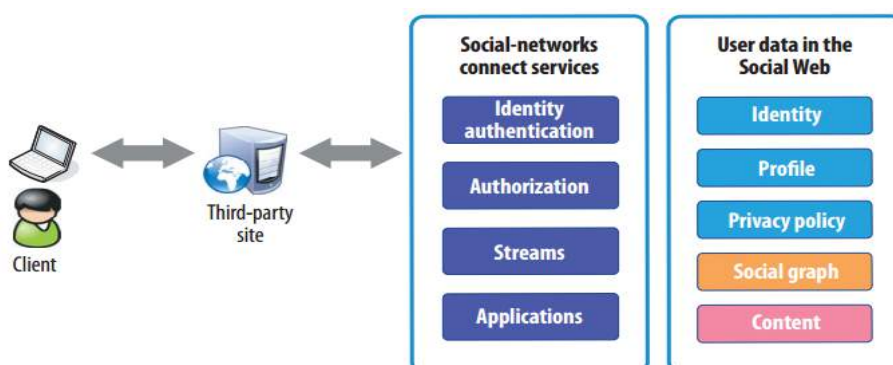
Fig. 1. Social-networks connect services framework (Source: Ko et al. 2010)

Posted graphics and text give interpretation about what is happening in own environments. Whereby physical cues of trust are missing in networked society, human-in-loops CPS form one of the equivalent supplement. Social networks connect entities globally –people and

organizations, with multiple links to friends and other information sources like institutional website. In place of peer-to-peer word-of-mouth, nevertheless, social networks and online communities play the role of exploring partner behaviors in trusting.

State of the Art Partner Trust in Networked Society

To apply CPS potentials in the building of partner trust on vehicle sharing, input knowledge from areas of computational trust, reputation systems and behavioral trust is considered. Within these areas, relevant overviews and concepts are characterized and highlighted in a manner of contributing to proposed approach.

Computational Trust. Computational security defines hard-trust relationship among computer devices and networks, comprising of diverse security mechanisms. Their purpose is to provide protection against malicious parties, thereby restricting access to only authorized users (Jøsang et al. 2005; Robinson et al. 2011). With emerging CPS innovations, there are soft-trust challenges difficult to handle by applying protection mechanisms. Community –partners are concerned if security mechanisms can ensure exchanged information remain within intended boundaries. To what extent can agents – human and software authenticated and authorized by security mechanisms, be trusted about data and information they disseminate is a major concern. Thus, there is a whole range of security challenges that are unmet by traditional security mechanisms (Jøsang et al. 2005).

Reputation Systems. In open environments, agents depend on reputation and trust mechanisms to evaluate behavior of potential partners (Pinyol and Sabater-Mir 2011). This reputation comprises community opinions on a specific entity with respect to a subject of interest. They are commonly used in connection with trust in traditional society and e-commerce. In e-commerce, online trading reputations systems are more centralized and closed to members registered e.g. ebay and Amazon. To supplement partner trust, CPS soft sensors in open community are thus key providers of required opinions. Although biasness may arise from unfair ratings –over-rated or under-rated, yet multiple friends connect can compensate it. A significant aspect is to deploy the soft sensor in manner of multiplicity.

Behavioral Trust. Behavioral trust refer to human trustworthiness and is constituted by aspects of cognition and emotion. Within the context of social reality, it is a mix of rational thinking and feelings (Lewis and Weigert 1985) a human being develops on personal basis, and in the organizational context. Behavioral trust is a key to everyday life, and is neither a blind faith nor a rationally calculated prediction. Behavioral trustor's primitives: social preferences and risk preferences are identified in (Gligor and Wing 2011). Within social preferences trust relate to a degree of betrayal against fairness, reciprocity, altruism. It is exercised through "social control – a way for the population of actors to avoid unwanted actors" (Rasmusson and Jansson, 1996) under norms of the respective community. Thus, behavior of the actor –partner are evaluated by the community to build reputation and trust profiles. Social controls in networked society are signaled by CPS soft sensors, shaped, filtered and stored as reputation data or information in social media and online communities (refer figure 1). Social mechanisms don't deny the existence of malicious participants, but avoiding interaction with them (Rasmusson and Jansson, 1996). Therefore, previous conduct of vehicle sharing partner and its friend connection assist in establishing partner trust.

Partner Trust in Vehicle Sharing: A Soft Sensor Approach

Proposition of an approach to supplement partner trust in vehicle sharing is led by an analogy in reputation and trust systems of traditional society. This approach (figure 2) employs existing social platforms: social media and online communities to supplement partner trusting processes in vehicle sharing. It is assumed that social network members are potential soft sensors on reputations and trust, through their tweets, friendship linkages as well as open ratings. The approach is far from replacement, but a supplement other cues of trust. The soft sensor approach applies to closed systems likely more centralized as well open systems which are decentralized.
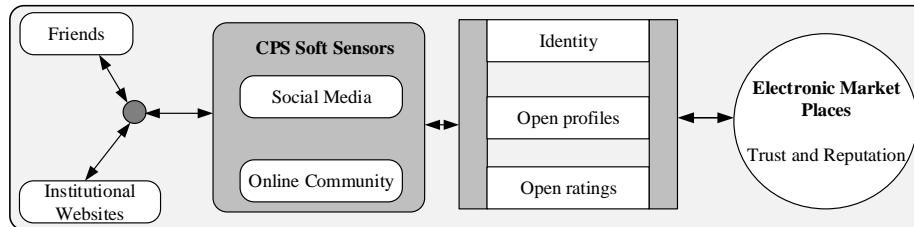
Fig. 2. A soft sensor approach on partner trust in vehicle sharing

Vehicle owner advertises available idle spaces via electronic market places thereby specifying required parameters. Negotiations begin between owner –seller and customer – buyer/renter of the idle space. Meanwhile, each actor gain an access to reputation and trustworthy profile stored in the electronic market place system (if any). It comprises of open ratings made by members of the community previously interacted with. Subsequently, both partners can further satisfy themselves by visiting profiles of those who rated, as well as attached friends –friend connect services. Inspecting posted tweets, organizations the partner is attached with and photos will render additional information to help deciding. Commonly, party behaves similar to ways of own friends. This is a comprehensive verification aimed to understand the partner prior to engage in vehicle sharing.

Similar to owner-renter trusting processes, more than one partner may share idle space in the same vehicle truck or car. As well, the customer-partners have to further verify trustworthy of others based on reputation in electronic marketing system as well as those of the outside community. A requirement here is to obtain community-referred opinions indirectly.

Conclusions, Implications and Future Work

Social reputation systems and controls are widely known about vital roles they play in societies. In traditional society, physical cues of reputation and trust were applied to build profile of community members, especially in small geographical areas. However, ICTs have led to the emergence of several new organizational forms, creating dynamic, strategic networks of individuals and small firms (Mulligan 2014) to share inefficiently utilized resources. While it is difficult to establish trust in collaborating partners, application of the analogy of the traditional society to networked society is prominent. It is a supplementary approach on top of computational security mechanisms and online reputation systems, to help partners explore further trust and reputation cues equivalent to physical ones in traditional society.

This research has proposed a soft sensor approach to mediate trusting in partners of vehicle sharing. The approach applies benefits of CPS: social media and online community to further verify partner reputation and trust. Its conception grounds in the reality that,

mostly friends connect to people with similar interests and behaviors. Tweets of the subject partner and connected friends constitute base data and information towards understanding partner trust. Therefore ad hoc verification via partner's own profile and connected friends help establishing trust prior to engagement. Finally, this work has contributed more on small-scale vehicle sharing -ride sharing. Further work is needed to explore how CPS soft sensors can be applied to building trust in partners sharing vehicle in large scale –vehicle trucks.

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DO BUYERS AND SUPPLIERS BEHAVE DIFFERENTLY IN THEIR EXCHANGE RELATIONSHIP AT DIFFERENT STAGES OF THE RELATIONSHIP LIFE-CYCLE?

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Abstract

How buyers and suppliers behave across their relationship life cycle is a rarely trampled-on area. This study examines the behavioral differences between farmers and farm produce buyers (traders) with respect to six constructs – use of contracts, transaction-specific investments, trust, cooperative norms, social bonds and long-term orientation - at the exploration, extension, and maturity phases of their relationship life-cycle. It found that while farmers and traders hold a comparable collaborative and supportive stance toward each other during the exploration and maturity phases, major differences exist at the extension stage with respect to trust and use of contract. We discuss the theoretical and practical implications of these findings, pointing to areas of further research.

1.   INTRODUCTION

Equity theory posits that an inequity occurs in a collaborative relationship when one party perceives that the benefit-to-effort ratio it obtains from the relationship is less than that of the other party (Adams, 1965). The existence of inequity in buyer-supplier relationships is largely due to behavioral differences between the exchange parties. For instance, Nyaga et al. (2010) found differences between buyers and suppliers in their emphasis of the antecedents and outcomes of collaborative relationships: suppliers concentrate largely on collaborative activities, such as information sharing, while buyers focus more on relationship outcomes, such as demonstrating trust and commitment.

Studies on how buyers and suppliers behave in their exchange relationships are on the rise. How these behavioral differences vary across the relationship life cycle, however, has not been fully explored. Because business interactions between exchange partners are context dependent (Wagner 2011), the level of efforts exchange partners put into building a relationship also change over time (Dwyer et al., 1987; Jap & Ganesan, 2000; Caniëls et al., 2010). The dynamics of business collaboration necessitates that the behavioral differences between buyers and suppliers be studied at each phase of the relationship life cycle, if a deeper understanding of these relationships is to be gained.

This paper examines the behavioral differences between buyers and suppliers with respect to six constructs – use of contracts, transaction-specific investments, trust, cooperative norms, social bonds and long-term orientation - known to affect collaborative business relationships across the first three stages of their relationship life-cycle. Its research question is: Do Buyers and Suppliers Behave Differently in their Exchange Relationship at different stages of the Relationship Life-cycle? The buyers and suppliers in our investigation are agricultural produce traders and farmers in Vietnam, a country where social relationships dominate business exchanges.

2.   LITERATURE REVIEW

2.1   Factors Affecting Buyer-supplier Relationship Development

Trust is at the heart of a dyadic exchange relationship. Sullivan and Peterson (1982) argue that: "where the parties have trust in one another, then there will be ways by

which the two parties can work out difficulties …" (p. 30). Trust, however, does not always exist in an exchange relationship, especially at the initial stages of transaction (Caniëls et al., 2010). Faced with transactional uncertainties, firms typically resort to transactional and relational governance mechanisms to safeguard their interests from their partner's opportunistic behaviors (Liu et al., 2009).

Transactional mechanisms refer to the use of formalized and legally binding agreements to protect firms' interests against exchange hazards and mitigate opportunisms (Lee & Cavusgil 2006). Transactional mechanisms are realized in practice as formal written contracts and transaction-specific investments (TSIs) (Liu et al., 2009). Formal written contracts specify rights and obligations of exchange partners by stating rules in detailed terms (Liu et al., 2010). They are enforceable, thus providing a legal framework for firms to deal with exchange risks and protecting a partner's specialized investments made to generate benefits for the exchange relationship (Yu et al., 2006).

TSIs are made by exchange partners to facilitate the staging of collaborative activities. They range from physical equipment to training and processes (Cai & Yang 2008). Investments made exclusively for transactions with a particular partner increase a firm's dependence on that partner and the cost of exiting the relationship. TSIs are thus signals of commitment to grow the relationship. They bind the exchange partners, creating barrier to exit the relationship due to the diseconomies of seeking alternatives and difficulties in redeploying physical assets to alternative uses or to use in other exchange relationships (Yu et al., 2006). Partners who have invested specifically in a relationship thus have little or no incentive to behave opportunistically.

In an exchange relationship, relational mechanisms are exemplified by trust and cooperative norms (Lee & Cavusgil, 2006). Trust depicts the faith and confidence one party has on the other party's motives, intentions, reliability, integrity and commitment to maintain and grow the relationship (Wilson & Jantrania, 1994). Research generally views trust as comprising two distinctive dimensions: competence (e.g., technical capabilities and experience) and integrity (e.g., honesty and motives) (Connelly et al., 2015). Between the two, integrity-based trust is about 10 times more effective at reducing transaction costs than competency-based trust (Connelly et al., 2015).

Cai and Yang (2008) define cooperative norms as "the shared belief and expectation of two parties that they must work together to achieve mutual goals" (p.56). Unlike contracts or TSIs, cooperative norms are self-motivated and self-regulated, rather than externally enforced (Zhou et al., 2015). Once cooperative norms are established, exchange partners would be unlikely to behave opportunistically (Liu et al., 2009). Cooperative norms, as such, increase partners' commitment to an exchange relationship, reflecting a willingness to sacrifice short-term benefits for long-term relational gains.

In a society where social connection has a direct implication on business dealings, such as China and Vietnam, the social relationship between the contact persons of the two parties in an exchange relationship influences the way the relationship would evolve. Labelling these types of relationship as social bonding, Mummalaneni and Wilson (1991) found that social bonding increases partners' commitment to the relationship and conclude that the contact persons of the transacting firms need to have some positive level of social bonding between them for the dyadic relationship to reach its full potential.

Another attribute impacting the continuity of an exchange relationship is long-term orientation. As a construct, long-term orientation signifies an intention to build an enduring, close relationship (Paulraj et al., 2008). Partners with a long-term orientation in a buyer-supplier relationship perceive relational outcomes as beneficial to both parties in the long run and would not act opportunistically to hurt the relationship but would continue to find ways to bring benefits to the partnership (Dwyer et al., 1987).

This study will examine how buyers and suppliers differ with respect to the above six constructs – use of contracts, TSIs, trust, cooperative norms, social bonds and long-term orientation – at different stages of their relationship life-cycle.

2.2   Relationship Life Cycle

Dwyer et al. (1987) contend that buyer-seller relationships typically develop over five phases: awareness, exploration, extension, commitment and dissolution. Each phase has a distinct set of characteristics that reflect how one party interacts with the other. While the five phases suggest a linear progression, Dwyer et al. (1987) remind us that not every exchange relationship would move from awareness to exploration through to expansion, commitment before dissolution.   The dissolution of a dyadic exchange relationship could happen at any stage during the relationship development cycle.

Extant literature on relationship life-cycle (e.g., Jap & Anderson, 2007) indicates that factors affecting buyer-supplier relationships differ significantly across stages of the relationship life cycle due to the nature of the transactions at each phase. The earlier stages are characterized by ad hoc or trial transactions associated with low level of trust and reciprocal involvement, and a higher probability of partners discontinuing the relationship (Caniëls et al., 2010). The latter stages are marked by a strong desire to engage more often and are associated with a high degree of dependence and trust, which drive satisfaction and mutual benefits (Jap & Ganesan, 2000).

Among the factors affecting exchange relationships, Liu et al. (2010) found that contracts is used more often than cooperative norms in initial transactions where trading partners are less willing to sacrifice short-term interests for long-term gains. Partly, Liu et al. (2010) explain, the use of contracts may reduce trust, which negatively affects long-term orientation. Further, the relationship-determining factors are also interrelated differently at different stages of the relationship life-cycle. Jap and Ganesan (2000), for instance, found that TSIs and contracts are linked to long-term orientation in the exploration phase. Cooperative norms, however, are more suited to maintain long-term orientation in the buildup and maturity phases than TSIs and contracts (Jap & Ganesan 2000). Liu et al. (2010) also note that cooperative norms have a higher effect on commitment than contract has in mature relationships. These findings lend weight to the argument that buyers' and suppliers' behaviors toward their exchange relationship with one-another should be explored with reference to each stage of the relationship life-cycle.

3.   Research Methodology

3.1   Study Context

Vietnam's agribusiness sector, which contributes to 18% of the nation's GDP in 2013 (World Bank 2015), provides the context for this study. Vietnam's agricultural outputs are diverse. Rice, coffee beans, cashew nuts, cassava and natural rubber are among the top agricultural produce in value term (FAO 2015).

3.2   Data Collection

Data for this study came from two separate surveys - a farmer (i.e., supplier) survey, and a trader (i.e., buyer) survey - in two strategic agribusiness regions of Vietnam: the Central Highlands and South-Central Vietnam. Both surveys used a structured questionnaire comprising three sections. The first section focused on the firm profile and general business information, including the number of suppliers (or buyers) the firm had. The second section centered on the most significant business relationship the responding firm had been having with one particular supplier (or buyer), including the stage at which the relationship was reckoned to be at. The third section comprised a series of behavioral

questions describing the characteristics of the specific exchange relationship between the responding firm (supplier or buyer) and the identified partner (supplier or buyer).

The questionnaire was developed in English and then translated to Vietnamese. Next, the Vietnamese version of the questionnaire was translated back to English by another person and compared against the original version, similar to what Liu et al. (2009) did. The translation was repeatedly refined until the re-translated English questionnaire matched its original English predecessor.

Farmer Survey
We approached the district heads in 18 selected districts in the two strategic areas to assist in inviting the farmers within their district to participate in the farmer survey. The District Heads organized a communal meeting for farmers agreeing to take part in the survey to meet with one of the authors and his assistant. During the communal meeting, participating farmers were explained the purpose of the survey and asked to fill out a paper copy of the questionnaire. Instructions and supervisions were provided to ensure participating farmers completed the survey questionnaire independently. A total 327 questionnaires were distributed in the 18 districts, of which 272 were returned, yielding a response rate of 83.2%.

Ten farmers who agreed to participate were unable to attend the communal meeting but consented to be interviewed by phone. This brings the total surveys completed to 282. After removing 37 incomplete questionnaires, 245 responses were used for analysis.

Trader (or Buyer) Survey
Information from the business databases held by various Government bodies in the two targeted agricultural regions revealed a total of 629 agriculture trading companies as prospective participants. We again requested the District Heads, who had close ties with these companies, to invite the company owners to participate in a trader survey on our behalf. The District Heads contacted 177 owners, 88 of whom agreed to participate in a face-to-face interview, while 11 accepted a phone interview. All 99 consenting traders completed the survey.

At the suggestion of the District Heads, the remaining 452 trading companies were invited to complete a self-administered postal survey. The first mail-out resulted in 17 completed returns. A reminder sent two weeks later generated an additional 50 responses, resulting in a total of 67 returned questionnaires, giving a response rate of 14.8% (67 out of 452). In total, the trader survey generated 166 responses, 31 of which contained missing data. The final sample used for the analysis was 135.

3.3 Data Analysis

All six constructs were multi-item variables (see Table 1), measured on a 7-point Likert scale with 1 denoting "strongly disagree" and 7, "strongly agree". We used correlation, reliability test and confirmatory factor analysis (CFA) to test for unidimensionality, reliability, convergent validity and discriminant validity of the measurement items and constructs (Hair et al. 2006). With the exception of TSI, in which two of its items has a correlation of 0.26, unidimensionality was established for the other five constructs, with the inter-item correlation coefficients for each construct exceeding the minimum value of $r > 0.3$. The CFA results, based on goodness-of-fit index (GFI), normed fit index (NFI), incremental fit index (IFI) and comparative fit index (CFI), showed that all constructs have GFI, NFI, IFI and CFI values within the range of 0.949 to 0.999 for both the farmer and trader samples, suggesting unidimensional characteristics. Construct reliability was confirmed by Cronbach's □, the smallest value for which is 0.70. Convergent validity was demonstrated, as all items loaded significantly ($t > 1.96$) on their respective construct. Discriminant validity for each of the six constructs was ascertained by comparing the average variance extracted (AVE) for each construct with the square of the correlation

between the said construct and all other constructs for both the farmer and trader samples. In all cases, the AVE value exceeds the associated squared correlation values.

To assess the behavioral norms of the farmers and traders on the six relationship nurturing constructs at different phases of their relationship life-cycle, we divided the relationship life-cycle into five phases by adopting the five scenario statements developed by Jap and Anderson (2007). Based on the responses obtained, the distribution of farmers and traders over the five phases are: Exploration (Farmers (F) = 44; Traders (T) = 35); Extension (F = 65; T = 31); Maturity (F = 126; T = 53); Dissolution (F = 4; T = 12); and Ending (F = 6; T = 4).

Owning to the small number of respondents in the Dissolution and Ending phases, our analysis will be confined to the first three phases of Exploration, Expansion and Maturity. We computed the mean value of the six constructs separately for farmers and traders at the first three phases and tested their differences using the two-sample t-test. Figure 1 depicts the ~~results of the~~

Table 1: Description of Relational Constructs

Construct	Description of Measurement Items	References	Cronbach's α	
			Farmer	Trader
Use of Contracts	• The contract serves as a primary mechanism to regulate the behaviour of this partner (buyer/farmer). • We are committed to be abided by our contract with this partner (buyer/farmer). • We always refer back to the contract when there is a dispute.	Jap & Ganesan (2000); Cai et al. (2009)	0.97	0.98
Transaction-specific Investments	• We have invested a great deal in conforming our produces to this partner (buyer/farmer)'s product line. • We have made a substantial investment in personnel dedicated to this partner (buyer/farmer)'s product line • We have made a substantial investment in logistics facilities dedicated to this partner (buyer/farmer)'s product line.	Liu et al. (2009); Claro et al. (2003)	0.81	0.76
Trust	• Though the circumstances change, we believe that this partner (buyer/farmer) will be ready and willing to offer us assistance and support. • Promises made by this partner (buyer/farmer) are always kept. • We respect and believe in the information that this partner (buyer/farmer) shares with us.	Zhou et al. (2015); Liu et al. (2009)	0.85	0.77
Cooperative Norms	• In this relationship, we expect that any information that may help this partner (buyer/farmer) will be provided to this party. • In this relationship, ideas or initiatives of both sides are widely shared and honestly welcomed via open communication	Liu et al. (2009)	0.70	0.78
Social Bond	• We always invite this partner (buyer/farmer) to come to business events and special gatherings to give them face. • The representative of this partner (buyer/farmer) is our good friend. • We care about the well-being of this partner (buyer/farmer) wholeheartedly. • We interact with the representative of this partner (buyer/farmer) frequently at a personal level.	Lee & Dawes (2005); Wang et al. (2008)	0.82	0.80
Long-term Orientation	• We want to maintain a long-term relationship with this partner (buyer/farmer). • We believe that over the long run our relationship with this partner (buyer/farmer) will be profitable. • We focus on long-term goals in our relationship with this partner (buyer/farmer).	Jap & Anderson (2003)	0.92	0.87

4. Findings

Our analysis of the behaviors of farmers and traders on the six constructs over the first three stages of their relationship life cycle shows some sharp contrasts between the two parties. As their business relationship moves from exploration to expansion, the following shifts are noted (see Figure 1):

- Farmers' tendency to use contract as a governing mechanism to manage their relationship with buyers increases. By contrast, traders' preference toward use of contract decreases (Figure 1.a). This difference in inclination toward use of contract between farmers and traders is significant (p<0.05) during the expansion phase.
- While both farmers and buyers do increase their TSIs as their business relationship progresses from exploration to extension (Figure 1.b), farmers' trust of suppliers (Figure 1.c), use of cooperative norms to foster the growth of the relationship (Figure 1.d), and sense of the transaction relationship being able to be continually maintained (long-term orientation) (Figure 1.f) tend to decrease. Conversely, traders appear to put greater efforts to practicing these four relationship-nurturing constructs during the extension phase compared to what they did at the exploration period.
- Despite pulling back in their efforts to nurture the transaction relationship with traders during the extension phase, farmers, like traders, do increase their efforts to create social bonds with their buyers (i.e., the traders) as their exchange relationship advances from exploration to extension (Figure 1.g). In comparative terms, however, the efforts put into social bonding by farmers are still less than that of traders (difference significant at $p < 0.05$) during the extension phase.
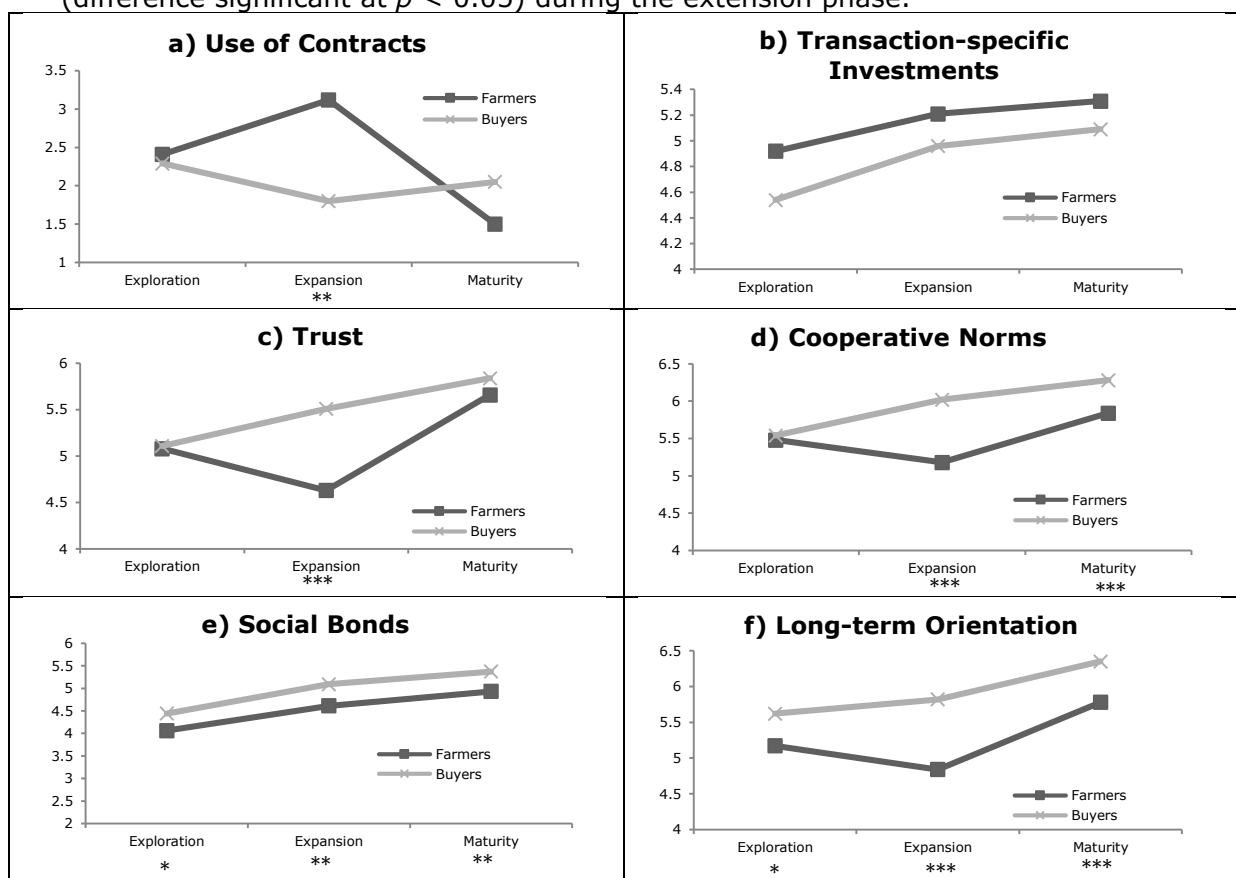
Figure 1: Plots of Farmers' versus Traders' inclination to:
  a) use contract to manage business relationship with partner (Use of Contracts)
  b) invest in assets dedicated to facilitate business relationship with partners (Transaction-specific Investment)
  c) trust partner in exchange relationship (Trust)
  d) cooperate with partner (Cooperative Norms)
  e) having a social relationship with partners (Social Bond)
  f) maintain long-term business relationship with partners (Long-term orientation)

Note: *, ** and *** denote differences between Farmers' and Traders' perception are statistically significant at $p < 0.1$, $p < 0.05$, and $p < 0.01$ respectively.

When the exchange relationship escalates from extension to maturity, the relative efforts devoted to grow the six relationship-nurturing constructs by farmers and traders tend to be less divergent compared to the extension stage:
- Apart from devoting similar levels of TSI to bloom their relationship (Figure 1.b), both farmers and traders exhibit a comparable level of mutual trust (Figure 1.c) and show no difference (statistically) in relying on contracts (Figure 1.a) to manage their transaction relationship with each other as their relationship matures.
- Farmers, like traders, increase their efforts to socialize with their business partners (Social Bond) (Figure 1.e), share business ideas (cooperative norms) (Figure 1.d) and show a willingness to work towards a long-term relationship (long-term orientation) (Figure 1.f) in the maturity phase. Yet, the extent of the efforts expended by farmers in all three constructs is still significantly below (statistically) that of traders.

5. Discussion

Taken together, our findings of the relative levels of efforts expended by farmers and traders on the six relationship-nurturing constructs suggest that several relational dynamics are at work. First, when their relationship with traders goes beyond the initial exploration stage, farmers feel the need for a tangible form of assurance (contracts) to guarantee that their TSIs made to expand their business transactions with the concerned traders would not be wasted. Because traders are less inclined to rely on use of contract to manage their business transaction with farmers during the extension phase, farmers, in general, have less trusts on traders and (thus) become less enthusiastic to work with traders to achieve mutual goals (cooperative norms). The lack of trusts on traders is further manifested in the drop in long-term orientation among farmers during the extension phase. Yet, farmers do show an increase in level of social engagements with traders during the extension phase. We interpret this dialectic as an internal tension that farmers try to juxtapose between wanting to continue the business relationship with traders and being cautious that the relationship may fail, given traders' reluctance to use contract as a mechanism to manage their exchange relationship.

This finding is not unexpected, given that the two survey regions in Vietnam have more farmers than traders, which suggests that traders would have more bargaining power than farmers. This observation mirrors those of Young and Wilkinson (1989), who examined trust in the context of distribution channels in Australia, and found that "[t]he more powerful firms were very trusting … less powerful firms were less confident of the trustworthiness of partners even when the relationship was progressing smoothly" (p. 117). On this account, we interpret that, as the exchange relationship moves into the extension phase, traders trust their farmer partners who have less alternatives, evidenced from the latter's continue increase in TSIs. Thus from the trader's perspective, they do not see a need to use a contract to manage the exchange relationship.

While we do not know how many of these inequitable exchange relationships at the extension stage eventually make it to the maturity stage, we wonder why farmers would want to continue participating in such inequitable relationships. As pointed out earlier, lack of alternative traders to turn to may be a reason. However, from the survey findings, we contend that it may be because farmers appreciate the increasing levels of social bonds and cooperative norms traders continue to provide them, not to mention the equally sizeable TSIs (i.e., of the same magnitude as the farmers') traders put in to enhance their exchange relationships. This interpretation draws from Thibaut and Kelley's (1959) reasoning that when a partner in an exchange relationship is perceived to fulfill its exchange obligations in an altruistic and humane fashion, the attractiveness of that partner to the other grows. This could have motivated farmers to stick to the exchange relationship with the same trader due to both a lack of alternative traders in the region plus the uncertainties associated with moving to a new trader.

6.   Conclusion and Further Study

Relationships are by nature multi-directional. Yet, most research on buyer-supplier relationships views them from one party's perspective. Exploring the extent to which buyers' and suppliers' attitudes concur, or differ, with respect to six vital constructs known to affect exchange relationships, this study reveals that trust asymmetry exists at a stage when both partners see value in continuing their relationship.

Extant literature on buyer-supplier relationship has repeatedly argued that a relationship without mutual trust is not expected to last. Yet, this study has found that in the case of the agricultural supply chain in a developing economy, farmer-trader exchange relationships at the extension phase are not characterized by mutual trust. We do not know how many of these relationships where asymmetric trust prevails would eventually survive to maturity. But based on the behavioral differences between farmers and traders in other relationship-enhancing factors, we argue that the more trusting partner is influencing the less trusting partner to engender a reciprocal trust in their continued exchanges, leading ultimately to a situation of mutual trust. Korsgaard et al. (2015), in an extensive review of the literature on dyadic trust, have called for more in-depth investigations of trust asymmetry and the factors and contexts surrounding its existence. This study has paved the way forward for more research in this direction.

To continue the momentum on this strain of research, the perceptual or behavioral differences between farmers and traders on other relationship enhancing constructs, such as information sharing, could be included in future studies. To obtain a more definitive answer on whether exchange relationships with asymmetric trust would survive because of the more trusting partner's altruistic behavior to engender reciprocal trust in the less trusting partner, a longitudinal case study of some of these partnerships would be a fruitful avenue for further investigation. Extending the current study to other settings or other supply chains in other developing or developed economies would help validate the generalizability of the current findings.

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Section 4: Maritime and port logistics

AN EXPLORATION OF RELATIONSHIP STRENGTH IN MARITIME LOGISTICS NETWORKS BY SOCIAL NETWORK ANALYSIS

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Abstract

Purpose of this paper:
Management of buyer-supplier relationships is central to the success of supply chains. As supply chains become more global, so maritime logistics plays an increasingly critical but often unnoticed role. Therefore, it is important to study the inter-organizational relationships in maritime logistics network (comprising the cargo owner, freight forwarder, shipping carrier and port operator). The dominant consideration of relationship management research in maritime logistics has been focused on a dyadic level, but few have looked at this issue from a network view. Therefore, this paper aims to explore the relationship structure of the main players in the maritime logistics network using social network analysis.

Design/methodology/approach:
A questionnaire survey was used to measure six dimensions of relationship strength among each of the main players in the maritime network in Taiwan, together with different levels of service complexity, and the value generated by the network. In total, 248 responses were obtained. Social network analysis (SNA), which is suggested being useful to supply chain researchers in further elaborating the potential of the network concept (Borgatti and Li, 2009) was applied to analyse the data. Through this, the position of each player, the relationship strength among them and the degree of supply chain integration in the network was identified.

Findings:
The major findings show that the links between cargo owner-port operator and freight forwarder-port operator are relatively very weak, and the links between shipping carrier-port operator, shipping carrier-cargo owner, and shipping carrier- freight forwarder are stronger. On the other hand, the shipping carrier is most embedded into the maritime logistics network, which shows the importance of its role as an integrator. These results give more objective evidence for the dominant position of shipping carrier (Ng, 2012) and the passive, double-derived demand role of the port operator in the maritime logistics network (Paixao and Marlow, 2003).

Value:
Social network analysis has not seen significant use in logistics research to date. Through this novel method, the outcomes of relationship structures in a maritime context were demonstrated by visual and quantitative ways, which can provide a foundation for industry to find the potential markets, work out new business models, and develop effective and efficient collaborative and integration strategies with other trading players in networks. Moreover, the results also benefit policy makers by demonstrating the structure of the maritime logistics industry in order to design policies fit for purpose.

INTRODUCTION

Management of buyer-supplier relationships is central to the success of SCM in firms (Harland 1996), and studies have shown that successful management of these relationships contributes to firm performance (e.g. Tan et al., 1999). Therefore, it is important for maritime logistics service providers to be embedded well in these systems (Song and Panayides, 2012). While the dominant consideration of relationship management research in maritime logistics has been on a dyadic level (e.g. Tongzon, 2009), the number of publications considering managing maritime logistics as an

integrated network is increasing (e.g. Lam, 2013). However, there is more emphasis within the research on relationship structures. This aim of this paper is to examine how relationships strengths vary between different members of the maritime logistics network.

The concept of maritime logistics is broader than just the sea transport element and encompasses other logistics services such as warehouse management, labelling and repairs (Nam and Song, 2011). There are a variety of views as to which organisations comprise the maritime logistics network (e.g. Woo et al., 2011; Lam, 2013), but for this research we focus on four main players – cargo owner, freight forwarder, shipping carrier and port operator – and the relationship strengths between them.

In doing so, we note that several researchers indicate that not all links throughout the supply chain should be closely coordinated (Hausman, 2001). The reasons for such contingent consideration include the high implementation costs to maintain close partnerships (Lambert et al., 1996), product complexity, the number of available suppliers, and the availability of raw materials (Cooper et al., 1997). Based on the research of Bask (2001), we particularly focus upon the nature of the logistics service to consider if this impacts upon the relationship strength and value generated.

LITERATURE REVIEW
Relationship strength is a broad term that encompasses the ideas and research concerning the closeness of a business relationship, which can be conceptualized as the ties between relational partners and reflects their ability to weather both internal and external challenges to the relationship (Hausman, 2001). Alternatively, it can be simply defined as the degree of the closeness of the ties among organizations in a supply chain (Golicic and Mentzer, 2006). There are several kinds of studies looking at supply chain relationships and their measurements, for example:
    (1) supply chain integration (SCI) from manufacturing perspective
    (2) partnership or collaboration in supply chains
    (3) relationships with third party suppliers
SCI can be defined as the degree to which a manufacturer strategically collaborates with its supply chain partners and collaboratively manages intra- and inter-organization processes, and SCI strength is the level or extent to which SCI activities are carried out (Flynn et al., 2010). In terms of partnerships and collaboration, authors such as Fynes et al. (2005) and Lambert (2008) identify various measurements for supply chain relationships including planning, trust, commitment, communication, power/dependence, joint operating controls and collaboration.

In the context of maritime logistics very few studies explicitly examine relationship strength. Bennett and Gabriel (2001) examine the relationship between three UK seaports and their customer shipping firms. The relationship-related measurements applied in this work include trust, commitment, information sharing, relationship-specific investment and cooperation. Jang et al. (2013) explore the role of logistics service quality in generating shipper loyalty, suggesting satisfaction, trust and commitment as the measures of relationship quality. Other work that looks more implicitly at the issue of relationship strength includes Lu (2003) investigating the impact of carrier service attributes on shipper-carrier partnering relationships, Carbone and Martino (2003) measuring the relationships between the relevant members of Le Havre Port logistics

network and Renault, and Hall and Oliver (2005) exploring the inter-firm relationships between (ocean) car carriers and automobile importers.

Further, various researchers have suggested that not every relationship should be fully integrated and involve partnerships. Cox et al. (2001) observe that relationship type should be matched to the level of supplier and customer dependency while Fisher (1997) considers product characteristics a key attribute. For logistics services, Bask (2001) distinguishes three types of efficient service relationships: routine service, standard service and customized. While a loose customer relationship fits with routine services, a close relationship fits a complex type of service characterised as customised services. The intermediate type of service is entitled standard services. In a maritime context, there is limited evidence of contingency in relationship management research. Heaver (2006) indicates that the elements of a liner shipping service may be conceived in different ways as a result of different types of businesses and processes, or they may be result from different visions, histories and preferences. Evangelista and Morvillo (2000) conclude that shipping lines respond to the needs of service differentiation through more or less broad levels of integration among partners while Lagoudis et al. (2010) identify four different types of ocean transportation and conclude that shipping carriers have to be responsive to a range of customer demands with different relationship strengths.

Synthesising the above literature, a number of gaps emerge. Firstly, much of the research on maritime logistics has a dyadic focus and identifies that relationship strengths vary between organisations. However, the lack of a network view in this work makes it difficult to consider a broader range of these organisations relative to each other. Further, while it has been identified that different types of maritime logistics service exist, the connection to relationship strength and value generated remains an important yet unexplored managerial aspect. The research in this paper will attempt to address these issues.

METHOD

Questionnaire survey
Using the above literature to identify appropriate measurement dimensions, a questionnaire survey was designed. Most of the questions were designed as closed-end style, with a five-point Likert scale applied to measure the participants' perceptions of the statements about relationship strength relative, service complexity, and value generated. Each respondent was required to complete the same questions three times, for each of their relationships within the maritime network, and for each service type. Additional questions collected demographic information about the respondents. A pilot survey with seven senior professionals in the shipping and port industry led to several revisions to the wording. English and Chinese versions of the questionnaire were produced.

The questionnaire survey was mainly conducted with the professionals from Taiwan-based companies and their major trading partners, which consist of cargo owners (CO), shipping carriers (SC), ocean freight forwarders (FF) and port operators (PO). Consideration was given to an internet based version of the survey, but issues around company security measures blocking access were identified. Therefore, the questionnaires were mainly distributed by e-mail through the relevant major industrial associations in Taiwan and by snowball sampling through the member companies within these associations. A small proportion of participants without e-mail access or who

preferred a paper questionnaire were provided with hard copies. In order to improve the response rate, a follow-up e-mail or telephone call was made to the low-respondent-rate associations after a four weeks' period. The total number of effective respondents is 248, as summarised in Table 1. Non-response bias was tested and found to be satisfactory.

Main Player	No.	Characteristics	Service type provided/received		
			Routine (%)	Standard (%)	Custom-ized (%)
SC	55	Professionals from top 30 global container shipping carriers	76	17	7
FF	53	Professionals from 50 leading freight forwarders mainly based in Taiwan	56	24	20
PO	67	Professionals from top 20 port operators in Taiwan	60	21	19
CO	73	A range of cargo owners including primary and secondary manufacturing, and retailing, mainly based in Taiwan	73	18	9
Total	248				

Table 1: Overview of survey sample

In terms of the data collection, a strategy of aggregation was adopted, where similar actors in a network are grouped together for analysis. The social capital theorists Lin et al. (2001) have advocated the use of "position generators" which is a survey technique in which the respondent is asked not for their ties to specific others, but to categories of others, such as "managers". For the supply chain case, this corresponds to aggregating by industry, technology, or some other convenient variable (Borgatti and Li, 2009). In this research, instead of asking for the relationship strength with individual trading partners, the respondent was asked for inputs from different categories of trading partners: cargo owners, freight forwarders, shipping carriers, port operators.

Analysis of the survey adopted social network analysis (SNA). In terms of the selection of SNA metrics, the simplest method of measuring network centrality for a node is by the way of degree centrality, which takes into account the number of direct connections with the nodes (Iyengar et al., 2012). This degree is a measure of the importance of a node in a network, and nodes with strong connections should be accorded more importance than nodes with only weak connections. Every link of weight n can be replaced with n parallel links of weight 1 each, connecting the same nodes. Therefore, techniques that can normally be applied to non-weighted graphs can be applied to the weighted graphs as well (Kim et al., 2011). Degree centrality can be extended to the sum of weights when analysing weighted networks and this measure has been formalized as follows (Newman, 2004):

$$s_i = C_D^w(i) = \sum_{j}^{N} w_{ij}$$

where w is the weighted adjacency matrix, in which w_{ij} is greater than 0 if the node i is connected to node j, and the value represents the weight of the tie. This weighting of a link was derived from the survey responses to each question. As well as the overall value of degree centrality, the weighting was also calculated separately for just the links leaving and entering a particular node (out-degree and in-degree respectively).

With regards to the network-level metric, network density is adopted as a measure of the overall connectedness of a network. Network density refers to the number of total ties in a network relative to the number of potential ties (Scott, 2000); Lee (2005) uses this as a measure of the degree of SCI. As applied in weighted node-level SNA, the network density for a weighted network can refer to the number of total weighted ties in a network relative to the number of potential weighted ties.

RESULTS

According to the results from the sum of both out-degree and in-degree, Figure 1 shows the degree centrality of each player and the importance level of each link. The node of SC is the biggest, while the PO are significantly smaller than the rest of players. This implies that SCs are most plugged into the maritime logistics network, or they tend to give and receive information more than other players. This also implies that SC is most competent to be an integrator, while the PO has a marginalized role in the maritime logistics network. Examining the data in more detail shows that the links between CO-PO (L3) and FF-PO (L5) are relatively very weak, and the links between SC-PO (L1), SC-CO (L2), and SC-FF (L4) are stronger, further reinforcing the perception of the SC being the central organisation in the maritime logistics network.
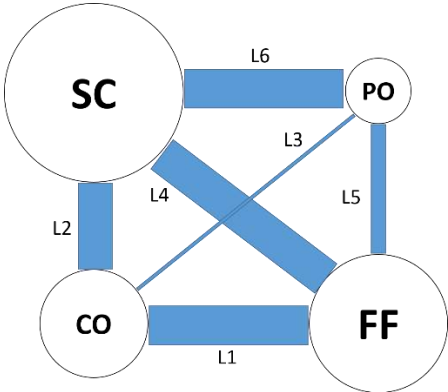
Figure 1: Sociogram corresponding to the importance level from micro-level view

In order to compare the relationship strengths for different degrees of service complexity, the network density measure of overall connectedness was adopted. The network density for this study can refer to the amount of total out-degree and in-degree links in a network relative to the amount of potential out-degree and in-degree links. There is only single value which is constant with total out-degree links, total in-degree links and the half of the total out-degree links plus total in-degree links. This can be referred as the network density for overall degree aggregation. In Table 2, the network density is presented by the aggregated and normalized (from 0 to 1) degree.

Relation Dimension	Routine Service		Standard Service		Customized Service	
	Total degree	Normalized degree	Total degree	Normalized Degree	Total degree	Normalized degree
Communication	42.94	0.716	44.91	0.749	47.83	0.797
Cooperation	40.44	0.674	43.52	0.725	46.91	0.782
Relationship duration	41.38	0.690	42.32	0.705	43.14	0.719
Commitment	46.18	0.770	46.14	0.769	46.63	0.777
Trust	41.62	0.694	42.72	0.712	43.20	0.720
Dependency	41.51	0.692	43.41	0.724	44.11	0.735
Average network density	42.34	0.706	43.84	0.731	45.30	0.755
Average value for service type	3.83		3.93		3.96	

Table 2: Network density for different networks

The results in Table 2 show that, with the exception of the commitment dimension, all other network density values rise with an increase in service complexity, communication and cooperation having the highest rate. This implies that generally there is a positive correlation between service complexity and relationship strength, especially for the networks derived by communication and cooperation dimensions. Commitment, however, is usually the highest level, except in the customized services. This means that the main players in maritime logistics networks have enduring desire to maintain a valued long-term business relationship with trading partners in all cases.

With customized services, the relationship strength dimensions are broken down into two groups by the degree of network density. Communication, cooperation and commitment were in the high-density group, while dependency, trust and relationship duration were in the low-density group. This means that the former are needed to provide and support the more customized or more complicated services. Finally, the increasing rates of the average value generated between standard service and customized service are smaller than the increasing rate of relationship strength. This implies that the value of customized service complexity is uncertain, maybe due to high costs and the risks from this type of service.

DISCUSSION AND CONCLUSION
Within the maritime network, the SCs are identified as integrator with the strongest relationship strengths. Weston and Robinson (2008) identify the role of 'integrator' and emphasize its importance in the maritime supply chain. They argue that the 'integrator' is not defined by type of firm or necessarily by the firm's position in the chain, but it is defined, critically, by the firm's 'ownership' of privileged and priority information about the end-user, by its core competency of high level management skills to leverage control throughout the chain effectively, and by control over the end points of the chain. The research suggests that SCs tend to give and receive information more than other players. Heaver (2006) supports such a role for shipping carriers, who work with cargo owners to become familiar with their various service requirements and the suppliers of those services in the region.

On the contrary, POs reveal the nature of double-derived demand (Marlow and Paixao-Casaca, 2003), and occupy the relative marginalized positions. POs are very dependent on SCs as their dominant customers, and are kept away from COs and FFs. However, if

we look at this issue from the opposite angle, the development of business relationships with COs and FFs could be a potential opportunity for POs. This echoes the emerging suggestions (such as by Woo et al., 2011) which urge ports to provide more logistics and value-added services to increase competitiveness and attract cargo from shippers.

This research also considered how service complexity may impact upon these relationships. Many authors identified earlier suggest that a loose customer relationship fits a simple type of service and a close, longer term relationship fits a complex type of service characterised as customised services. The results show that, except for the commitment dimension, the network densities for the other five dimensions rise with the increase of service complexity. This implies that the more customized services require closer relationships, and therefore a positive correlation with service complexity exists. However, the relationship is not linear, with a significant increase in relationship strength between standard and customised services. It could be that the role of maritime network is limited to operational issues when the CO sees the outsourcing option as the means to achieve cost savings. But when the outsourcing decision is made due to resource considerations, as is often the case for customised solutions, the members of the maritime network are seen as strategic partners who have a critical role in the customer's supply chain strategy.

Finally, the strength of relationships for each service type and the average value generated from this was compared. While the average network density and average value perceived in these three networks rise consistently with the increase of service complexity, the increasing rate of the value between standard and customized service is less than the increasing rate of the SCI degree between these two service types. This implies that the association between value and service complexity is not a simple positive relationship. One reason may be that the added value for customized service (vis-à-vis standardised service) is unclear. This may be due to the high cost and risk of this type of service. This point partially reflects literature which suggests that the relationship strength is positively related to supply chain value (Lam, 2013) and that logistics performance is maximised when all of the logistics activities are performed in a highly integrated manner (e.g. O'Leary-Kelly and Flores, 2002).

There are a number of contributions that arise from this work. In terms of the topic area, there are very few studies that examine the implications of service complexity in maritime logistics, and those that do tend to be case study rather than survey based studies. Therefore, this work provides a greater depth of understanding, albeit within the context of the Taiwanese maritime logistics network. Further, this work focuses not just on the service type but also the value that this brings. Finally, the concept of relationship strength is examined through a multi-dimensional approach. This gives greater insights into how the different aspects of relationships vary for service types. From a methodological perspective, the applications of SNA in maritime related research is almost non-existent (the only exception being Lee, 2005) yet the importance of the wider logistics network shows this to be an opportunity to develop further insights in this sector using this method.

Turning to the wider implications, by enabling managers to understand both the importance of different relationships and the perceived value as service types vary, so more appropriate decisions can be made. There is clearly the need for far closer relationships when offering customised solutions compared to the more easily achieved

routine or standard offerings. Failing to do so may result in the members of the network achieving lower levels of value than might otherwise be achieved. Port authorities are always interested in their stakeholder relations management in order to cope with the changing environment. Therefore, it is crucial for policy makers to learn the structure of the maritime logistics industry in order to design policies fitting for purpose. In contrast, if policy makers lack of clear insights into market dynamics, it could lead to wishful thinking by governments and an overoptimistic perspective on the logistics development potential of the regions concerned. This is particularly true in countries like Taiwan where government retains a significant role in the ownership and management of port infrastructure.

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SMOOTHING CAPACITY UTILISATION IN MARITIME LOGISTICS NETWORKS

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Abstract
Purpose of this paper:
The container shipping industry requires large capital investments, such as container ships and port facilities. In order to secure adequate and reasonable returns on investments, there needs to be a degree of stability in the maritime part of the international supply chain, especially after the global financial crisis of 2008 (Mason and Nair, 2013).
Although the container shipping industry has been undertaking several strategies to smooth capacity utilisation, the theoretical supports from academia are still limited. Maritime reflections of the uneven capacity utilisation in the literature consider the importance of a seamless information flow without time delays in order to moderate the capacity issue (Elbert et al., 2010). However, there are established theories and practices in the field of operations and supply chain management, discussing the approaches to smooth capacity utilisation. As shipping carriers are most embedded into the maritime logistics network, playing an important role as an integrator in the maritime logistics network (Lin, 2015), this paper aims to explore their service capacity utilisation issue through operations and supply chain management theories.

Design/methodology/approach:
Case studies comprising interviews with professionals and secondary data collecting from documents and leading shipping database were conducted in this research. Based on the theories in operations and supply chain management, we use analogy to identify the emerging and potential strategies for shipping carriers to smooth capacity utilisation.

Findings:

Regarding to the strategy of horizontal integration, evidences shows that the formation of mergers, acquisitions and strategic alliances between shipping carriers fits the concept of reducing the unevenness of capacity utilisation. So does the establishment of trunk-and-feeder system, which creates a hierarchy of hub and feeder ports. In terms of the strategy of vertical integration, not only through the operation of dedicated terminals in port area, but also through the provision of integrated logistics and intermodal services by themselves or with other stakeholders in container maritime logistics networks could be considered by shipping carriers. Within this part, the strategies of adjusting vessel allocations in different shipping routes between peak and off-peak seasons, integrating warehousing function and sharing information with cargo owners are suggested.

Value:

There are quite a few studies looking at the service strategies of shipping carriers from shipping economics discipline, but only little research such as this one attempting to analyse the issue from the lens of supply chain and operations management to date. Moreover, through applying the theories in operations and supply chain management, the more comprehensive solutions of smoothing capacity utilisation in the container shipping industry could be proposed, which could help to moderate this volatility and maximize vessel utilisation rates. This is significant for shipping carriers to survive in such competitive and challenging era. Therefore, this paper contributes to academia and have an impact on industry.

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THE DEVELOPMENT OF A CONTAINER PORT SELECTION INDEX IN EAST MEDITERRANEAN USING A FUZZY AHP APPROACH FOR

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ABSTRACT

Competition between ports receiving container ships has started to attract more clients such as freight forwarders, importers, exporters, shipping lines, ship owners and logistics service providers. Container terminals play a substantial role in global cargo transportation by serving as an intermodal between the maritime and by a variety of carriers. This paper aims to investigate those criteria that can be applied by port clients (shipping lines only) when they select their calling ports. A questionnaire has been developed to identify those criteria that are currently applied by shipping lines in the container market in calling seven ports East Mediterranean region. Data and answers are collected for this questionnaire and in turns they have been compared with those criteria discussed in the available literature. Several interviews have been conducted with different shipping lines working in the east Mediterranean region in order to select the most important criteria from their perspective. The most important criteria identified by shipping lines are grouped into seven categories. Fuzzy AHP approach is applied to weight each criterion. The results were distributed again in a second questionnaire to the experts and academics in the field to highlight the basic criteria from their perspective. Finally, the results of both questionnaires are given weight for each criterion through the AHP method of analysis and K-firm concentration ratio. A ranking index of ports is developed based on the criteria identified by the shipping lines. It is concluded that the port charges criteria was the highest measure that is currently applied by the shipping lines in East Mediterranean container market.

KEYWORDS

East Mediterranean Ports, Port selection index, fuzzy AHP, K-firm concentration ratio

INTRODUCTION

Containerization plays an indispensable role in reducing transport cost of international trade. Hence, shipyards have started to produce new designs, which are technically better in terms of their adaptability to the new market conditions, more economical and above all highly competitive compared to the existing ships. On the other hand, ports play important role in accommodating new designed ships with larger volumes of cargo. The quality of facilities inside ports can achieve faster ship turn-around time, less unit cost, and provide added value activities. This helps in enhancing port competitiveness. Instead, those facilities are represented as criteria that are used by port clients (shipping lines) for selecting a calling port. It is obvious that the market of maritime container transport is quite oligopolistic, where substantial volume is being carried by a small number of "Mega Carriers-Top ten" such as Maersk Line, MSC, and CMA - CGM. The increase of their market share has been impressive from 50% to 60% over the period 1999-2009 (Elsayeh, et al., 2011). Hence, different shipping lines apply different criteria

in selecting their calling ports. This paper is designed as follows; section one starts with an introduction of the paper regarding the nature of the Container market, research problem, research methodology and research structure. Section two discusses the development of container terminals and liner shipping companies in East Mediterranean region and critically reviews the literature of service quality criteria and attributes used in selecting the calling container terminals. Section three conducted Fuzzy AHP, (FAHP) technique, data analysis phase and rating scale for selected ports. Section four provides conclusions.

LITERATURE REVIEW

A huge amount of research has been conducted to study port selection criteria for quality services from different perspectives. Many of them have focused on the selection criteria for mode and carrier from the shipper's point of view. These studies are mainly based on cost factors and qualitative evaluation. Other studies have based their methodology on an Analytic Hierarchy Process (Bagchi, 1989). Chang et al. (2008) has listed those factors that affect port selection. D'Este et al. (1992) and Chang et al. (2008) have studied the port/ferry choice. Both studies have been carried out using surveys and focusing on factors such as quality service level, frequency of service, price, facilities etc. Lagoudis et al. (2006) developed a Generic System Model which assisted in the identification of a number of variables that affect the port selection in the total supply chain for international trade. They also adopted the Soft Systems Methodology as a more holistic approach in order to identify the wider possible variety of factors that determine and affect the port selection in the modern business environment. Chang et al. (2008) focused on port choice models made by shippers rather than by other stake-holders. Tjong Kim Sang and De Meulder (2003) distinguished external factors of using a port from internal factors relevant to major port arena and attempted to check if these factors changed over time. They highlighted the most important, where time invariant was the most important in the internal factors, and whereas time variant was the most one in the external factors were. Using container transhipment in Northern Europe as a case study, Chang et al. (2008) applied an analytic hierarchical process (AHP) method to reveal liners transhipment port selection. Their empirical test showed that both container liners carriers and port service providers have a similar perception about the most important service attributes for port selection. Other factors, notably, time efficiency, geographical location and service quality, should also be taken into consideration. On the other hand, using a revealed preference approach, (*Tongzon, J. L., & Sawant, L, 2007)* concluded that port costs and range of port services to be the only significant factors in shipping lines' port choice.

For East Mediterranean ports, they are experiencing a period of revival and now offer the same number of departures both towards the West and the Far East as do northern European ports (Tiwari et al., 2003). The forecasts concur in predicting that transhipment will continue to grow in the main countries bordering on the Mediterranean. As defined the east Mediterranean region including (Egypt, Cyprus, Turkey, Syria, Lebanon and Israel) that are competing in Maritime transport market within the region with a total number of 22 commercial ports, where 15 of them are including at least one containers terminal. Those container terminals were selected from the Group of the Eastern Mediterranean and the convergence in size to compete with each other and thus show how difficult the selection process due to the convergence of the distances between those terminal as well as the volume of containers handled per year. Port Said, Ashdod, Haifa, Damietta, Mersin, Piraeus and Alexandria are selected as case study in this paper. This questionnaire was sent to most of the shipping companies that serve the container market in the study area (Eastern Mediterranean ports), in order to identify the most important criteria and related attributes from their perspectives. The most quality criteria in port container terminals include Port Features (5 attributes), Port Charges (3 attributes), Operations Management (3 attributes), cargo Handling (3 attributes), Customer Service Levels (6 attributes), Information Technology (4 attributes) and External Factors (4 attributes).

RESEARCH PROBLEM

This paper aims to address how do shipping lines select their calling container terminals in the East Mediterranean? What are the criteria and attributes currently applied by the shipping lines? How can ports in the East Mediterranean be ranked according to the shipping lines' criteria?

METHODOLOGY

The methodology in this paper is an empirical enquiry that investigates a contemporary phenomenon within its real-life context. The paper will make use of multiple methods of collecting data, which will be both qualitative and quantitative in nature. The methods used in this paper mainly include literature review, structured interviews, and administered questionnaire. Also, the Analytic Hierarchy Process (AHP), and the K-Firm Concentration (KCR) tools will be used for data analysis. Fuzzy AHP is a widespread multi criteria decision making and has been used widely in the literature (Chang, 1996; Bashiri and Hosseininezhad, 2009; Cinar and Ahiska, 2010). A set of structured interviews with a group composes of 20 interviewees have been conducted to confirm the validity and appropriateness of the most quality criteria in port container terminals discussed in the literature. An administered questionnaire has been distributed over seven out of the most important 25 operating shipping lines in the world in general and out of 10 particularly in the Eastern Mediterranean region.

Container Port Selection Criteria

The analysis of the data provided by the first questionnaires that has been sent to the shipping lines shows that the category of "Port Charges" constitute the most important factor with a percentage of 57%., followed by "Information Technology" with a percentage of 43%. "Operation Management" category has the lowest weight by 14 %. This explains that the shipping lines are interested more in the outcome of the management decisions related to the port fees and associated charges.

Each selection criteria is a set of different attributes. Analysing questionnaires' results, Port Depth is the most important attribute in Port Features category, followed by Location attribute. While, Handling Fees and Operating's Costs are the most important attributes in Port Charges. Relations with Staff became the most important in Operations Management category, whereas cargo Volumes was the highest attribute in Cargo Handling category. Planning Movements was the highest attribute in Customer Service Levels category, while Gate Automation and Service Efficiency were the highest attributes in Information Technology category. Finally, Competitor Ports was the highest attribute in the External Factors category.

An AHP questionnaire was developed and posted to four groups, each of five respondents with a total of twenty respondents. The first group represents ports management, the second represents maritime practitioners, and the third group represents academic experts, while the fourth group represents the terminal professionals' operators. The responses were analyzed by the AHP approach to obtain the relative degree of importance of each category and attributes, and the performance of each port on these seven categories.

Fuzzy Analytic Hierarchy Process

The AHP of (Saaty, 1977) only makes use of the pair-wise comparison matrix to evaluate the ambiguity in multi-criteria decision marking problems as in formula (1). First, Let C1, C2, Cn denote the set of elements, while (aij) represents a quantified judgment on a pair of elements Ci, Cj. The relative importance of two elements is rated using a scale with the values 1, 3, 5, 7, and 9, where 1 denotes equally important, 3 for slightly more important, 5 for strongly more important, for demonstrably more

important, and 9 for absolutely more important. An n-by-n matrix A can be expressed as follows:

$$A = [aij] = \begin{array}{c} \\ C1 \\ C2 \\ \vdots \\ Cn \end{array} \begin{array}{cccc} C1 & C2 & \dots & Cn \\ \begin{bmatrix} 1 & a12 & \dots & a1n \\ \frac{1}{a12} & 1 & \dots & a2n \\ \vdots & \vdots & \vdots & \vdots \\ \frac{1}{a1n} & \frac{1}{a2n} & \dots & 1 \end{bmatrix} \end{array} \qquad (1)$$

Where C₁, C₂,…, Cₙ denote the set of elements, aij = 1 and aij =$\frac{1}{aij}$ i, j= 1, 2,…,n

Second, the structuring of the pair-wise ratio matrix is with the triangular fuzzy numbers. The ratings are converted into the following scale including triangular fuzzy numbers developed by (Bozbura, F. T., & Beskese, A, 2007). The geometric mean accurately highlights the consensus of experts, and is the most widely used in practical applications. Here, geometric mean (which represents the consensus of experts) is used as the model for triangular fuzzy numbers that is the mean of membership = 1. A fuzzy pair-wise comparison matrix based on triangular fuzzy numbers is established as follows:

$\tilde{u}ij = (Lij, Mij, Uij), Lij \leq Mij\ and\ Lij, Mij\epsilon[\ 1/9, 1] \cup [1,9]$ (2)

$Lij = \min(Bijk),$ (3)

$Uij = \max(Bijk).$ (4)

Where Bijk represents a judegment of expert k for the relative importance of two criteria i-j.

$$\tilde{A} = [aij] = \begin{array}{c} \\ C1 \\ C2 \\ \vdots \\ Cn \end{array} \begin{array}{cccc} C1 & C2 & \dots & Cn \\ \begin{bmatrix} 1 & a12 & \dots & \tilde{a}1n \\ \frac{1}{\tilde{a}12} & 1 & \dots & \tilde{a}2n \\ \vdots & \vdots & \vdots & \vdots \\ \frac{1}{\tilde{a}1n} & \frac{1}{\tilde{a}2n} & \dots & 1 \end{bmatrix} \end{array} \qquad (5)$$

Third, the value of synthetic extent is calculated with the Equations (6), as the preferences of experts are relatively subjective opinions, and their responses could differ depending on the degree of environmental uncertainty and depending on whether the experts adopt a conservative or optimistic attitude when determining their preferences. Therefore, the degree of environmental uncertainty and the degree of experts' confidence in their preference have been taken into consideration.

For the questionnaire responses:

$(a_{ij}^a)^\lambda = \left[\lambda.L_{ij}^a + (1-\lambda).U_{ij}^a\right], 0 \leq \lambda \leq 1, 0 \leq a \leq 1$ (6)

Consistency Test

Table 1- of consistency

Test the consistency					
Selection Criteria	EIGENVALUE	N	CI	RI	CR
The Main Factors	7.444745	7	0.07412417	1.32	0.05615467
The Port features	5.204506644	5	0.05112666	1.12	0.0456488
The port Charges	3.08969393	3	0.04484697	0.58	0.07732235
The Operation Management	3.1	3	0.05	0.58	0.0862069
The Cargo Handling	3.037285906	3	0.01864295	0.58	0.03214302

Customer Service level	6.303668115	6	0.06073362	1.24	0.04897873
Information Technology	6.353508	6	0.0707016	1.24	0.05701742
External Factors	4.148487771	4	0.04949592	0.9	0.05499547

Table 1 shows that the consistency is perfect, since the CR is less than 0.1. This means that the results are consistent and the test is valid.

Rating Scale for selected ports

Decision makers associate different importance weights with different criteria at different levels. Then, the weights of criteria of different levels are aggregated to obtain final weights of the decision alternatives. Many approaches have been developed to aggregate the performance from multi-criteria expressions; such as: the weighted mean aggregation operator, to handle hierarchical links, the port terminal operator, for taking interactions into account, and the AHP technique, to quantify the weights and the performance elementary expression (Berrah, L., & Clivillé, V, 2007).

In the proposed FAHP technique, the weighted average aggregation method is used to aggregate the performance of all S C performance measurement attributes. After determining the performance rate (R) and the relative weight (W) of each attribute, the weighted rate (WR) of each attribute is calculated by multiplying the relative weight of each attribute by its performance rate.

$$WR = W * R \hspace{4cm} (7)$$

Where W = the weight of the attribute and

R = the assigned performance rate for the attribute

Then, the weighted rates of all performance measurement attributes are aggregated for each selected port in this paper in order to obtain the overall SC operations' performance in terms of SC index (SCI). This index reveals the overall SC performance according to an interval based performance scale:

$$[0.0<R<=0.3], [0.3<R<=0.7], [0.7<R<=1]; \hspace{2cm} (8)$$

Where R denotes value of the SCI,

[0.0<R<=0.3] denotes poor performance,

[0.3<R<=0.7] denotes good performance,

[0.7<R<=1] denotes excellent performance.

Table 2–Alexandria Port Index for Example

Attribute	Min (2007 - 2011)	Max (2007 - 2011)	Current (2012)	Scale	Rate R	weight W	WR
Location (Dev. Distains)(N.M)	32	32	32	Poor	0.3	0.371	0.1113
Port depth (M)	14	14	14	Poor	0.3	0.109	0.0327
Storage Capacity (TEU)(No.)	31	39	54	Excellent	1	0.123	0.123
Berth length (M)	15.6	19.4	24.63	Excellent	1	0.153	0.153

Handling Equipment availability (No. of gantry crane)	11	15	21	Excellent	1	0.245	0.245
						index	0.665

The seven indexes are represented in table 3 below in a descending order according to importance. Thus, a new ranking for the selected East Mediterranean container terminals is established.

Table 3- The East Mediterranean Container Port Selection Index

The port	W.R
Alexandria port	0.665
Port said port	0.5054
Mersin port	0.5054
Haifa port	0.3983
Damietta port	0.3983
Piraeus port	0.3003
Ashdod port	0.3003

K-Firm Concentration Ratio

Chen et al. (2004) introduced a K-firm concentration ratio indicator for determining the market share as:

$$CR_m = s_1 + s_2 + ... + s_m \qquad (9)$$

Where s_i is the market share and m defines the ith firm

The previous equation was used to rank East Mediterranean container terminals in the Period from (2011-2012) as displayed in table 4.

Table 4- East Mediterranean Container Terminals Rank

Port	2011	Share	Port	2012	Share
Port Saied	,366,968	40.85%	Port Saied	4,831,165	35.39%
Piraeus	,680,133	12.79%	Piraeus	2,745,012	20.11%
CR2		53.64%	CR2		55.49%
Alexandria	1,490,000	11.34%	Alexandria	1,500,000	10.99%
Haifa	1,235,000	9.40%	Haifa	1,372,209	10.05%
Damietta	1,200,000	9.13%	Mersin	1,263,495	9.25%

CR5		83.52%	CR5		85.78%
Mersin	1,126,588	8.58%	Ashdod	1,181,000	8.65%
Ashdod	1,038,950	7.91%	Damietta	760,000	5.57%
Total	13,137,639	100%	Total	13,652,881	100%

The researchers used the k-firm concentration in order to conduct an objective comparison between K-Firm Concentration Ratio method and the Fuzzy AHP as shown in the table 5 below.

Table 5- Ranking for East Mediterranean Container Terminals

Rank	Ranking for East Mediterranean container terminals (K-Firm Concentration Ratio)	Ranking for East Mediterranean container terminals (Fuzzy AHP)
1	Port Saied	Alexandria port
2	Piraeus	Port said port
3	Alexandria	Mersin port
4	Haifa	Haifa port
5	Mersin	Damietta port
6	Ashdod	Piraeus port
7	Damietta	Ashdod port

CONCLUSION

Container terminals can play an important role in attracting more clients and in enhancing port competitiveness. The availability and quality of facilities at the terminals are being considered as criteria for many shipping lines when they select their calling ports. Different criteria are applied by different shipping lines for this purpose. Seven categories of criteria and their related attributes have been discussed, including Port Features, Port Charges, Operations Management, cargo Handling, Customer Service Levels, Information Technology and External Factors. Seven East Mediterranean container terminals were identified. Two questionnaires were developed and structured interviews were conducted for collecting data in order to identify the most important criteria applied by the shipping lines for selecting their calling ports. It is concluded that the port charges was the most important criteria, followed by the information technology. Two different methods were applied in this paper to rank the selected container terminals, including Fuzzy AHP method of analysis and K-firm concentration ratio. A ranking index was developed, where Alexandria port was ranked the highest using Fuzzy AHP method, while Port Said was ranked the highest using K-firm concentration ratio.

It is recommended to extend the study in the future to include other port clients, such as importers and exporters, stevedoring companies and freight forwarders, in order to identify the most important criteria for selecting the calling port from their perspectives. This may lead to change the ranking of the selected container terminals in East Mediterranean.

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THE ROLES OF INTERMEDIARIES IN AUGMENTING SHIPPERS' SATISFACTION WITH CONTAINER SHIPPING

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Abstract
Purpose of this paper:
Increasing importance of the international shipping has signified the roles of intermediaries for enhanced international logistics services. As Marlow and Nair (2008) pointed out, liner companies providing multimodal point-to-point services are engaged in the direct competition with intermediaries, such as freight forwarders, NVOCCs and 3PL companies. These intermediaries transform a basic transport service offered by liner companies into a new value-added logistics service, thus increase overall satisfaction with container shipping.
This research aims at highlighting the influences of intermediaries on the satisfaction of shippers with container shipping. It compares the perception between a shipper group directly using liner companies and another shipper group using intermediaries in order to identify the logistics service factors that intermediaries make a great contribution to the service level.

Design/methodology/approach:
A large-scale questionnaire survey with shippers was adopted to collect empirical data. Questionnaires were distributed to 300 Korean shippers who are involved in international logistics. The construct model of logistics service factors derived from Lu (2000) were tested by confirmatory factor analysis. Critical service factors were identified by multi-stage analyses which combined multi-group analysis, analytic hierarchy process and the model developed by Aaker and Day (1980).

Findings:
Intermediaries were found to be superior in terms of Easy Process and Value-added Service factors while liner companies had competitive edges in Equipment & Facilities and Image & Promotion factors. Although the perception of relative importance differed between the respondent groups, the intermediary users prioritise Freight Rate, Speed & Reliability and Sales Representative Factors to other factors. Overall weighted index of satisfaction showed that the influences of Process Easiness and Value-added Service factors definitely exist but might be limited. A further analysis using the Aaker and Day Model revealed that Freight Rate and Sales Representative factors emerged as the most influential factors to augment the satisfaction of shippers with liner services through intermediaries.

Value:
Despite the myriad studies on criteria for selecting carriers, there has been little empirical research relating to intermediaries' influences on liner service satisfaction. This research is the first study to highlight the roles of intermediaries by considering multi-faceted logistics service attributes to shippers' satisfaction with liner services.

Research limitations/implications:
This research provided several theoretical contributions by validating a construct model of logistics service attributes and by analysing the attributes by a combination of quantitative methods.

Practical implications:
The results emphasised the current competitive advantages of intermediaries and their strategic directions in the future. These will be also useful for liner companies to provide better services to their direct shippers.

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IMPLICATION OF SERVICE IN SHORT SEA SHIPPING

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ABSTRACT

The attributes of a service can be categorized as service quality and service preference. While studies have addressed the importance of service quality and perceived value, the service preference of shippers and its relationship to perceived value and purchase intentions remain unexplored. Therefore, this study proposes a causal model in the context of coastal shipping services to investigate the influence of purchase intention through the shipper's service preference and perceived value. We apply structural equation modeling to assess the empirical strength of the relationships in the proposed model. The model is validated through empirical testing. Our results show that for short sea shipping, timing-related services, price-related services, warehousing services, sales services, door-to-door services, information services, and advertising services positively affect service preference.

Key Words: Service preference, Perceived value, Purchase intention, Coastal shipping

1. Introduction

Coastal or Short Sea Shipping (SSS) is the transport of cargo around the coast of a country and is a cost effective alternative to road freight. In addition to bulk cargo, SSS includes the transport of international ISO containers (Brooks & Frost, 2004) through feedering and the re-positioning of empty containers between ports in a country by ocean-going vessels. The purpose of SSS includes a leg of transshipment or a replacement for road transport. SSS has advantages, such as the reduction of air pollution and overall cost savings for ship operators. SSS is also particularly important to alleviating road congestion (Paixão & Marlow, 2002; Ng, 2009; Douet & Cappuccilli, 2011). Exploiting the economies of scale, several large vessels are now been used as regional feeders. For instance, short sea shipping accounts for 40% of the internal transport of goods in the European Union (EU) and is instrumental in reducing congestion, ensuring territorial cohesion, and promoting the sustainable development of Europe (Grama & Patache, 2011). In Japan, 7.9% of domestic freight transportation is carried by SSS (IOT, 2007); in the US, the figure is only 2.0% (Medda & Trujill, 2010). In addition, the potential cost reduction by switching from road transport to SSS in the EU is 35% (Saldanha & Gray, 2002). As such, SSS is receiving
The survey responses indicate green supply practices as one of the important criteria in supplier selection. This suggests that automotive manufacturers should realize the importance

of green practices while selecting their suppliers. This will help them to meet their own green goals while simultaneously meeting the government environmental regulations.

considerable attention in the shipping industry and with shippers. In the EU, more than 400 studies on SSS were already sponsored in the 1990s (Brooks & Frost, 2004). Taiwan is an island nation with limited land resources to build highways on. Thus, using the sea shipping mode to move domestic cargo around the island is a potential option. However, SSS carries only 1.8% of the domestic freight transport in Taiwan (IOT, 2007). Government policy on promoting SSS to move cargo around the island is not enforced in Taiwan. Thus, understanding the service preference of shippers and designing the SSS service according to such preference can increase a shipper's perceived value of the SSS service and motivate them to use SSS to move freight around the island. Measuring the service preference is thus useful for informing policy and provides a mechanism for optimal price setting of SSS services.

Service preference, pertaining to the preferred selection by an individual (O'Cass & Lim, 2001), is the preference perceived by customers and therefore also refers to customer preference. For example, everyone favors low price and good product quality, but not everyone needs a dedicated transport service. Prior research has identified several attributes of service in maritime firms (Paixão & Marlow, 2005, 2009; Lu & Marlow, 1999; Lu, 1999, 2000, 2003), such as the reliability of sailing, availability of cargo space, and on-time pick-up, and their influence on carrier selection (Lu, 2003). However, few studies have specifically explored the influence of service attributes on service preferences in the SSS context. While preferential decisions is an ongoing research topic in the social sciences (Muthitacharoen et al., 2006), little effort has been made to incorporate service preference decisions into shipping service research. In Taiwan, only one policy research has been conducted by the Institute of Transportation (2000) to study the economic feasibility of the development of container SSS. The study found that the volume of container SSS can only be slightly increased in comparison with road haulage due to the poor service quality and high cost of SSS. Thus, our study attempts to determine the service attributes of coastal ocean container carriers that are preferred by shippers in Taiwan and suggests a strategy to attract more shippers to use SSS as a substitute for road transport, especially in the context of littoral states and environmental consciousness in Asia.

Studies have investigated the effect of the service quality of carriers, shipping agencies, and freight forwarders on the degree of satisfaction of their shippers (Lu & Marlow, 1999). Voss et al. (2006) employed the theory of reasoned action (TRA) to determine the most important selection criteria of carriers as perceived by shippers and to predict the carrier choice behavior of shippers. Their research indicated that reducing transport cost, preparing for unforeseen circumstances, and increasing emphasis on supply chain security are attributes valued by the individual making the transportation purchase. The TRA model explains the relationship between the value of attributes and the transportation purchase behavior. However, few studies have dealt with the shipper's perceived value in the SSS setting. Our study therefore aims to (1) investigate the importance of SSS service attributes from the perspective of shippers, (2) examine the relationship between the shippers' service preference and their perceived value, and (3) examine the association between shippers' perceived value and their purchase intentions. Hypotheses are proposed and tested to answer the following research questions: What service attributes influence the service preference of a shipper? Is perceived value a significant determinant of purchase intentions in the SSS context? Is service preference a significant determinant of perceived value and purchase intentions in the SSS context?

2. Theoretical Background and Hypothesis Development

2.1 Definition of SSS and Service Attributes

Various definitions of SSS exist in the literature, suggesting the complexity of the concept. From the logistics and regulatory perspectives, SSS research can study different ships from conventional to innovative ones such as fast ships, with various cargo handling techniques (horizontal, vertical, or a mixture of both), ports, networks, and information systems. Crilley and Dean (1993) defined coastal and short sea ships as ships used to move goods and passengers loads of between 100 and 5000 gross tons. SSS can also be categorized based on the type of cargo transported, namely: (1) the feedering of domestic and international containers with lift-on lift-off feeder vessels or container barges and (2) the transportation of domestic trailers with roll-on roll-off ships (Perakis & Denisis, 2008).

As SSS carriers can either own and operate several ships or own and run only one or a few ships, service providers of different types may offer various services to their customers (Paixão & Marlow, 2002). The relevant research on the service attributes can be found in Brooks (1983, 1984, 1985) who examined the determinants that affect the container carrier choice of shippers, and Lu (2003) who identified how the service attributes of four generic carriers influence their service quality from the perspective of shippers.

As a result of the pursuit of scale economies, liner operators have turned to using larger vessels and increasingly rely on hub-and-spoke configuration for their sailing routes. This makes regional feeders and SSS even more important. Sambracos and Maniati (2012) indicated that compared with road links, SSS has the advantage of lower costs, fewer accidents, and lesser environmental impact. Ng (2009) indicated that cost significantly influences the competitiveness of SSS against road haulage. Paixão and Marlow (2005) identified eight service attributes of SSS in integrated multimodal transport service.

However, they concentrated on service attributes in the quality dimension and neglected other preference issues. As not all service attributes are uniformly critical to every firm (Lu & Marlow, 1999), the key to creating a competitive advantage is to understand the influence of the various service attributes on the service preference of shippers. Paixão and Marlow (2007) characterized the SSS market by assessing the influence of trans-European transport networks. They classified services into three types, namely, dedicated services, systems, and standard operations, which reflect the extent of service preference toward the shipper. In addition, Paixão and Marlow (2009) developed 13 logistics strategies out of the 75 best practices of SSS operators using exploratory factor analysis. Most of the 75 service attributes positively affect the improvement of SSS service quality. Medda and Trujillo (2010) studied how SSS can alleviate traffic congestion and enhance economic development by maintaining freight flow efficiency and found that SSS is one of the most sustainable and economically competitive modes of transport. Baindur and Viegas (2011) found that consignors will switch from roads to alternative transport modes (namely, rail, inland navigation, or SSS) only if the transport costs are 30% to 50% lower than the road costs. They argued that SSS can penetrate the road transport market by offering the same overall service quality as that of road transport. Likewise, Brooks and Frost (2004) studied SSS in Canada and the US, and found that reliability, high frequency, and short transit times are key to the successful operation of SSS. Table 1 summarizes the literature on the service attributes.

<Insert Table 1 around here>

2.2 Service Preference

Preference is "the setting by an individual of one thing before or above another thing" (Cobb-Walgren et al., 1995). Consumers prefer services that are congruent with their self-concept and thereby reflect what they would really like to be (O'Cass & Lim, 2001). The importance of service preference in relation to other psychological variables, such as beliefs and intentions, has been observed in previous studies (Anderson, 1982; Chandrashekaran, 1994). According to Hsu and Lu (2007), service preference is the degree of positive feelings that users have toward the products and services of a vendor. Caplan (2003) found that individuals prefer online socialization over face-to-face socialization, indicating that social interaction plays an important role. The positive feelings of customers influence their service preferences, and such preferences can be measured by service accessibility and service variety, which include the ability to provide different services that satisfy the various needs of customers (Muthitacharoen et al., 2006).

However, few studies have empirically developed a framework to measure service preference. Researchers still have not explored service attributes and service preference. Lu (2003) investigated the effect of the service attributes of carriers on the satisfaction of shippers with the shipper–carrier partnership. An evaluation of the aggregated perceptions of shippers on the service attributes of carriers revealed all 30 attributes to be satisfactory. Using factor analysis, Lu (2003) identified six service modules or key dimensions from the perspective of shippers: timing, pricing, warehousing services, sales services, door-to-door services, and information. Our study attempts to examine the relationship of service attributes with the preference of shippers to use SSS. Brooks and Frost (2004), and Brooks and Trifts (2008) studied Canadian and North American SSS respectively, and created mode choice models from the perspective of the cargo stakeholders. The studies indicated that transit time, price of service, perceived reliability, perception of SSS service quality, frequency, situational variables, and buyer requirements affect the shippers' mode choice. Daniels, Marcucci, and Rotaris (2005) noted that the following service attributes influence shippers' preference regarding the purchase of a shipping service and are normally used by shippers in choosing transportation alternatives: (1) travel time (in days or hours), (2) freight cost and freight (in monetary terms), (3) reliability (through an indicator, such as percentage of on-time deliveries), (4) loss and damage to goods transported (number of occurrences or value of goods stolen or damaged), (5) frequency (number of shipments per day or week), and (6) flexibility (hours or days of notice required for a change in delivery condition). Jiang et al. (1999) studied the choice of freight transport mode and found that the transportation facilities of a firm (e.g., warehouses) are closely related to its transportation demand and significantly influence its modal choice. In addition, the information system of a firm strongly influences its logistics practices and plays an increasingly important role in its transportation decisions. Table 2 shows the service attributes that influence the preference of shippers regarding SSS based on the findings of Lu (2003), Muthitacharoen et al. (2006), and Jiang et al.(1999). Based on these attributes, we posit the following hypotheses:

H1: All service attributes are positively related to service preference.

H1a: Timing-related services are positively related to service preference.

H1b: Price-related services are positively related to service preference.

H1c: Warehousing services are positively related to service preference.

H1d: Sales services are positively related to service preference.

H1e: Door-to-door services are positively related to service preference.

H1f: Information services are positively related to service preference.

<Insert Table 2 around here>

2.3 Perceived Value

The service offered by a firm is only as good as how the customer perceives that service. Value indicates that customers believe that their choices are better than any substitute and that they have selected what is best for them (Solomon, 2006). Value is the perception of a tradeoff between benefits (including quality) and costs (Zeithaml, 1988; Parasuraman et al., 1988; Kotler, 2003). Bolton and Drew (1991) conceptualized value as a tradeoff between quality and price, though several studies claim that value is more complex and that its other dimensions have to be included (Bolton & Drew, 1991; Ravald & Grönroos, 1996; Holbrook, 1994).

The difference between quality and value is that quality is abstract but value is personal. Perceived value is a concept that is difficult to define and measure (Zeithaml, 1988; Woodruff, 1997) because it is personal and unique and may vary widely from one client to another (Zeithaml, 1988; Holbrook, 1994). Zeithaml (1988) identified four types of values: (1) low price, (2) whatever is wanted in a product, (3) the quality obtained for the price paid, and (4) what is obtained in exchange for what is given. Zeithaml combined these values into a general definition: "perceived value is the consumer's overall assessment of the utility of a product or service based on perceptions of what is received and what is given." The various meanings of value held by customers compromise the validity of a measure (Botanic, 1996). In addition, perceived value has its roots in the concept of equity, which refers to customer evaluation of what is fair, right, or deserved for the perceived cost of the service or goods offered (Bolton & Drew, 1991). Perceived value intrinsically entails subjective judgment and thus complicates the measurement task. Sheth et al. (1991) indicated five factors of consumption values, namely, social, functional, conditional, emotional, and epistemic values, and how they influence consumer choice behavior. If customers can identify the benefits of products or services, such as safety, performance, appearance, comfort, economy, and durability,

customers can easily perceive their values (Palmroth, 1991). Parasuraman and Grewal (2000) proposed four types of perceived values, namely, transaction, acquisition, redemption, and use. Moreover, customer perceived value results from a mental weighing of the relative rewards and sacrifices associated with the services or goods offered. Customers feel equitably treated if they perceive that the ratio of their outcome to their input is comparable to the ratio of the outcome obtained by the company to its input (Petrick, 2004).

According to Christopher (1992), logistics services are explored to seek an advantageous position based on value advantage. Relative value can help a firm gain additional competitive advantage (Ernst, 1988). The perceived value construct has not received as much attention as other constructs in transportation literature. Unlike those of other industries, customers of SSS pay directly for the service rendered. SSS has third-party logistics service providers (3PLs) who pay for all or part of the service provided. Coverage by 3PLs may affect customer understanding of the price and perceived value offered by the SSS carriers. How the perceived value of the services of 3PLs is influenced in the SSS context is difficult to analyze. A customer perceives high value if all service attributes (including service quality) of the provider meet his or her requirement (Kuo et al., 2009). In the SSS context, the role of perceived value should be examined as the shipper may not always consume the best service and may instead purchase a 3PL service according to their assessment of the value of a service (Cronin & Taylor, 1992). However, if the carrier provides services preferred by shippers, the shippers may perceive more value from a psychological evaluation of the relative rewards and losses associated with the offering. This observation leads to the following hypothesis:

H2: Service preference is positively related to perceived value.

2.4 Purchase Intentions

Most studies have focused on understanding the initial purchase behavior or behavioral intention of customers, including their willingness to buy (e.g., Jarvenpaa et al., 1999), their purchase intention (e.g., McKnight et al., 2002), their willingness to transact (e.g., Bhattacherjee, 2001), and their behavioral intention to use (e.g., Suh & Han, 2003). Multiple behavioral intentions include customer loyalty, positive recommendation behavior, and repurchase intentions (Zeithaml, 1996; Cronin et al., 2000; Oh, 1999). In addition, Zeithaml et al. (1996) proposed a multidimensional measure of these indicators that includes purchase intentions, complaint behavior, price sensitivity, and word-of-mouth communication. Perceived value is a direct antecedent of behavioral intentions and a significant factor in purchase intentions (Dodds et al., 1991; Cobb-Walgren et al., 1995; Cronin et al., 2000). In addition, given that service is intangible, inseparable, heterogeneous, and perishable (Etzel et al., 2001), service preference stresses service accessibility and service variety, which involve the ability to provide different services that satisfy the various needs of customers (Muthitacharoen et al., 2006). According to Ajzen's (1991) theory of planned behavior, if shippers obtain information and perceive that the service of a vendor (e.g., a short sea carrier) has high quality, they generate a favorable attitude and preference toward the service and demonstrate behavioral control over it and thus develop greater intention to purchase the service (Pavlou & Fygenson, 2006). Taylor and Baker (1994), and Kuo et al. (2009) indicated that service quality is a key factor that influences the purchase intentions of consumers in the

services industry. The nine measures of the three constructs (service preference, perceived value, and purchase intention) are summarized in Table 3.

<Insert Table 3 around here>

Based on the above discussion, the following hypotheses are proposed:

H3: Perceived value is positively related to purchase intentions.

H4: Service preference is positively related to purchase intentions.

On the basis of these hypotheses, we propose our research model, as found in Figure 1.

<Insert Figure 1 around here>

3. Method

A questionnaire comprising 25 items was generated, and the list of the items is shown in Tables 2 and 3. All the items were measured on a five-point Likert-type scale with anchors ranging from strongly disagree (1) to strongly agree (5). For this study, all measurement items in the questionnaire were developed either by adapting the measures validated by other research or by converting the definitions of the constructs into a questionnaire format. The questionnaire was pretested to ensure content validity and reliability within the target context. Five experts in the maritime field were invited to assess wording clarity, task relevance, and the suitability of the question item sequence. As a result, several minor modifications of the wording and item sequence were made. Next, a pilot was conducted on 30 individuals with experience with carriers or shippers. Their comments and suggestions on the item content and structure of the instrument were solicited.

A mail survey was used to collect data to investigate the research model. Candidate firms were randomly selected from the members list of the International Ocean Freight Forwarders and Logistics Association in Taiwan. Subsequently, 200 firms were contacted through an introductory letter and a follow-up phone call describing the goal of the study and soliciting the support of the firm. All respondents were required to have knowledge of logistics and transportation. At the end of the screening, 130 questionnaires were sent to those firms willing to participate in the study. In an e-mail welcoming and thanking the respondents for participating in the survey, several statements were included to assure them of the confidentiality of their responses. From August to September 2011, 105 complete questionnaires were returned; 86 of these questionnaires (81.9% response rate) provided usable data and were thus used in the analysis.

Three statistical analyses used in this study: (1) exploratory factory analysis, to confirm the hypothesized nine-factor model (Table 2); (2) confirmatory factor analysis, to test reliability and validity (a reliability test for each construct was applied to assess internal consistency from composite reliability (Table 4); and (3) structural equation modeling (SEM), to verify the goodness of fit of the research model and to describe the relationships among the constructs (Figure 2). To investigate the objectives of this study and test the hypotheses, partial least squares (PLS) was employed to analyze the collected data (Table 5). PLS facilitates the analysis of both measurement and structural models and places minimal restrictions on measurement scales, sample size, and residual distribution (Chin & Newsted, 1999).

4. DATA ANALYSIS AND RESULTS
4.1 Reliability and validity tests

Data on the measurement and structural models were analyzed. The adequacy of the measurement model was evaluated according to reliability, convergent validity, and discriminant validity. Reliability was examined using composite reliability values, which should be greater than the benchmark of 0.7 to be considered adequate (Fornell & Larcker, 1981). Table 3 shows that all the values were above 0.7, indicating adequate reliability. Additionally, the convergent validity of the scales was verified by using the two criteria suggested by Fornell and Larcker (1981): (1) all service attributes' loadings should be significant and should exceed 0.7 (Table 4) and (2) the average variance extracted (AVE) by each construct should exceed the variance because of the measurement error for that construct (i.e., AVE should exceed 0.5). Most items exhibited a loading higher than 0.7 on their respective constructs, providing evidence of acceptable item convergence on the intended constructs. Different fit indices (GFI, AGFI, CFI, RMSEA, and RMR) were all above the threshold suggested by Hair et al. (2006). Construct reliability was between 0.85 and 0.92, and the AVE values were all above 0.69. Therefore, both conditions for convergent validity were met.

<center>**<Insert Table 4 around here>**</center>

Discriminant validity was assessed by examining the factor loadings to determine if the questions were loaded more highly on their intended constructs than on other constructs (Fornell & Larcker, 1981). We considered both loadings and cross-loadings to establish discriminant validity, and all items had higher loading on their own construct than on other constructs in the model (Table 4). In addition, the square root of the AVE from the construct should also be greater than the correlation between the construct and other constructs in the model for satisfactory discriminant validity. Table 5 lists the correlations among the constructs, with the square root of the AVE on the diagonal. The diagonal values exceeded the inter-construct correlations; thus, the discriminant validity was acceptable. Therefore, the measure for each construct satisfied construct reliability and validity.

<center>**<Insert Table 5 around here>**</center>

4.2 SEM

This study aims to identify the relationships among service attributes, perceived value, and purchase intentions. To achieve this objective, SEM was employed to test the interrelationships among all the research constructs and to compare the modeled relationships with the observed scores. The proposed SEM is shown in Figure 2.

<center>**<Insert Figure 2 around here>**</center>

On the effect of attributes on service preference, empirical findings showed that timing-related services, pricing-related services, warehousing services, sales services, door-to-door services, information services, and advertising services positively affect service preference. Lu (2003) found that both door-to-door and information services were not significantly correlated with the satisfaction of shippers. By contrast, our study found that door-to-door and information services positively affect service preference, although the significance of these two services

is weaker than that of the other attributes, such as timing-related services, pricing-related services, warehousing services, and sales services. As the current study mainly investigated the effect of the service attributes of carriers on service preference from the perspective of shippers, it differs from Lu's (2003) study, which focused on the satisfaction of shippers with the shipper–carrier partnerships. A possible explanation is that shippers are concerned with door-to-door services, including the good condition of containers, and information services with cargo tracking. Customer preference strongly affects perceived value ($p < 0.001$) and thus validates H2. The greater the shipper's preference, the greater the value perceived by the shipper regarding the carrier's service. Service preference also directly and significantly affects purchase intentions ($p < 0.01$) and thus validates H4. In addition, H3 is validated because perceived value strongly affects purchase intentions, consistent with previous research (Dodds et al., 1991; Cronin et al., 2000). In short, customers perceive that value significantly influences purchase intention transactions.

5. CONCLUSION

The development of SSS services offers a potential and environment-friendly market (Paixão and Marlow, 2002). However, research has paid minimal attention to this trend. The current study empirically examines the effects of perceived value on purchase intentions in the SSS context and identifies the relationship between service attributes and service preference. This study can help carriers to manage relationships with their shippers. Most carriers focus on providing excellent service quality, but they may ignore the relationship between service quality specification and shipper preference. Thus, carriers should provide proper service quality with each of the attributes and constructs to effectively increase the degree of customer preference toward their SSS service. Through our research, SSS service providers can identify the factors that affect the purchase intentions of shippers as well as factors that increase customer loyalty. The research also has managerial implications as managers of carriers can assess and then increase the degree of service preference of their shippers by providing appropriate freight service quality with the attributes indicated in Table 2. The results are also significant as they provide information on a previously uninvestigated area, and as such, can lead to the creation of a framework to better understand the link between service preference, perceived value, and the important attributes of service preference. On the multiple attributes of service preference and perceived value, the findings should lead to an understanding of the broader issue of the mechanisms whereby shippers are attracted to make a purchase.

This study has several limitations. First, this study investigates purchase intentions from the perspective of shippers only. Other firms, such as third-party LSPs, are excluded. Second, we limit our survey subject to the SSS context in Taiwan. Third, this study focuses on only one antecedent of perceived value and purchase intentions. Future research has several directions that can strengthen the results of this study. First, purchase intention could be explored from the perspective of other firms. Second, other factors that result in preferred services could be examined. Finally, a business positioning framework based on this study can be developed.

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Table 1 Items and sub-items of the service attributes in short sea shipping

Constructs / Items	Measures	Jiang et al. (1999)	O'Cass & Lim (2001)	Lu (2003)	Brooks & Frost (2004)	Brooks & Trifts (2008)	Daniels et al. (2005)	Muthitacharoen (2006)	Voss et al. (2006)	Medda & Trujillo (2010)	Baindur & Viegas (2010)
Service Attributes (H1)											
Timing/reliability (H1a)	On-time pick-up			✓		✓	✓		✓		✓
	Short transit time			✓	✓	✓	✓		✓	✓	✓
	High frequency of sailing			✓	✓	✓					✓
Pricing related (H1b)	Freight rates				✓	✓	✓	✓	✓	✓	✓
	Price and discount structure			✓	✓		✓		✓	✓	
	Willingness to negotiate			✓							
Warehousing (H1c)	Customs clearance service			✓							
	Storage service	✓		✓			✓				
	Packaging/labeling service (to avoid cargo damages)	✓		✓			✓			✓	
Sales (H1d)	Frequency of sales representatives' calls to shippers			✓							
	Knowledge ability of sales personnel			✓							
	Ability of sales representatives to handle problems			✓							
Door-to-door service (H1e)	One stop logistics service			✓							
	Seamless logistics service			✓						✓	
Information (H1f)	Computer EDI interface	✓	✓	✓					✓	✓	
	Computerised cargo tracing	✓	✓	✓	✓				✓	✓	

Source: this research.

Table 2   Exploratory factor analysis of short sea shipping service attributes

Construct/Factor	Attribute	Measure	Factor Loading
Timing related services (TS)	TS1	On-time pick-up	0.92
	TS2	Short transit time	0.95
	TS3	High frequency of sailing	0.89
Pricing related services (PS)	PS1	Freight rates	0.88
	PS2	Price and discount structure	0.90
	PS3	Willingness to negotiate	0.86
Warehousing services (WS)	E1	Customs clearance service	0.75
	E2	Storage service	0.92
	E3	Packaging/labeling service	0.82
Sales services (SS)	S1	Frequency of sales representatives' calls to shippers	0.79
	S2	Knowledge ability of sales personnel	0.85
	S3	Ability of sales representatives to handle problems	0.83
Door-to-door services (DS)	DS1	One stop logistics service	0.78
	DS2	Seamless logistics service	0.80
Information services (IS)	IS1	Computer EDI interface	0.77
	IS2	Computer cargo tracing	0.91
Service Preference (SP)	SP 1	Transaction cost preference	0.94
	SP 2	Product preference	0.88
	SP 3	Social interaction preference	0.79
Perceived value (PV)	PV1	The service would be economical	0.80
	PV2	The service is value for money compared with that of major competitors	0.88
	PV3	The choice of transacting with the firm is a right decision when price and other expenses are considered	0.82
Purchase intentions (PI)	PI1	I intend to transact with the firm in the near future.	0.82
	PI2	I plan to purchase the service from the firm in the near future.	0.89
	PI3	I predict that I would consider purchasing the service from the firm in the near future.	0.92

Table 3 Nine measures of the three constructs in the Theory of Reasoned Action

Constructs	Measures	Hsu & Lu (2007)	Marcussi & Rotaris (2005)	Caplan (2003)	Zeithaml (1988)	Botanic (1996)	Bolton & Drew (1991)	Sheth et al. (1991)	Palmroth (1991)	Parasuraman & Grewal (2000)	Petrick (2004)	Jarvenpaa & Tractingsky (1999)	McKnight et al. (2002)	Bhattacherjee (2001)	Suh & Han (2003)
Attitude: Service Preference (SP)	Transaction cost preference		✓												
	Product preference	✓													
	Social interaction preference			✓											
Norm: Perceived Value (PV)	The service would be economical				✓		✓	✓	✓						
	Value for money compared with that of major competitors				✓	✓	✓	✓		✓					
	The choice of transacting with the firm is a right decision				✓	✓	✓	✓		✓	✓				
Behaviour: Purchase Intention (PI)	I intend to transact with the firm in the near future.											✓			
	I plan to purchase the service from the firm in the near future.											✓		✓	
	I consider purchasing service from the firm in the near future.												✓		✓

Table 4 Confirmatory Factor Analysis

Construct	Attributes	Factor Loading	Construct Reliability(CR)	Average Variance Extracted (AVE)
Timing related services (TS)	TS1	0.92	0.91	0.75
	TS2	0.95		
	TS3	0.89		
Pricing related services (PS)	PS1	0.88	0.93	0.86
	PS2	0.890		
	PS3	0.86		
Warehousing services(WS)	WS1	0.75	0.82	0.71
	WS2	0.92		
	WS3	0.82		
Sales Service (SS)	SS1	0.79	0.87	0.79
	SS2	0.85		
	SS3	0.83		
Door-to-door services (DS)	DS1	0.78	0.91	0.75
	DS2	0.80		
Information service (IS)	IS1	0.77	0.94	0.83
	IS2	0.91		
Service Preference (SP)	SP1	0.94	0.85	0.80
	SP2	0.88		
	SP3	0.79		
Perceived value (PV)	PV1	0.80	0.91	0.85
	PV2	0.88		
	PV3	0.82		
Purchase Intentions (PI)	PI1	0.82	0.92	0.69

Table 5 Discriminant Analysis between Constructs

Construct	TS	PS	WS	SS	DS	IS	SP	PV	PI
TS	0.87								
PS	0.92	0.93							
WS	0.35	0.15	0.84						
SS	0.24	0.44	-0.23	0.89					
DS	0.45	-0.35	-0.12	-0.65	0.87				
IS	0.16	-0.26	-0.19	0.72	-0.43	0.94			
SP	0.28	-0.17	-0.04	0.36	-0.23	0.28	0.89		
PV	0.60	-0.50	-0.34	0.38	-0.38	0.40	-0.08	0.92	
PI	0.29	-0.39	-0.20	0.78	-0.46	0.73	-0.26	-0.56	0.83

Note: Shaded values in the main diagonal represent the AVEs of the nine constructs; non-shaded values represent the coefficients of the correlation between the constructs.
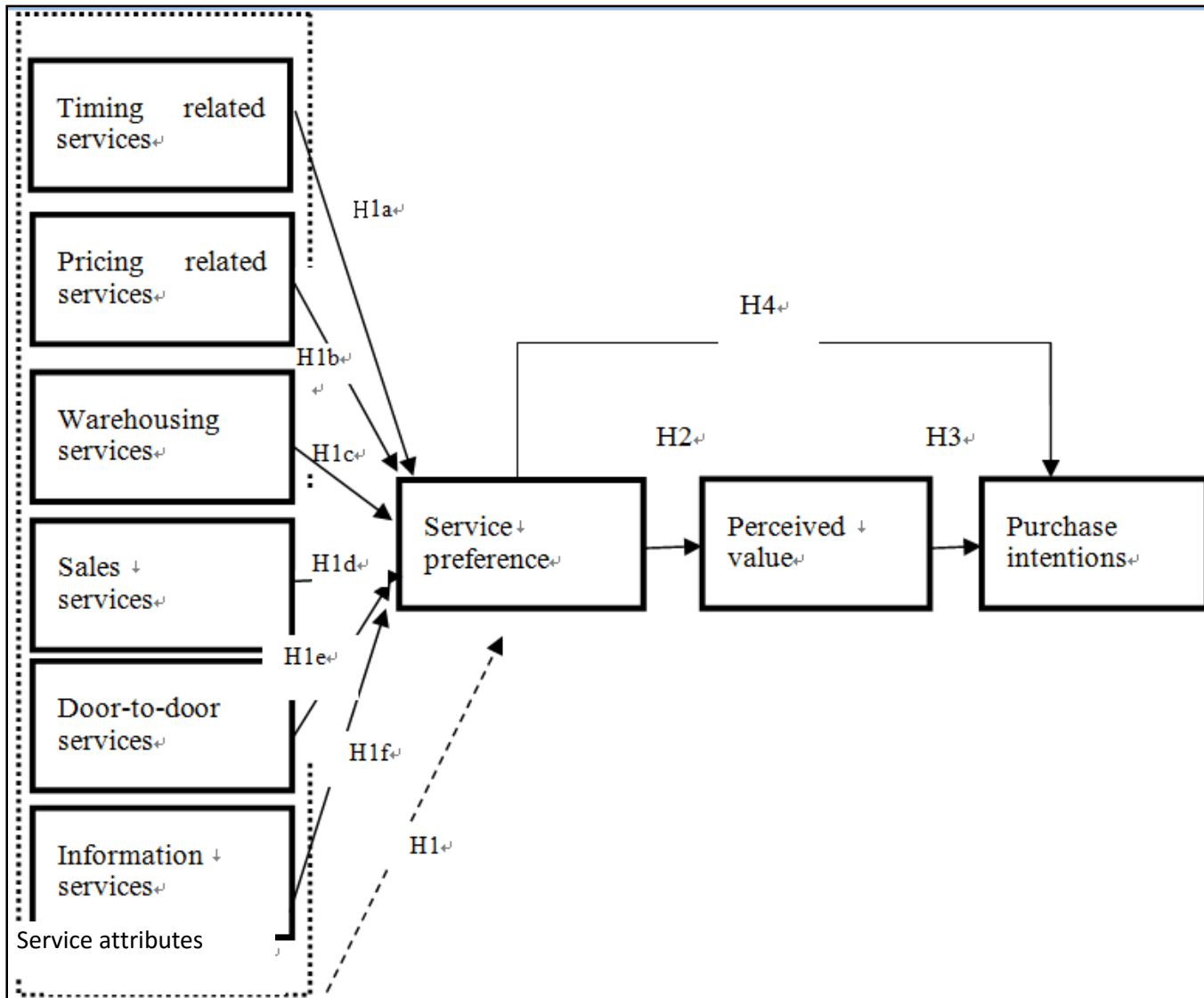
Figure 1 Research Model
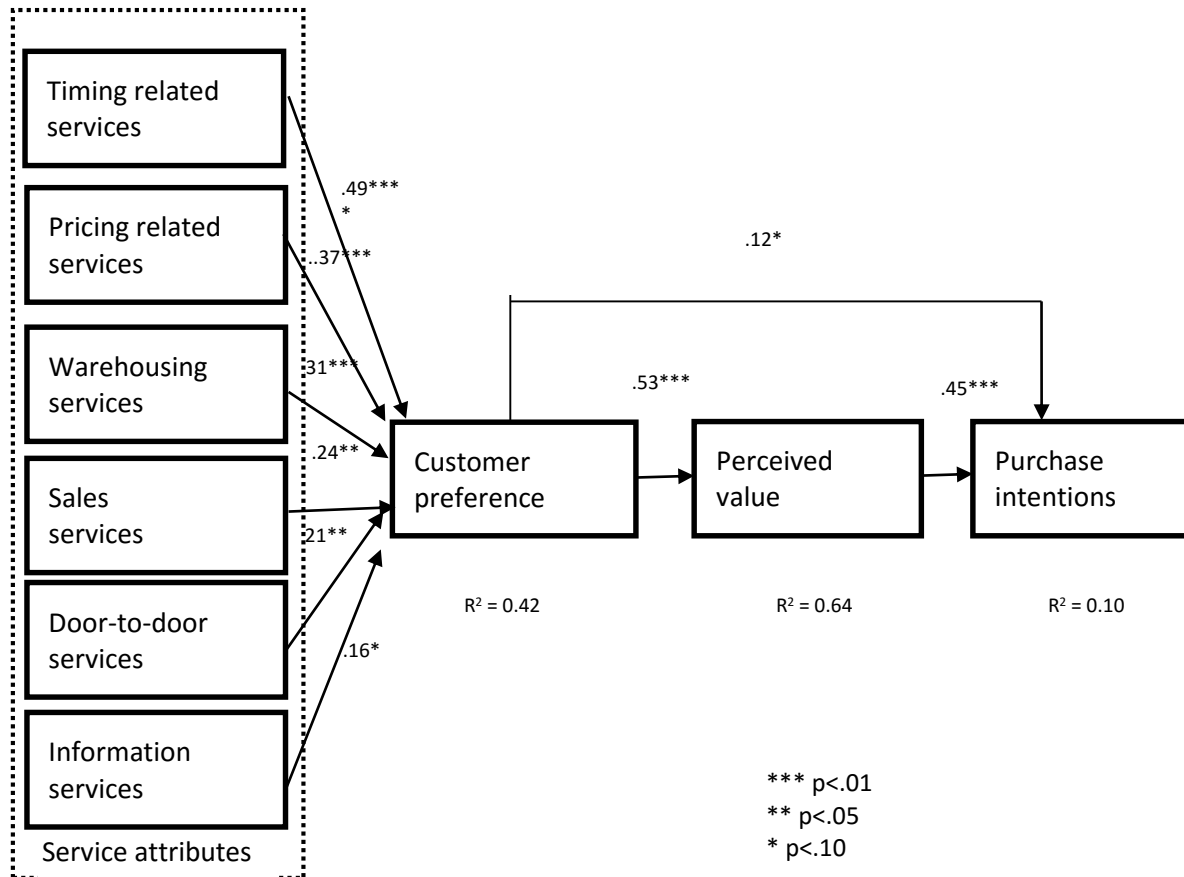
Figure 2 Model for SEM analysis

MEASURING MARITIME TRANSPORT CARBON FOOTPRINT: A VESSEL-RATING APPROACH

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ABSTRACT

Purpose of this paper
What are the reason(s) for writing the paper or the aims of the research?
This paper addresses the measurement of carbon footprint of maritime supply chains. The research is based on a real life case study with container import flows from a UK leader in retail distribution, and its logistics partners. The originality of this work is that it investigates two aspects of maritime carbon footprint: the evolution and diversity for emission factors data, the measurement at the vessel level and its general implications.

Design/methodology/approach
How are the objectives achieved? Include the main method(s) used for the research. What is the approach to the topic and what is the theoretical or subject scope of the paper?
Methodology is based on a case study, with some generalisation when possible. Authors used four emission factors sources: IMO (2009), RightShip (2013), Clean Cargo Working Group (2013), and UCL (2015). The latter was produced for the IMO 3rd GHG Study. Authors measure the impact of different data sources on total emissions and modal transfer decisions. Also, differently from other research works that focus either on ports & hinterland optimisation or vessel routing; this research focuses on purchase order postponing and/or re-routeing towards cleaner vessels, considering the vessel schedule as given.

Findings
What was found in the course of the work? This will refer to analysis, discussion, or results.
Research conclude that discrepancies between results could reach up to 69% depending on the data or methodology used. However this difference wouldn't have an impact on the modal choice decisions used for this case study. Authors illustrated situations where this would not be the case. Also, the purchase order re-routeing algorithm shows a potential reduction of carbon footprint in the sample of 13.6% (if using the same route) and 14.4% (if allowing alternative port of arrival in the UK). Study shows that in most cases the choice of the vessel had more significance than the choice of the arrival port in the UK. A mathematical relationship defining the payback distance where this assertion is valid has been developed and applied.

Value
What is new/original in the paper? State the value of the paper and to whom.

Traditionally, in the container sector, shippers do not focus on the vessel used for each voyage but on the best of the average fleet performance of the vessel company. This research shows the possibilities of making of such choice during the ordering process. Also the paper illustrates the intrinsic uncertainties on all CO2 measurements based on emission factors. Finally, it shows the impact of mixing CCWG, and IMO/EVDI data to benchmark a fleet performance.

Research limitations/implications
(if applicable): If research is reported on in the paper this section must be completed and should include suggestions for future research and any identified limitations in the research process.
The limitation of this work is that the emission factor used at the vessel level uses design data (EVDI) rather than actual marginal impact on the fuel consumption. Potentially the future MRE regulation could provide more accurate data. Another potential impact of a broader use of independent vessel-rating approach is that shipping companies would have a more direct motivation in using more energy efficient fleets.

Practical implications
(if applicable): What outcomes and implications for practice, applications and consequences are identified? Not all papers will have practical implications but most will. What changes to practice should be made as a result of this research/paper?
This research has considered the practical implications of implementing this ordering process as most of the data are already available in the current information systems. Also, in order to minimise the impact on inventory management, the re-routeing algorithm only modifies order dates within a range smaller or equal to a week.

INTRODUCTION
This paper addresses the measurement of the carbon footprint of maritime supply chains. The topic is analysed using a case study with data from a UK leader in retail distribution, and its logistics partners, which are logistics subsidiaries of two large shipping companies. The originality of this work is that it investigates two aspects regarding the measurement of maritime CO_2 emissions in this industry: the evolution and diversity of data sources; and the measurement of CO_2 emissions at the vessel level and its implications.
As part of the analysis of all the available dataset, this work looks at the implications of measuring maritime CO_2 at the vessel level instead of using values based on average vessel size or a shipping route. However, such data are only available from shipping companies' own data, so in order to provide an initial insight into the possibilities behind such measurements, the authors used EVDI data from RightShip's Existing Vessel Design Index (EVDI™)[1], a Greenhouse Gas (GHG) Emissions Rating system that addresses vessels currently in service (IMO, 2012). Unlike for EEDI, we are not aware of much independent research work that draws upon EVDI data as outlined in the review of relevant literature section of this paper.
This paper aims to provide a better understanding of the following four issues: First, the final discrepancies in CO_2 measures due to the use of different datasets and methods. Second, the potential impact on the transport mode decision for short shipping routes. The third issue this paper investigates is the interest or limitations of the freight forwarder fleet efficiency performance measurement in terms of emission factors. Finally, the fourth issue we aim to investigate, which is explained in more detail in the Research Work section, concerns the interest of managing flows taking into consideration a vessel's 'environmental quality'. In other words, whether it is 'worth' waiting for a cleaner vessel (resulting possibly in an alternative UK port of arrival) in order to reduce emissions.

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[1] EVDI™ addresses the vessels in service, while IMO's Energy Efficiency Design Index (EEDI) applies to new ships only. Website : site.rightship.com

Data availability and/or unavailability are considered as a given, representing real application conditions in business situations.

REVIEW OF RELEVANT LITERATURE

There is an extensive literature about carbon footprint mitigation in maritime supply chains. Some works address the problem looking at the ports and the hinterland. This is the case for Sanchez Rodrigues et al (2014, 2015) who analyse it for the UK, looking at the use of alternative ports and multimodal freight transport. They have defined five reference scenarios where alternative ports of arrival could be used and then used a Linear Programme that minimises the total TEU.km. Carbon footprint mitigation of maritime Supply Chains have also been recently analysed with the perspective of ports hinterland by Bouchery et Fransoo (2015). They showed that maximising modal shift with a given set of intermodal infrastructures is harmful from both emissions and cost perspectives. They also showed that, even though cost and CO_2 models share the same structure, the location of the intermodal terminal will differ depending on whether costs or emissions are being minimised.

There is also a good quantity of work that addresses the problem looking at the maritime side, which complements the hinterland view. An extensive literature review is provided by Mansouri et al (2015), where research work is grouped into three categories: A) Environmental Sustainability, B) Decision-Support Systems and C) Multi-Objective Optimisation. The authors go on to call for more research work that simultaneously covers these three categories.

Another comprehensive review is provided by Meng et al (2014) on liner shipping optimisation. The research community usually addresses the problem using vessel scheduling as a variable, whereas for us this will be a given and we will only work with a (rather limited) 'order rescheduling' variable. Meng et al (2014) also call, amongst other topics, for research with better benchmarks and unifying models, for green shipping and for models oriented to practical application.

Lun et al (2015) address the question of carbon mitigation in maritime supply chains by analysing the environmental governance mechanisms in shipping firms. They define three categories of governance mechanisms: contractual, relational and organisational. The study points out the difficulty to implement complete contracts between partners in a changing and uncertain environment.

DESCRIPTION OF THE PROBLEM

The case study

In 2012, the authors provided expertise to a major UK distributor to measure their maritime carbon footprint. The resulting work has been presented at an industry session of the Low Carbon Shipping conference, held in Newcastle. The activity analysed for this expertise covered the period from 2008 to 2011.

The logistic data from that period is still representative of today's distributor activity, with similar volumes, a significant part of maritime flows imported from Asia and other deep sea trade routes, a periodic replenishment and the use of 40-foot containers in the majority.

The flows analysed in this paper concern the import of non-food products shipped by containers, originating from 20 different countries, in the majority from the Far-East and the Indian sub-continent. Products were shipped mostly in standard 40-foot and high cube 40-foot containers, and a minority in 20-foot or 45-foot containers. Destination warehouses, the majority located in the UK, are shown in figure 1.

Figure 1: Destination warehouses (in red) and ports of arrival (in blue).

The transport is managed almost entirely by two logistics services providers called here freight managers. These freight managers are contract logistics and freight forwarding subsidiaries of two major container shipping companies. One of the freight managers shipped 43% of the containers, while the other one 57%.

Data were presented to researchers as a file of Purchase Orders (POs) from 2008 to 2011. Researchers selected a sample from October 2008 to October 2009 representing 97475 POs, 11385 containers and about 400 different vessels. The choice of this sample is due to the fact that for this period, the extracts contained information about the vessels' names, which wasn't the case for other periods. The PO dataset fields included, amongst others: container size, origin and destination ports, cubic meters shipped (CBM), dates of departure and arrival, vessel name, supplier location and final warehouse destination.

As usual in such large data files, some data cleansing was necessary, bringing the total scope analysed from 11385 to 10761 containers. In analysing the data set, for all Purchase Orders from file, we initially created a container Single Identification Number (SIN), which is the concatenation of the container number and the shipment date. This was necessary in order to distinguish containers making multiple voyages. Subsequently, the PO lines were consolidated by container-SIN and only 'SEA' shipment mode was selected. This process led to the initial total of 11385 containers. Of these, a number were excluded from the analysis for all containers-SIN as shown in Table 1:

Data cleansing process	nb of entries
Number of Purchase Orders	97 475
Number of container SIN*	11 385
Among those :	
… without vessel name	472
… with unkown destination port	11
… unable to identify vessel	49
… excluded from scope (minor routes)	92
Total containers in scope	**10 761**

Table 1: Data cleansing process

The data sources

Although the order rescheduling algorithm has been applied using EVDI™ data only, a range of possible results has been assessed using different data sources, in order to estimate the results' variability depending on the method used. The authors used emission factors from CCWG[2] (BSR, 2011), from the IMO 2009 GHG study (IMO, 2009), which uses a sample from 2007 shipping activity, and more recent emission factors provided by the UCL Energy Institute as a follow-up to the 3rd IMO GHG study (IMO, 2014; Smith et al., 2015), covering the period 2010-2012.

Road emissions have been calculated for the UK leg only. Defra emissions factors for 50% loaded articulated vehicles (>33T) have been used (Defra, 2011), which is consistent with a 7 tonnes per TEU assumption (IMO, 2009) and the average load of 1.8 TEU per shipment observed in our sample.

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[2] http://www.bsr.org/en/collaboration/groups/clean-cargo-working-group

RESEARCH WORK

The overall approach used to analyse this case study is shown in figure 2. Since we are working at the vessel level, a vessel database has been built, containing all information needed to define the emission factors. We can see from figure 2 that from the purchase order list and the maritime distances we assess the transport work in TEU.km, then we associate the appropriate emission factors and calculate the resulting CO_2 emissions. New shipping schedules and road emissions are calculated as required to answer the questions.
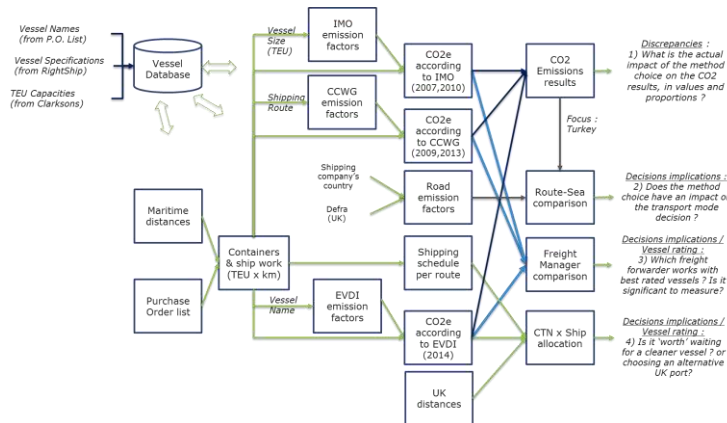
Figure 2: Data used, overall approach and questions addressed

Emissions are calculated by multiplying the emission factor with the distance and the amount of cargo. Similar approaches have been used in several previous works, including Rigot-Muller et al. (2012, 2013) and Gibbs et al. (2014). The generic formula can be expressed in the following form:

(1)   Emissions = EF x DISTANCE x CARGO.

Where,
- Emissions = Total CO_2 emissions associated with the cargo transported (expressed in gCO_2).
- EF = Emission Factor of the vessel used (expressed here in gCO_2/TEU.km).
- DISTANCE = Distance between the origin and destination ports (expressed in km).
- CARGO = Cargo quantity (in TEU, assessed from container size).

Allocation of containers to vessels: the rescheduling process

In this paper, we developed an algorithm to assess the potential interest of rescheduling containers into 'cleaner' vessels. Two possibilities have been analysed:
i.   The possibility to ship the container in the next vessel departing from the same origin port and to the same destination port.
ii. The possibility to ship the container in the next vessel departing from the same origin port towards the UK, either to the same port or an alternative one. When required, CO_2 emissions from the new road arrival route in the UK are then calculated to replace the previous arrival route. Overall emissions from the maritime leg and road leg in the UK are then compared.

The algorithm logic can be presented as follow:
- For every shipment, we identify the route (origin-destination), either port-to-port (i) or port-to-UK (ii).
- The algorithm finds the next departure for this same route, and measures either the new maritime emissions (in case i) or maritime + UK road emissions (in case ii) generated by this new shipment.
- If the next departure has a better carbon footprint, it is 'flagged' as a valid alternative, and the algorithm saves the CO_2 reduction.
    o If a shipment is the last one of the data sample for a specific route, the simulation programme doesn't offer any possible alternative shipment.

-   At the end of the process, the user selects the maximum number of days of delay s/he can accept in order to assess the potential emissions reduction.

The algorithm has been implemented with an Excel-VBA programme.

Assessment of alternative vessel solution

The algorithm for container-to-vessels allocation described previously calculates carbon emissions using the formula (1), with the values corresponding to the actual container sizes, vessel specifications and port-to-port or port-to-warehouse distances of each shipment.

The results are obviously valid only for the current case study, so a more generic analysis of the results is also realised using the following approach:
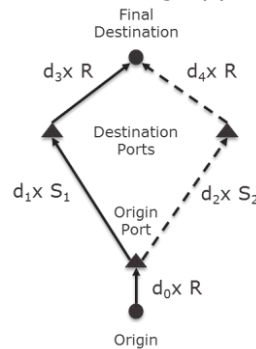
Figure 3: Representation of alternative vessel route, with emission factors R, S_1 and S_2

The proposed analysis aims to verify under which conditions, for a shipment in a vessel with emission factor S_1, the alternative route using a vessel with emission factor $S_2 < S_1$ but with longer journeys $d_2 > d_1$ and $d_4 > d_3$ will be, overall, more efficient from an emissions perspective than the original shipment.

In other words, under which conditions we have:

(2) $S_2 . d_2 + R . d_4 < S_1 . d_1 + R . d_3$

Where

- d_i = distances, as shown in figure 3 ;
- R = road transport emission factor ;
- S_i = shipping transport emission factors, as shown in figure 3;
- $S_2 < S_1$; $d_2 > d_1$ and $d_4 > d_3$.

If we define the following notations:

- $S_2 = K.S_1$,with $0 < K < 1$; where K represents the emission factor performance ratio between the two vessels;
- $d_1 = d_s$ ('s' for sea);
- $d_3 = d_r$ ('r' for road);
- $d_2 = d_s + \delta d_s$, where $\delta d_s > 0$ represents the extra maritime distance of the alternative route;
- $d_4 = d_r + \delta d_s$, where $\delta d_r > 0$ represents the extra road distance of the alternative route.

We can then write equation (2) as:

(3) $K.S_1 . (d_s + \delta d_s) + R . (d_r + \delta d_r) < S_1 . d_s + R . d_r$

And finally:

(4) $d_s > \frac{1}{1-K} \left(\frac{R}{S_1} . \delta d_r + K . \delta d_s \right)$

We define the minimum value d_s respecting equation (4) as the "payback distance", which is the distance from which it is more effective to use the longer route $d_2 > d_1$ in a more efficient vessel with $S_2 < S_1$.

RESULTS AND ANALYSIS

Results from the analysis by data sources suggest that differences can be quite significant, with a range of 59%, depending on the data source or method selected. As expected, we find, as in Smith et al (2015), a significant difference between their results

(under "UCL" label here) and the ones from the 2009 GHG Study. EVDI results are in the lower range of the results, and CCWG data, with load factors, are the highest ones. Analysis of freight managers' fleet efficiency illustrates the importance of CCWG as a benchmark when analysing multiple/mixed flows: when looking at EVDI, IMO or UCL data only, the results seem inconclusive, but compared to the global CCWG fleet, we see that FM1 is actually operating in routes where average efficiency is lower than those where FM2 is operating.

Absolute values analysis

Total emissions, using…	Tonnes of CO2	Ratio
UCL (2015: 2010)	19 027	100%
EVDI (2014: N/A)	21 496	113%
CCWG (2014: 2009)	22 609	119%
IMO (2009: 2007)	29 012	152%
CCWG (2014 : 2009 load factor 2012/2013)	30 308	159%

Comparative Analysis : Average E.F.

Average E.F. in gCO2/TEU.km	EVDI	CCWG	CCWG + LF	IMO	UCL
Freight Manager 1	74.21	76.03	102.68	102.41	64.17
Freight Manager 2	73.01	69.24	93.27	104.92	67.34
Difference : (FM2-FM1)/FM1	-2%	-9%	-9%	2%	5%

Table 2: Total carbon footprint and Freight Managers fleet efficiency according to different data sources and methods

As we illustrated in Figure 4, the difference between vessels' emission factors for the same route can represent up to 25 gCO_2/TEU.km. An analysis of the dataset shows that a typical S/R ratio - as defined in (2) - can easily reach the 0.2-0.3 range for low performing vessels. The research showed that overall, decisions of modal transfer "road towards sea" for UK import flows remained robust for origins such as Porto or Istanbul (included in the case study), but not for Zürich.
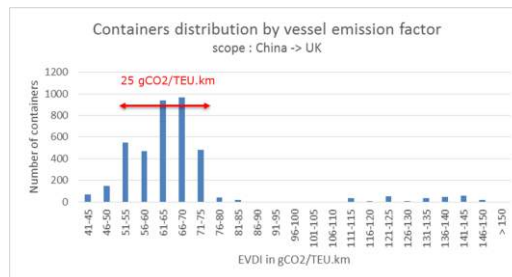
Figure 4: Containers distribution by vessel emission factor, scope China →UK

Rescheduling to next vessel in the same port-to-port route

In this section we analyse the potential interest of dynamic shipment management, based on the vessel performance. The analysis of the potential CO_2 savings with an allocation in the next cleaner vessel is illustrated in Figure 5. We can see that, of all containers in the dataset, 37% have the possibility to be shipped in an upcoming vessel with a better emission factor. Then, if we consider only 'realistic' options, i.e., vessels arriving at the latest in the next week, we can see that the carbon footprint measured could be reduced by 866 Tonnes of CO_2, representing a 13.6% reduction from the containers concerned, and 4.0% reduction from all containers shipped.

Next vessel has…	Containers	%
Better emission factor	3 907	37%
Worse or equal	6 556	63%
Total containers	**10 463**	**100%**

waiting up to 7 days

Algorithm result	Tonnes CO2	%
CO2 reduction	866	
…from sample	6 378	13.6%
…from total	21 513	4.0%
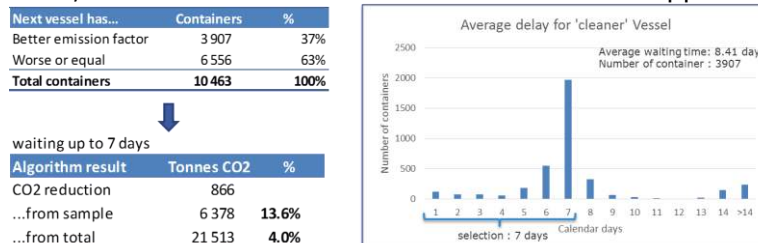
Figure 5: Carbon footprint potential reduction, using a delay up to 7 calendar days

Rescheduling to next vessel in the same port-to-UK route

When we look at the results obtained for all possible routes towards the UK only, including the use of alternative arrival ports in the UK, it results in a potential reduction of 853 tonnes of CO_2 in the carbon footprint measure, representing an average reduction of 14.4% for the containers concerned and 4.0% if we look at all eligible containers. The average waiting time is reduced to 5.76 days.

Also, it appears from this simulation that overall, the arrival port choice in the UK has less influence than the choice of the vessel itself, considering of course, that all other parameters remain unchanged. Indeed, from the 9262 containers in the sample for this analysis it was possible to find 799 cases where both road and shipping emissions could be reduced, 2650 where only shipping emissions could be reduced, and 1572 where only road emissions could be reduced. In the other 4241 cases, the next shipment provided worse road and maritime emissions. Among the containers, those with a better shipping option have 94% chances of success even if the road option was worse or equal. Alternatively, those with a worse or equal shipping alternative, had only a 14% chance of a reduction in total carbon footprint.

This result is obviously valid for the current case study only, even though the highly 'common' profile of our data suggest that for similar activities, similar results may also occur: in other words, the choice of the vessel may be more important than the arrival port. A way to analyse this problem with a more generic approach is to use formula (4). As a reminder, we define the "payback distance" as the distance from where is it worth using a cleaner vessel (since longer origin distances will allow the most efficient vessel to ensure the payback). We can see from (4), using the case of flows arriving into the English Channel from the Atlantic, with Southampton and Felixstowe as port arrival options, and using a conservative ratio R/S = 5, that for a 'reasonable' ratio K=0.80 between vessels emission factors, we have:

- for a warehouse located in Leicester (with very small $\delta dr \approx$ 2km and $\delta ds \approx$ 288km) the choice of the vessel becomes significant from ds = 1202 km;
- for a warehouse located in Southampton (theoretical worst-case scenario with $\delta dr \approx \delta ds \approx$ 288km) the choice of the vessel becomes significant from ds = 8352 km.

	Southampton	Leicester
K	ds (km)	ds (km)
0.99	172 512	29 512
0.95	34 272	5 672
0.90	16 992	2 692
0.85	11 232	1 699
0.80	8 352	1 202
0.75	6 624	904
0.70	5 472	705
0.65	4 649	563
0.60	4 032	457
0.55	3 552	374
0.50	3 168	308
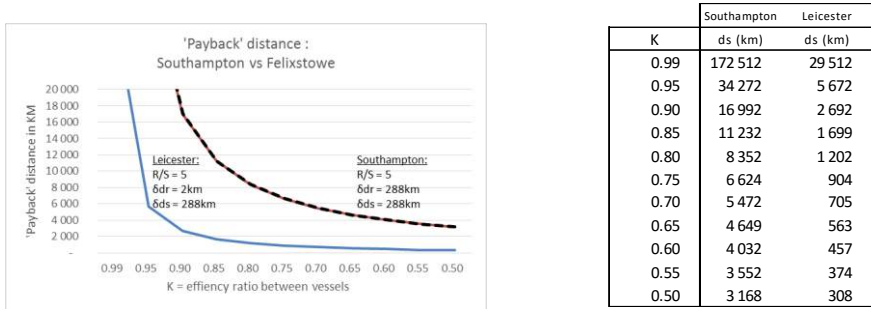
Figure 6: Payback distance, based on efficiency ratio between vessels

The theoretical approach illustrated in figure 6 corroborates our case study, where we see:

- From figure 1, that the warehouses are located in areas with small δdr ;
- From figure 4, that the K ratio - in equation (3) - can be significant ;
- From the case description, that most flows come from distant countries (high d_s).

This suggests that in general, the origin distance d_s is higher than the payback distance, hence that there is a possibility to reduce emissions by selecting better vessels independent of the port of arrival in the UK.

DISCUSSION AND CONLCUSIONS
Our research concludes that discrepancies between results could reach up to 59% depending on the data or methodology used. The magnitude of this discrepancy should encourage a closer cooperation between researchers in order to analyse methodologies and define where discrepancies appear. The container re-routeing algorithm shows a potential reduction of carbon footprint in the sample of 13.6% (if using the same route) and 14.4% (if allowing alternative port of arrival in the UK). Our study shows that in most cases the choice of the vessel had more significance than the choice of the arrival port in the UK. A mathematical relationship defining the payback distance where this assertion is valid has been developed and applied.

It is important to note that with this method, only further shipments actually used by the distributor are considered. Other ship departures that could have happened (from the

same or other shipping companies) are not considered due to the lack of information. From this perspective, therefore, the results we find are a lower estimate of what could be achieved.

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Section 5: Transport and distribution

OPTIMAL DELIVERY POSTPONEMENT STRATEGIES IN DEADLINE ORIENTED LAST-MILE LOGISTICS

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Abstract

Purpose of this paper:
Delivery time guarantee has become a common marketing strategy for retailers. For example, Amazon offers "Get it Today" to its customers when they place their orders by a certain cutoff time. While offering a guaranteed delivery requires an immediate shipment, offering such service must be tempered by the need to provide service at low cost. Postponing the truck dispatch allows shipment consolidation across time which leads to a lower delivery cost due to economies of scale; however, longer distances traveled and compensations are often results of late dispatches. In this paper, we address the "postponement problem," in which marketing and operational decisions are linked.

Design/methodology/approach:
We consider systems in which a continuous flow of customer orders having a certain deadline is accumulated and dispatched together. We develop analytical models to determine optimal timing of shipments for retailers which perform last-mile deliveries in deadline-oriented environments. We also simulated a set of deadline oriented last-mile logistics systems to assess how much our approximations and the overall cost vary from the solution in which the truck follows an optimal route.

Findings:
Computational results reveal a substantial cost saving of about 18.7%, in addition to 16.8%, and 7% improvement in the service level and truck utilization, as a consequence of implementing the optimal postponement strategy compared to intuitive policies.

Value:
To the best of our knowledge, the present paper is the first to address the time based shipment consolidation strategy in a deadline oriented environment.

Research limitations/implications (if applicable):
Our models determine the best postponement strategy by finding the optimal dispatching times for a given set of cost and other operating parameters; however, they only consider a single truck serving the service area. That is, how to model problems with multiple delivery trucks in the same service area remains as a future extension.

Practical implications (if applicable):
For retailers which perform their last-mile deliveries against a daily deadline, postponing truck dispatching times is critical. Because the cost associated with transportation, lost sales and late deliveries can be expressed as a function of dispatching times, it directly determines the success of business. Although intuition might suggest that finding the optimal timing of a single dispatch is straightforward, we showed that it requires substantial effort, due to the non-convexity of the objective function. Nevertheless, we have derived closed form expressions of the optimal timing of a single dispatch by taking the advantage of objective function's piecewise structure.

1. INTRODUCTION

Development of e-commerce transactions (e.g., business-to-business and business-to-consumer) has enabled customers to choose from a wide range of products, save shopping time and cost, and more importantly to get their orders when they want and at their convenience. For example, a recent study has shown that customers in major U.S. cities are willing to pay for the same-day delivery (Figure 1).
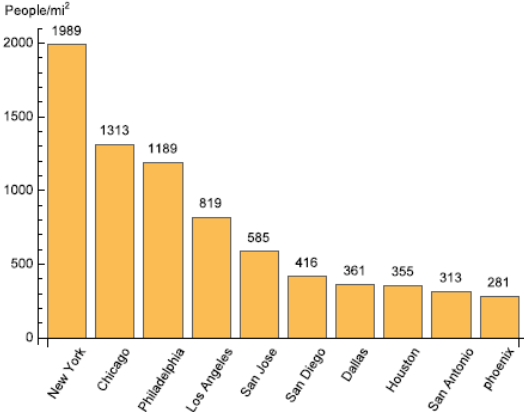
Figure 1. People/mile^2 who says they would pay for same-day delivery (Halpin 2015).

To reach remotely located customers and respond to their demands in a timely manner, retailers (and the third party logistics service providers) have been moving their distribution facilities relatively close to the area that they serve. DCs closer to the delivery region shorten the delivery time by moving the final fulfillment step to the well-known "last-mile" stage. Because last-mile logistics requires economies of scale to be broken down, it implies a high level of operational complexity, directly affecting the success of business. In outbound logistics, this complexity is mainly a result of consolidating customer orders within the same delivery region to achieve efficiency and low cost in distribution, while decreasing the likelihood of on-time deliveries. Late deliveries can be compensated to maintain customer satisfaction; however, lost sales (in the case of retailer's unavailability to respond the demand) and transportation cost should also be considered to maintain the efficiency in last-mile operations.

The last-mile delivery can be very costly and volatile for at least two reasons: (1) the need for minimizing lost sales due to late deliveries may lead to a greater proportion of less-than-truck (LTL) shipments and, (2) locations of customers may require longer miles traveled. The latter can be reduced by optimizing delivery schedules (i.e., routes); however, the cost of empty (or LTL) truck-miles can only be reduced by improving the "hit density," which corresponds to the average time between deliveries to customer locations on the outbound route (Wulfraat 2013). The hit density can be improved by consolidating as many customer orders as possible and taking the advantage of lower transportation charges that come from larger load sizes (Hall 1987). Consequently, postponing the dispatching time of delivery trucks as late as possible is at the very heart of improving hit density, but also means that some orders will have to wait longer until they are transported and longer routes due to the increased the number of stops. To illuminate the tradeoff between longer waiting times and hit density, we present an example illustrated in Figure 2.
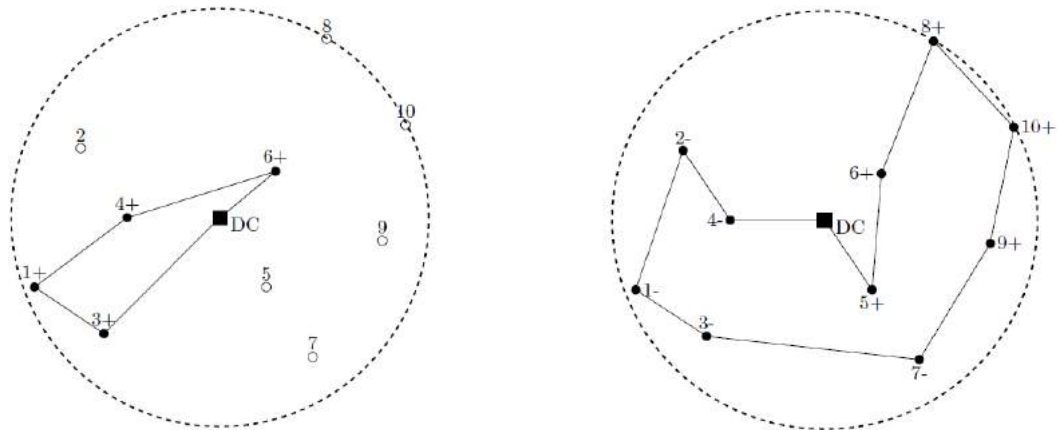
(a) Realization and on-time delivery status at time t_1.

(b) Realization and on-time delivery status at time t_2.

Figure 2. Customer locations are shown as circles. Orders realized (nodes) and delivered by the deadline are marked with "+" sign (and with "-" sign if they are realized but not-yet-delivered by the deadline).

Consider a group of uniformly dispersed customers in a geographical region and the retailer ships the orders from a single DC. The geographical region (hereafter, we use "service area") may refer to a cluster of customers which are in close proximity or having same deadline requirement. Although multiple trucks can be dispatched from the DC to make deliveries to the same service area, we assume each service area is served by a single truck.

Customers place their orders at random times throughout the day. We assume a common same-day delivery deadline TD for all customers in the service area, and set it to the end of day with no loss of generality. (That is, we set $T_D = 1$.) Examples of such systems include retailers offering guaranteed same-day deliveries and the next-day delivery providers such as FedEx and UPS (see Chatterjee et al. (2002) and Campbell and Thomas (2008) for more examples). Although an immediate shipping would increase the chance of delivery by the deadline, a later truck dispatching time would allow the DC to consolidate more orders in a larger load and thus achieve economies of scale in transportation.

In Figure 2a, four customers have placed their orders by time t_1 (customers 1, 3, 4 and 6). At this time instant, the shortest distance connecting those customers can be determined by solving the corresponding traveling salesman problem (TSP). The path given in Figure 2a shows the shortest path. If the delivery truck is dispatched at this time, then 40% of all customers would be delivered on-time. Customers whose orders are delivered by the deadline are shown by "+" (otherwise "-") signs. Because only a subset of all customer orders is realized at t_1, the solution of the TSP must be updated as new customers are observed. If the truck is dispatched at time t_2, an additional 10% of success in on-time deliveries would be achieved with a different TSP solution (Figure 2b). That is, realization of each order leads to a different delivery route and the solutions can only be used after a postponement decision. Therefore, the solutions cannot be used to determine the optimal timing of a truck dispatch; whereas they affect the success of deliveries and must somehow be considered in deciding the optimal dispatching time. What is the optimal time to dispatch the truck and, how much does a later dispatching time affect the operational costs and the service provided in return? How does the truck capacity or truck speed would affect the timing of dispatches? Because the presence of customers is uncertain (e.g., the next customer location can be close to or far from the existing route of delivery, or even may not be realized), the answers depend on how long to wait before dispatching the truck.

In this paper, we address the "postponement problem," in which marketing and operational decisions are linked. An aggressive marketing strategy requires offering the latest cutoff time to the customers, thus dispatching the truck as late as possible; while increasing the cost of transportation and late deliveries. The main contributions of our paper may be summarized as follows: (1) we provide models that jointly capture three cost elements in deadline oriented delivery systems: costs of transportation, lost sales, and the late deliveries. We accomplish this by defining each cost as a function of dispatching times. (2) We obtain a closed-form solution for the optimal dispatching time when there is a single dispatch. This enables us to provide interesting insights on the behavior of the optimal dispatching times with changes in problem parameters (e.g., service area, customer density, delivery speed).

2. RELEVANT LITERATURE

Research into methods for determining the timing of truck dispatches can be classified into three groups: deterministic, dynamic, and stochastic. Studies by Blumenfeld et al. (1985) and Hall (1987) are two most relevant work to our study which present models to determine the timing of dispatches when customer demand is deterministic. Postponement decisions can also be made each time a customer order arrives (Abdelwahab and Sargious 1990). Although dynamic policies are effective in maximizing the truckload, resulting delivery schedules change as new orders arrive. Consequently, stochastic approaches are proposed to determine the timing of dispatches in the presence of random customer order arrivals. Zinn (1988) conducted a simulation study to analyze when the postponement strategy is justified by considering uncertainty in demand and price of products. Brennan (1981), Bookbinder and Higginson (2002), and Cetinkaya and Bookbinder (2003) studied a probabilistic (a renewal process) model to choose the maximum holding time and the desired dispatch quantity. Minkoff (1993) and Higginson and Bookbinder (1995) used Markov decision process to address dispatching quantity policy.

We consider systems in which a continuous flow of customer orders having a certain deadline is accumulated and dispatched together. Cetinkaya and Lee (2000) addressed a joint replenishment cycle and quantity for a vendor managed inventory system in which there is no deadline requirement but the cost associated with customer waiting time in each cycle was considered in the cost function. Different then our model, the expected cost function was assumed to be linear because there is no deadline and the lost sales due to early dispatches were not considered. Further, expected transportation cost was not considered, whereas the locations of customers can also affect the lead time, thus the replenishment cycle. Existing literature focuses on the traditional metrics, such as maximum and average order delay. Cetinkaya et al. (2014) derive expected waiting times for time and quantity based shipment consolidation policies and compare them. Gupta and Bagchi (1987) used a stochastic clearing system to determine the dispatch quantity which is similar to our work; however, there is no consideration of delivery deadlines.

In all the literature just discussed, time based consolidation strategies are only considered for systems with no deadline requirement. To the best of our knowledge, the present paper is the first to address the time based shipment consolidation strategy in a deadline oriented environment. The main contribution of this paper is the models determining optimal dispatching times for retailers which operate against daily time guaranteed deliveries.

3. PROBLEM CONTEXT & THE MODEL

3.1. Problem Context

Consider a retailer which offers same day delivery to its customers and performs the last-mile delivery. Total cost of a delivery has three components: transportation cost, cost of unserved customers whose orders arrive after the dispatching time (i.e., lost sales), and the cost of late deliveries.

Transportation cost includes the fixed cost of a dispatched truck and the transportation cost due to visiting customer locations, which depends on the number of customers to be visited. We assume the customer orders arrive according to a Poisson process with a rate λ per unit time and the expected number of orders accumulated within a time interval t is equal to λt.

It is worth noting that calculating the number of orders is straightforward; however, the locations of customers are not known beforehand. Consequently, the shortest route length (and time) cannot be calculated before t, but can be approximated. For a closed service area A, Daganzo (1984) and Burns et al. (1985) approximate the shortest path connecting m randomly located nodes as $K\sqrt{Am}$, where K is a constant approximately equal to 0.75 for the Euclidean distance (Hall 1993). Considering the fixed cost of a dispatch c_f and the traveling cost per mile by c_v, the expected transportation cost of delivering λt customer orders using the shortest path is given by

$$C_1(t) = c_f + c_v K \sqrt{A\lambda t}.$$

The retailer ships orders to all customers who are present at the time of dispatch. For a single dispatch per day, then the expected truck load will be λt. Then, $\lambda(1-t)$ customers will not be served within the current day. Because of the deadline, each customer order that is not included in the truck load implies a lost sale. Denoting the cost of a lost sale by c_u, the total cost of lost sales

$$C_2(t) = c_u \lambda (1 - t).$$

Although postponing the dispatching time decreases the cost of lost sales, complaints and compensations due to late deliveries are often the results. A late delivery cost c_ℓ incurs if an order is included in the departing truck's load but delivered after its deadline. Considering the early completion of a delivery tour and using triangular similarity to calculate the number of late deliveries, expected cost of late deliveries at the deadline

$$C_3(t) = \max\left\{ c_\ell \lambda t \left(1 - \frac{v(1-t)}{K\sqrt{A\lambda t}} \right), 0 \right\},$$

where v is the speed of the truck.

3.2.   The model

Our objective is to find the optimal dispatching time which minimizes the expected overall cost which is equal to the sum of transportation cost, cost of lost sales and the late delivery cost, i.e., $C(t) = C_1(t) + C_2(t) + C_3(t)$. It is worth to note that $C(t)$ is a nonlinear, piecewise function of the truck dispatching time t . Before deriving expressions of the optimal dispatching time t^*, we require two necessary conditions. First, a dispatching decision within a single day requires $0 \leq t \leq 1$. Second, a feasible solution requires the truck to be present at the DC by the next dispatching time instant. When there is a single dispatch per day, the time between two consecutive dispatches is equal to one day. Consequently, the time required to deliver all customer orders, which are included in the truck's load, should be less than one. That is, $t \leq v^2/(A\lambda K^2)$ (we set $t_0 = v^2/(A\lambda K^2)$). Combining these two necessary conditions, the optimization problem is given by

$$\min C(t); s.t. \ 0 \leq t \leq \min(1, t_0).$$

Although dispatching time t is the only decision variable in the above problem, deriving a closed form solution requires some effort due to the nonlinearity of the objective function. Nevertheless, $C(t)$ is a piecewise function due to $C_3(t)$ and thereby can be examined in two pieces.

<u>Case 1:</u> The delivery tour is completed by the deadline, i.e. $t + \left(\frac{K}{v}\right)\sqrt{A \lambda t} \le 1$. Solving for t for its positive values gives

$$t_1 = \frac{K(A\lambda K - \sqrt{A\lambda}\sqrt{4v^2 + AK^2 v})}{2v^2}.$$

That is, when $t \le t_1$, the delivery tour is completed before the deadline and the resulting objective function $C(t) = C_1(t) + C_2(t)$. The second order derivative implies $C(t)$ is a concave function for the interval $0 \le t \le t_1$ with a minimizer of zero, t_0 or t_1. Otherwise, consider

<u>Case 2:</u> The delivery tour is completed after the deadline. In this case, $t_1 \le t \le 1$ and consequently $C_3(t) = c_\ell \lambda t \left(\frac{v(1-t)}{K\sqrt{A \lambda t}}\right)$. Then the second order derivative implies $C(t)$ is convex if $t > \frac{1}{3}\left(\frac{c_v A K^2}{c_\ell v} - 1\right)$. That is $C(t)$ is concave in both $0 \le t \le 1$ when $\frac{c_\ell}{c_v} \times \frac{v}{A} \le K^2$ and the minimizer of $C(t)$ is zero, t_1, or one. If this inequality does not hold, then the function is convex in the first part but depends on the dominance of $C_3(t)$ over $C_1(t) + C_2(t)$. Setting the first order derivative of $\frac{dC(t)}{d(t)} = 0$ and solving for t, we have

$$t_2 = \frac{c_\ell^2(2A\lambda K^2 + 3v^2) - Ac_\ell K^2(4c_u\lambda + 3\,\alpha v) + 2M}{9c_\ell v^2},$$

where $M = \sqrt{A\,\lambda K^2\left(c_{\ell-c_u}\right)^2\left(c_\ell^2(A\lambda K^2 + 3v^2) - Ac_u K^2(2c_\ell\lambda + 3\,\alpha v) + A\,c_u^2\lambda K^2\right) - Ac_u^2\lambda K^2}$. If $t_2 \le t_1$, then the function is increasing in $t_1 \le t \le 1$ and $t^* = argminC(t; t \in \{0, t_0, t_1\})$, otherwise $t^* = argminC(t; t \in \{0, t_0, t_2\})$.

4. ANALYSIS & JUSTIFICATION

4.1. Analysis

Certain data have been adopted from a retailer performing the last-mile delivery and offering guaranteed delivery to its customers in larger Los Angeles area (Wulfraat 2013). We set c_v =\$1 per mile and c_f =\$25 per dispatch as constants and vary other parameters, namely:

- Service area. A circular service area A is defined as $A \in \{\pi, 3\pi\}\,mi^2$ with a DC located at the center.
- Customer locations. For each of the service area, customer locations are distributed uniformly. The number of customers per day λ is varied between 100 to 1000 with increments of 100.
- Cost distribution. The unit and lateness costs are generated relative to the cost per mile. That is, the cost of an unserved customer was defined as $c_u \in \{0.5, 1, 1.5\}$ and the lateness cost c_ℓ was set to $c_\ell \in c_v \times \{0.33, 0.66, 1, 1.33, 1.66\}$.
- Delivery speed. In most urban areas, the maximum speed limit is 30 mi/h, but slower speeds are often results of congestions. Consequently, we set the speed of the delivery truck at three levels, $v \in \{6, 18, 30\}\,mi/h$.

The combination of all different configurations explained above resulted in 900 instances. For each instance, we apply the procedure give in the previous section to determine the optimal dispatching time. Table 1 shows the optimal dispatching times when the service area $A = \pi\,mi^2$.

<p style="text-align:center">Table 1. Optimal truck dispatching times for a service area $A = \pi$ mi².</p>

$A=\pi(mi^2)$	$c_u=0.5c_v$														
	$c_\ell=0.33c_v$			$c_\ell=0.66c_v$			$c_\ell=c_v$			$c_\ell=1.33c_v$			$c_\ell=1.66c_v$		
λ	v=6	v=18	v=30	v=6	v=18	v=30	v=6	v=18	v=30	v=6	v=18	v=30	v=6	v=18	v=30
100	0.46	0.64	0.77	0.29	0.64	0.77	0.29	0.64	0.77	0.29	0.64	0.77	0.29	0.64	0.77
200	0.28	0.54	0.69	0.19	0.54	0.69	0.19	0.54	0.69	0.19	0.54	0.69	0.19	0.54	0.69
300	0.19	0.47	0.63	0.14	0.47	0.63	0.14	0.47	0.63	0.14	0.47	0.63	0.14	0.47	0.63
400	0.14	0.48	0.59	0.11	0.42	0.59	0.11	0.42	0.59	0.11	0.42	0.59	0.11	0.42	0.59
500	0.11	0.51	0.56	0.09	0.39	0.56	0.09	0.39	0.56	0.09	0.39	0.56	0.09	0.39	0.56
600	0.10	0.54	0.53	0.09	0.35	0.53	0.08	0.35	0.53	0.08	0.35	0.53	0.08	0.35	0.53
700	0.08	0.57	0.50	0.08	0.33	0.50	0.07	0.33	0.50	0.07	0.33	0.50	0.07	0.33	0.50
800	0.07	0.6	0.48	0.07	0.31	0.8	0.06	0.31	0.48	0.06	0.31	0.48	0.06	0.31	0.48
900	0.06	0.57	0.48	0.06	0.29	0.46	0.06	0.29	0.46	0.06	0.29	0.46	0.06	0.29	0.46
1000	0.06	0.51	0.50	0.06	0.27	0.44	0.05	0.27	0.44	0.05	0.27	0.44	0.05	0.27	0.44
λ	$c_u=c_v$														
100	0.57	0.8	0.77	0.57	0.64	0.77	0.29	0.64	0.77	0.29	0.64	0.77	0.29	0.64	0.77
200	0.28	1	0.72	0.28	0.54	0.69	0.27	0.54	0.69	0.19	0.54	0.69	0.19	0.54	0.69
300	0.19	1	0.87	0.19	0.48	0.63	0.19	0.47	0.63	0.14	0.47	0.63	0.14	0.47	0.63
400	0.14	1	1	0.14	0.52	0.59	0.14	0.42	0.59	0.13	0.42	0.59	0.11	0.42	0.59
500	0.11	1	1	0.11	0.55	0.56	0.11	0.39	0.56	0.11	0.39	0.56	0.09	0.39	0.56
600	0.10	0.85	1	0.09	0.58	0.53	0.09	0.35	0.53	0.09	0.35	0.53	0.08	0.35	0.53
700	0.08	0.73	1	0.08	0.61	0.50	0.08	0.33	0.50	0.08	0.33	0.50	0.07	0.33	0.50
800	0.07	0.64	1	0.07	0.64	0.49	0.07	0.31	0.48	0.07	0.31	0.48	0.06	0.31	0.48
900	0.06	0.57	1	0.06	0.57	0.5	0.06	0.31	0.46	0.06	0.29	0.46	0.06	0.29	0.46
1000	0.06	0.51	1	0.06	0.51	0.52	0.06	0.31	0.44	0.06	0.27	0.44	0.05	0.27	0.44
λ	$c_u=1.5c_v$														
100	0.57	1	0.88	0.57	0.64	0.77	0.57	0.64	0.77	0.36	0.64	0.77	0.29	0.64	0.77
200	0.28	1	1	0.28	0.76	0.69	0.28	0.54	0.69	0.28	0.54	0.69	0.24	0.54	0.69
300	0.19	1	1	0.19	0.92	0.63	0.19	0.49	0.63	0.19	0.47	0.63	0.19	0.47	0.63
400	0.14	1	1	0.14	1	0.68	0.14	0.53	0.59	0.14	0.42	0.59	0.14	0.42	0.59
500	0.11	1	1	0.11	1	0.74	0.11	0.56	0.56	0.11	0.39	0.56	0.11	0.39	0.56
600	0.10	0.85	1	0.09	0.85	0.8	0.09	0.59	0.53	0.09	0.37	0.53	0.09	0.35	0.53
700	0.08	0.73	1	0.08	0.73	0.86	0.08	0.62	0.50	0.08	0.38	0.50	0.08	0.33	0.50
800	0.07	0.64	1	0.07	0.64	0.92	0.07	0.64	0.5	0.07	0.38	0.48	0.07	0.31	0.48
900	0.06	0.57	1	0.06	0.57	0.97	0.06	0.57	0.51	0.06	0.39	0.46	0.06	0.29	0.46
1000	0.06	0.51	1	0.06	0.51	1	0.06	0.51	0.52	0.06	0.39	0.44	0.06	0.27	0.44

Do solutions always suggest earlier dispatches if the truck can deliver faster? The results suggest, no. To show this, we plot the results for $c_u = 0.5\,c_v$ and $c_\ell = 0.33\,c_v$ when $v = 18$ and $v = 30\ mi/h$ (corresponding to the top-left results in Table 1) in Figure 2.
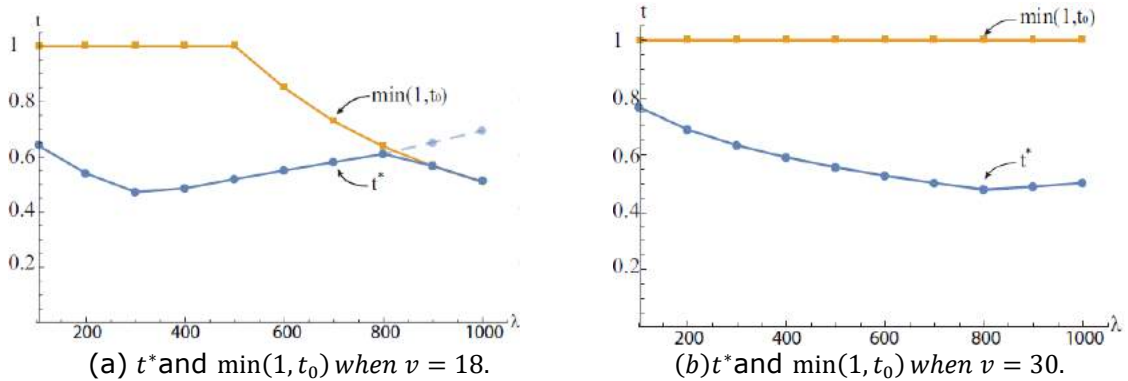
<p style="text-align:center">(a) t^* and $\min(1, t_0)$ when $v = 18$. (b) t^* and $\min(1, t_0)$ when $v = 30$.
Figure 2 .The solutions suggest first earlier and then later dispatching times as the number of customers increases, given that $t^* \le \min(1, t_0)$.</p>

How much do the unit lateness and the lost sale cost affect the timing of a dispatch? We observe that the results suggest a later dispatch -to include more orders in the truck load, as a result of an increase in the lost sales cost and confirm the intuition. Further, as unit lateness cost increases, the truck dispatching time should be postponed.

4.2.   Justification

The model assumes uniformly distributed customer locations over a given circular service area A That is, the shortest time for a delivery route cannot be determined before the time of a dispatch and therefore we use our result to approximate the expected time. How

much accurate is this approximation and how much does the overall cost vary from the solution in which the truck follows an optimal route? To answer these questions, we simulated a set of deadline oriented last-mile logistics systems. Common to all systems, the DC was located at the center of service region (i.e. $(x_i, y_i) = (0, 0)$) and the locations of customers were uniformly distributed. At the time of a dispatch, the simulation model generated the number of customers (assuming a Poisson process). Once the number and the locations were determined, we determined the optimal route solving the corresponding TSP problem. For each run, we compare the average simulated overall cost, which is associated with the shortest routing, with the expected overall cost approximated by the analytical model. Runs last 30 simulated days with 30 replications. Figure 3 shows the results where horizontal axes show the number of customers per day within a range of (10, 1000), and the vertical axes correspond to the percentage deviation of the expected overall cost, which is suggested by the model, from the simulated overall cost.
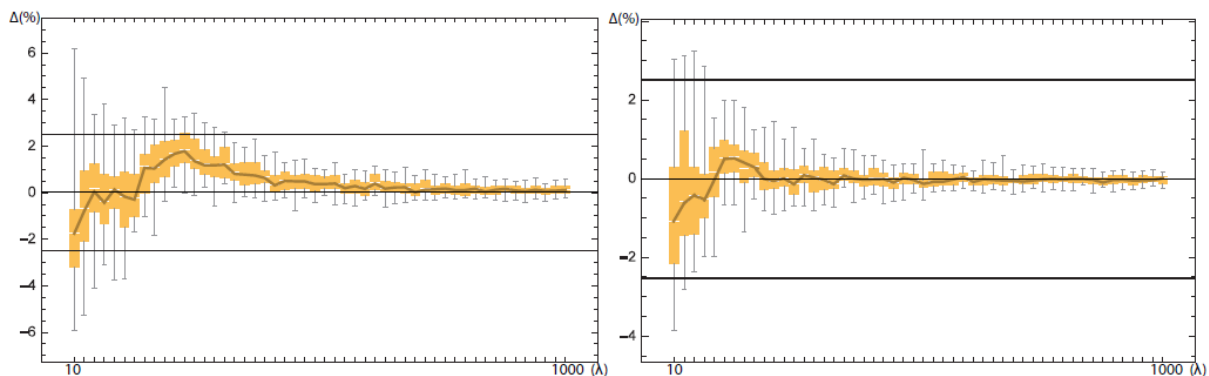
Figure 2 . Percentage deviation from the simulated overall cost (on the left: $A = \pi, v = 18$; on the right: $A = 3\pi, v = 18$).

Results of each replication are shown with a box plot and connected through their means for each λ value. We observe that the expected cost deviates within 2.5% of the simulated cost (within the dashed lines).

5. CONCLUSIONS

For retailers which perform their last-mile deliveries against a daily deadline, postponing truck dispatching times is critical. Because the cost associated with transportation, lost sales and late deliveries can be expressed as a function of dispatching times, it directly determines the success of business. Although intuition might suggest that finding the optimal timing of a single dispatch is straightforward, we showed that it requires substantial effort, due to the non-convexity of the objective function. Nevertheless, we have derived closed form expressions of the optimal timing of a single dispatch by taking the advantage of objective function's piecewise structure. We also provided a sensitivity analysis to mimic what a manager may like to examine by using a set of parameters. We assumed stochastic customer presence, where customers are uniformly dispersed over the service area and their orders arrive according to a Poisson process, and the assumption was justified through a simulation study.

Although we believe our models demonstrate one of the most critical tradeoffs in the deadline oriented last-mile logistics, we acknowledge the need for future research. Our models determine the best postponement strategy by finding the optimal dispatching times for a given set of cost and other operating parameters; however, they only consider a single truck dispatch in a single service area. That is, how to model problems with multiple dispatches and delivery trucks in the same service area remains as a future extension.

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LOCATING ALTERNATIVE FUEL REFUELING STATIONS TO MINIMIZE DRIVERS' DEVIATIONS FROM THEIR PLANNED ROUTES

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Abstract

The use of alt-fuel vehicles (AFVs) is currently inconvenient for drivers because of their limited driving range and the scarcity of refueling stations. Due to such limitations, drivers may need to deviate from their normal routes for refueling in order to complete longer trips. A number of flow demand-based refueling station location models have been proposed in the literature to minimize the total construction cost of refueling stations to service all Origin-Destination (O-D) trips (using set-coverage models) or maximize the coverage of O-D flows for a given p stations (using maximum-coverage models). However, the inconvenience and energy loss incurred by the deviations made for refueling suggest that the minimization of such deviations might be desirable. This paper thus presents a link-based alt-fuel refueling station location model to objectively minimize the maximum percentage of deviations of all O-D trips within a transportation network. The research problem reduces to a range-limited shortest feasible path subproblem if the locations of the stations are given. We develop a non-dominate labeling reachable shortest path algorithm to solve the subproblem. It is embedded in the implicit enumeration algorithm to exactly solve the model. The results of numerical experiments show that the exact algorithm performs well. The tradeoff graph between the number of stations and maximum percentage of deviations indicates that increasing the number of refueling stations in adequate locations can decrease the driver's maximum percentage of deviations without increasing the vehicle's range. This practice may be important for promoting AFVs, especially when the improvement of the AFVs' range is expensive and challenging for manufacturers.

1. Introduction

Alt-fuel vehicles (AFVs) are expected to replace petroleum-based automobiles as one of ways to reduce global CO_2 emissions, climate change and air pollution. However, the use of AFVs is currently inconvenient because of their limited range and lack of alt-fuel refueling stations (AFSs). These two limitations could exist for many years due to technological constraints and the high capital cost of the construction of AFSs. Consequently, AFVs drivers may need to refuel multiple times and deviate from their normal routes to do so (Kelly and Kuby,2013; Kuby et al., 2013). A few studies have examined the deployment of AFSs, AFVs' vehicle range and the possibility of refueling multiple times, thus proposing optimization-based location models (e.g., Kuby and Lim, 2005; Wang and Lin, 2009; Wang and Wang 2010; MirHassani and Ebrazi, 2012; Wang and Lin, 2013). These models generally consider the singular shortest paths and select stations at nodes along these. Different objectives have been optimized in these models, such as minimizing the total location cost of refueling stations to serve all refueling demand (i.e., set-coverage models) or maximizing the coverage of service demand for a given p stations (i.e., maximum–coverage models). Alternatively, the inconvenience and energy loss incurred by the deviations made for refueling suggest that the minimization of deviations might be desirable. In this paper, we used the modeling concept of P-center instead of set coverage or maximum coverage to propose a link-based model to determine the locations of refueling stations in order to objectively minimize the

maximum percentage of deviations of all O-D trips within a transportation network, while meeting the refueling demand.

2. Literature review

The AFSs location problem is a new research problem and has two unique characteristics that cannot be handled by the conventional location models with the assumption of node-based demand. First, people usually refuel their vehicles during their trips from the home or workplace to other destinations. In other words, they usually do not make a special trip from home to a refueling station and then simply return to home. The refueling demand of vehicles is thus generally in the form of traffic flows that pass by the refueling facilities. Second, AFVs with limited driving range may need to refuel multiple times for longer trips and/or deviate from their normal routes for refueling if necessary. Kelly and Kuby (2013) and Kuby et al. (2013) provided empirical evidence of these two characteristics.

Hodgson (1981) argued that certain types of facility, such as child care facilities, are employed by people who travel to the facility from their homes and continue their journey to another location. He thus formulated a discrete-space location-allocation model minimizing the sum of the deviations from the users' journeys to work.

Hodgson (1990) and Berman et al. (1992) independently proposed a discretionary service facilities location problem. They considered that the service demand for discretionary service facilities is in the form of traffic flows. They proposed a flow-capturing location model (FCLM) whose objective is the maximization of the total flow volume passing by the service facilities being sited. Later, Berman et al. (1995) extended the FCLM to consider that the customers may deviate from their preplanned routes to visit a discretionary service facility. One of the objectives in the deviation version of the FCLM (DFCLM) is to minimize expected inconvenience (deviation distance). However, the FCLM and DFCLM assumed that the traffic flows can be serviced by any one facility being sited on a node of the related path and cannot be applied to AFVs with limited range, since these may need to carry out multi-stop refueling *en route*.

Kuby and Lim (2005) modified FCLM to propose a flow-refueling location model (FRLM). They considered the opportunity to refuel AFVs multiple times to extend their range limitation in the middle of a trip. The objective of the FRLM is to maximize coverage of the O-D flows that can be refueled by the AFSs being sited. Kim and Kuby (2012) also provided a deviation version of the FRLM (the D-FRLM) to allow drivers to make necessary deviations from their shortest paths to get to fuel stations. Kim and Kuby (2013) designed two heuristic algorithms to solve larger scale D-FRLM problems, including a greedy and a greedy substitution algorithm.

Wang and Lin (2009) used the modeling concept of set-coverage to propose a flow-demand based formula to determine the locations of refueling facilities which can guarantee that all of the refueling demand can be fulfilled. Later, their model was extended to determine the minimum number and locations of refueling stations, such that the total coverage of population demand is maximized and the refueling demand is satisfied(Wang and Wang, 2010), and they also studied the problem of the deployment of multiple types of recharging stations for refueling electric vehicles (Wang and Lin, 2013).

Briefly summarizing the works mentioned above, the FCLM, FRLM, and Wang and Lin's model (2009) all assume that AFVs follow a singular path travelling from an origin to a destination, without any other alternative paths. There is thus no deviation cost in these models. However, to better reflect the actual refueling behavior of drivers, the assumption of shortest path traveling was relaxed in the D-FCLM and D-FRLM. However, the objectives of all these models are either the maximization of flow capturing or the minimization of location cost, and thus they do not consider the deviation cost for refueling.

It appears that no work in the literature aims to directly and solely minimize the inconvenience and energy loss incurred by the deviations needed for refueling, and thus we propose a link-based model to locate AFSs to objectively minimize the maximum percentage of deviations of all O-D trips within a transportation network.

3. Proposed Model

The proposed model is an uncapacitated refueling station location problem to select the optimum locations of a given number of refueling stations, such that the maximum percentage of deviations for each of the drivers is minimized. The proposed model was based on the following three considerations. First, we assume all the trips are round trips. Drivers will determine a shortest directed (forward) path from their origins to destinations, and return with a directed (backward) path to their origins. We assume that their backward paths are identical to the forward paths, but with an opposite direction. Second, the research problem is defined on a bidirectional urban transportation network $G = (N, A)$, where N includes O–D nodes, candidate refueling facility locations with element n, and A is the set of arcs. It is assumed that each node in the network can be the site of a refueling station and the service capacity of each station is unlimited. Third, the deviation distances incurred by refueling are specified by those in excess of the shortest path journey. To reflect and minimize consumers' psychological perceptions of the deviations they need to make, we define the objective value as the maximum percentage of deviations among all OD pairs. The following additional notations are used to formulate the proposed model.

Sets and Parameters:

K^{rs} : The set of paths for an O-D pair r-s with generic $k \in K^{rs}$.

R : The set of origin nodes with generic $r \in R$.□□

S : The set of destination nodes with generic $s \in S$.□

A : The set of arcs with generic element $ij \in A$.

v : Vehicle fuel tank capacity.

d_{ij} : The distance between nodes i and j, which is equivalent to the amount of fuel consumption.

γ^{rs} : The shortest-path distance for an O-D pair r-s

β_k^{rs} : The distance of a path k of K^{rs} .

M : A big value.

Decision variables:

$e_{k,i}^{rs}$: The remaining tank fuel level upon arrival at node i along a path k of an O-D pair r-s.

Y_i : 1 if we locate a station at node i, 0 if not.

x_k^{rs} : if path k of K_{rs} is a feasible path to travel from origin r to destination s and return in its opposite direction, 0 if not.

z^{rs} : The shortest deviation-path distance for an O-D pair r-s.

w^{rs} : The minimal percentage of deviations for an O-D pair r-s.

The mathematical formulation of the location choice modeling problem is as follows:

$$\text{Minimize} \quad \left\{ \max\left\{ w^{rs}, \forall r \in R, \forall s \in S \right\} \right\} \tag{1}$$

Subject to

$$w^{rs} = (z^{rs} - \gamma^{rs}) / \gamma^{rs} \qquad \forall r \in R, \forall s \in S \tag{2}$$

$$z^{rs} = \min\left\{ \max\left\{ x_k^{rs} \beta_k^{rs}, (1 - x_k^{rs})M \right\}, \forall k \in K^{rs} \right\} \qquad \forall r \in R, \forall s \in S \tag{3}$$

$$\sum_{i \in N} Y_i = p \tag{4}$$

$$\sum_{k \in K^{rs}} x_k^{rs} \geq 1 \qquad \forall r \in R, \forall s \in S \tag{5}$$

$$e_{k,j}^{rs} = x_k^{rs} \left[(1 - Y_i)(e_{k,i}^{rs} - d_{ij}) + Y_i (v - d_{ij}) \right] \forall k \in K^{rs}, \forall r \in R, \forall s \in S, \forall (i,j) \in A, \forall i, j \in N \quad (6)$$

$$0 \leq e_{k,i}^{rs} \leq v \qquad \forall i \in N, \forall k \in K^{rs}, \forall r \in R, \forall s \in S \quad (7)$$

$$e_{k,s}^{rs} \geq x_k^{rs}(1 - Y_i)(v/2) \qquad \forall i \in s, \forall k \in K^{rs}, \forall r \in R, \forall s \in S \quad (8)$$

$$Y_i, x_k^{rs} \in \{0,1\} \qquad \forall i \in N, \forall k \in K^{rs}, \forall r \in R, \forall s \in S \quad (9)$$

The objective function (1) seeks to minimize the maximum percentage of deviations among all OD pairs. Constraint (2) specifies the percentage of deviations for each O-D pair as its shortest deviation distance dividing by its shortest-path distance. Here, the shortest deviation distance is calculated by subtracting the shortest-path distance from the shortest deviation-path distance. Constraint (3) determines the shortest deviation-path distance for each O-D pair. Constraint (4) specifies the number of AFSs to be sited. Constraint (5) ensures that there exists at least one range limited feasible path for the traversal of each of the origin destination round trips. Constraint (6) expresses the fuel level conservation relations, indicating that if a path k is feasible for the traversal of O-D pair round trip rs ($x_k^{rs} = 1$), the amount of fuel upon arrival at node j ($E_{k,j}^{rs}$) equals the amount of fuel at the prior node i ($e_{k,i}^{rs}$) plus the refueling at the prior node i and minus the fuel consumed traveling between them. Constraint (7) ensures the fuel level does not to exceed the fuel tank capacity. Constraint (8) ensures that if a path k is feasible for the traversal of the O-D pair rs round trip, there must be sufficient fuel at destination node s to continue to return to the origin node r. Finally, the binary integrality for variables is ensured by Constraint (9).

4. THE SOLUTION METHODOLOGY

In this research, we design an exact optimal solution without explicitly generating all possible deviation paths. Observe that for a given set of locations of refueling stations, the research problem is reduced to a range-limited shortest path subproblem, which consists of constraints (5)-(9). We propose a non-dominate labeling reachable search procedure to find the range limited minimum cost paths for each OD pair. It consists of two major steps, node selection and node label updating. For each node i of the graph, we create a set of labels L_i, which contains the labels $\omega_i^n = (fuel_i^n, cost_i^n)$ to represent the nth path from origin node to node i. The label ω_i^n has two attributes: $fuel_i^k$ is the fuel level at node i of this path and $cost_i^k$ is the cost of travelling along this path from the origin node to node i. The algorithm starts with the origin of the trip and conducts a forward search. While moving forward on a link, the departure node is a tail node and the arrival node is a head node of that directed link. The head node is reachable if the vehicle has sufficient fuel ($fuel_i^n \geq 0$) to travel from the tail to the head node. Whenever a node is reached (head node of leaving link), we calculate the travelling cost and fuel level for on-road consumption and apply domination rules to ensure only efficient labels are maintained in L_i. Of course, the $fuel_i^n$ is reset to a full tank if the head node is designated a refueling station. When a node is selected in the node selection step, all its leaving links are scanned in the step of updating the labels. Figure 1 shows an illustrative example of the non-dominate labeling reachable shortest path algorithm. The non-dominate labeling reachable shortest path algorithm is embedded in the scheme of the implicit enumeration solution method. The method branches on the refueling facility location binary variable, open or closed, of a refueling facility at the candidate locations. The search tree is shown in Figure 2. A node in the search tree in Figure 2 is associated with a *complete* or *incomplete* infrastructure of refueling facilities. A node under evaluation is denoted as a *search* node. When the open/closed statuses of all of the refueling facilities are labeled or a given number of *p* stations are completely assigned, the infrastructure is *complete*. We may evaluate the objective value and update the incumbent solution if a superior and feasible solution is obtained. In contrast, if the infrastructure is incomplete then this implies that the refueling facilities at some candidate locations have yet to be assigned. We may then determine the associated lower bound and minimum total number of stations. The branches from a search node

are a tree rooted at that node if no feasible solutions are available on the branch, or the minimum total number of stations is not smaller than the given p stations and/or the lower bound is not better than the incumbent. In this case, we search backward. Otherwise, we perform a depth search by moving downward. The complete flowchart for the implicit enumeration algorithm is shown in Figure 3.
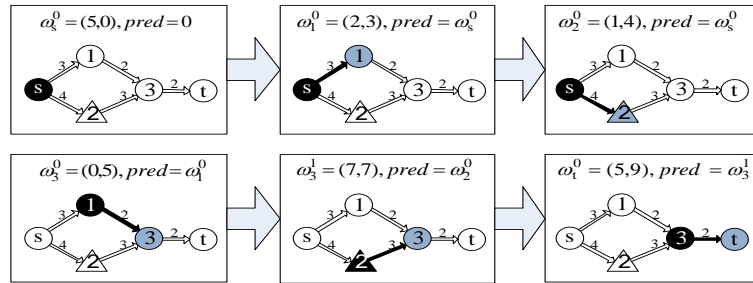
Figure 1: An illustrative example of the non-dominate labeling reachable shortest path algorithm.
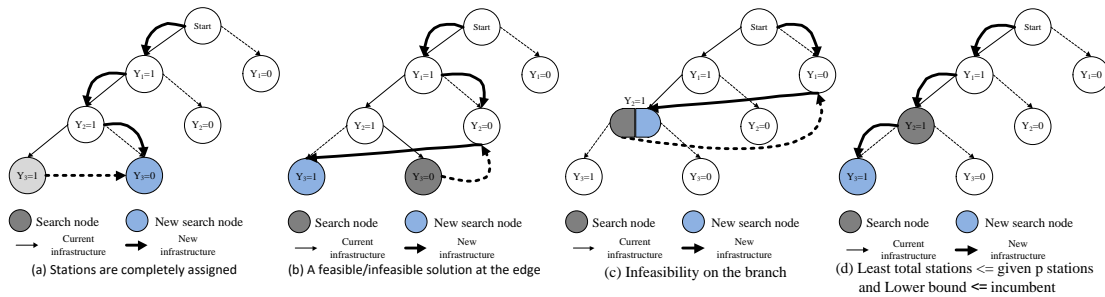
Figure 2: An illustrative search tree and search scenarios.
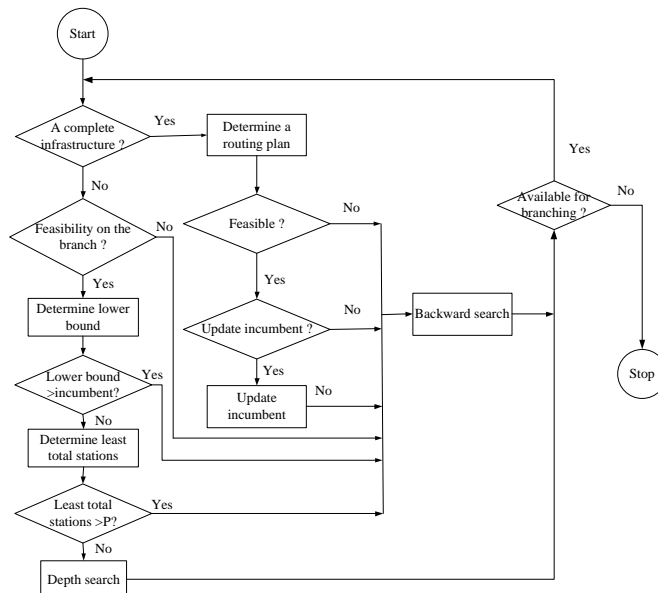
Figure 3: The flowchart of the implicit enumeration algorithm

5. Computational results

Figure 5 shows a 25-node test network (Hodgson, 1990); all 25 nodes are considering as origins, destinations, and candidate sites, giving 600 (25*(25-1)) O-D pairs. We used the network for all our numerical testing on a PC with a 2.13 GHz core and 4 GB RAM. Nine different numbers of stations (from 11 to 19) were used to test this model, with a vehicle range of nine.
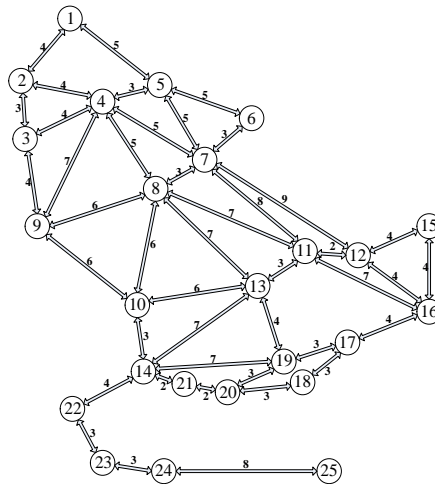
Figure 4: Hodgson's 25-node network (1990)

The maximum percentage of deviations, number of alternate optima, highest total travel cost, lowest total travel cost, and solution for the lowest total travel cost are given in Table 1. In this table, the highest total travel cost is the maximum sum of the travel cost of all O-D pairs among all alternate optima and the lowest total travel cost is the minimum sum of the travel cost of all O-D pairs among all alternate optima. From the table, we can see that the objective value does not necessarily decrease as the number of stations increases. In addition, we found that there exist alternative optimal solutions that have different total travel costs. For example, when 11 stations are sited, there are 25 alternative optimal solutions and the biggest gap in the total travel cost in those alternative optimal solutions is 1776. Such a gap in the total travel cost is important for refueling facility planning, from the perspective of saving energy.

Table 1: Solution results for a vehicle range of nine

# stations	Maximum percentage of deviations	# alternate optima	Highest total travel cost	Lowest total travel cost	Solution (locations) for lowest total travel cost
19	0	8	17080	17080	1,3,4,5,6,7,8,9,10,11,12,13,14,16,17,20,23,24
18	0.4286	14	17344	17184	1,3,4,5,6,7,8,9,10,12,13,14,16,17,20,23,24,25
17	0.6	14	17368	17208	1,3,4,5,7,8,9,10,12,13,14,16,17,20,23,24,25
16	1	155	18344	17280	1,3,4,5,7,8,9,10,12,13,14,17,20,23,24,25
15	1	10	18336	17576	1,3,4,5,7,8,9,12,13,14,17,20,23,24,25
14	1.2	185	18868	17440	2,4,7,8,9,10,12,13,14,17,20,23,24,25
13	1.2	10	18868	17736	2,4,7,8,9,12,13,14,17,20,22,24,25
12	2	6	19368	18752	2,4,7,9,10,12,13,17,20,22,24,25
11	4	25	21932	20156	2,4,7,9,10,12,19,20,22,24,25

Figure 5 shows the optimal distributions of stations for p=15, 16, 17 when the vehicle range is 10. With p=15, nodes 3 and 4 are not sited stations, and the objective value is 0.75 for p=15. With other nodes locked in, node 4 is added when p is increased to 16. The objective value is 0.428 for p=16. Lastly, drivers make no deviations when node 11 is added.

Number of stations: 15 Obj value=0.75   Number of stations: 16 Obj value=0.428   Number of stations: 17 Obj value=0
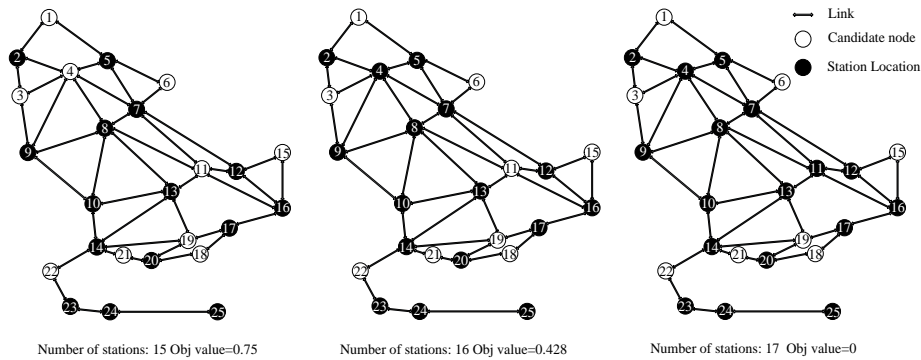
Figure 5: Optimal distributions of stations for p=15, 16, 17, range =10

Figure 6 shows the results of the sensitivity analysis of vehicle range to the maximum percentage of deviations. The test uses the vehicle range of 10, and this is increased by two until 16 is reached. It is obvious that the longer the vehicle range, the fewer stations are needed to achieve any given maximum percentage of deviations. However, the impact of vehicle range on the maximum percentage of deviations decreases if the number of stations achieves a certain level of density. The reason why the increase in the vehicle rage does not lead to a decrease in the maximum percentage of deviations may be that when the density of stations achieves a higher level, drivers would have more opportunities for refueling and this can thus compensate for the vehicle range limitation. This practice may be important for promoting AFVs, especially when improving the AFVs' range is expensive and challenging for manufacturers.
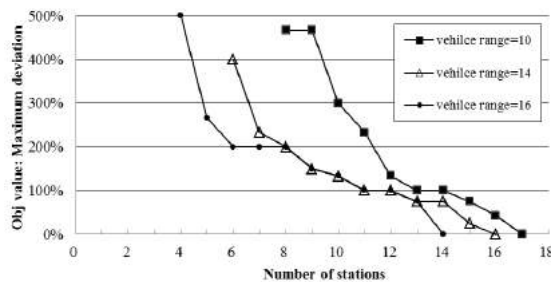
Figure 6 Trade-off graph between number of stations and maximum percentage of deviations, for different vehicle ranges.

5. Conclusions

In this paper, we used the modeling concept of P-center instead of set cover or maximum cover to propose a link-based model to determine the locations of refueling stations and objectively minimize the maximum percentage of deviations of all O-D pairs within a transportation network while meeting refueling demand.

A non-dominate labeling reachable shortest path algorithm embedded in the implicit enumeration algorithm was proposed to exactly solve the proposed model. Tests in the 25-node network (Hodgson, 1990) showed that the solution algorithm performs well. In addition, we also conducted the sensitivity analysis on the vehicle range and number of stations been sited. The trade-off graph between the number of stations and maximum percentage of deviations showed that increasing the number of refueling stations in adequate locations can decrease the inconvenience of having to make deviations without increasing the vehicle range. This practice may be important for promoting AFVs, especially when improving the AFVs' range is expensive and challenging for manufacturers.

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AIR FREIGHT HUB COMPETITION WITH AIRPORT DEMAND ENHANCING SERVICES

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Abstract

Purpose: Competition for market share among the freight forwarders is high. Integrated Service Providers (ISPs) dominate the market due to their ability to control huge parts of the air freight supply chain. To maximize profit and gain greater market share, airlines need to engage the logistics service providers (LSPs), who help to complete the ground pickup, storage and delivery of freight from/to customers. LSP services are demand-enhancing as they increase demand for the air freight service offered by the airline-LSP consortium. We consider how airlines can optimally structure their flight routes and frequency between hubs and prices to increase profits by working with the LSPs.

Approach: We first use mixed integer programming to generate the hub locations, routes and their frequencies for an airline, based on node-to-node demand, to maximize profit while reducing cost, by utilizing the demand-distance product and extractable demand for an airline at a node, relative to an ISP. Next, using a 3-player Stackelberg game, we find the best response for the airline, LSP and ISP, in terms of the offered service level and price, based on each player's ability to generate demand, the intermodal integration costs, and competition between the airline and ISP. We set the airline as a follower to the LSP and ISP.

Findings: We show the importance of airport demand enhancing services on profitability. We find the optimal price, service level, frequency, routes, hub location and profit under equilibrium. We show how airlines can compete with ISPs, and how LSPs can hold their profit and chain position.

Value: Privatization and deregulation in the air freight industry have invited competition. Airlines need to collaborate with the LSPs to improve their performance, or else airlines must reduce the dependence on the LSPs by starting in-house units to compete with the ISPs. LSPs realize that their services are increasingly commoditized and they need to improve service and reduce price to remain profitable and be an economic partner for the airlines. This paper concentrates on factors, especially demand enhancing services, to determine service level and price. Studies on LSP-airline collaboration to generate freight demand are scant and this paper contributes in that respect.

Research implications: We provide insights into the design of route frequency and service offered by airlines based on the airline's and LSP's value-of-service. A 3-player cooperative game theoretic model involving collaboration between LSPs and airlines to the ISPs adds to the literature.

Practical implications: Airlines can apply the results to effectively utilize LSPs' services to enhance the demand for their own services.

1. INTRODUCTION

By 2015, over US$6.4 trillion worth of goods, forming almost 35% of world trade by value, was moved by air (IATA, 2016). Comprising nearly 230 cargo airlines/integrators and thousands of freight forwarders, the airfreight industry is highly fragmented. ICAO's 2014 annual report mentioned that world airborne trade grew from 8.7 million tons and 45 billion freight tonne kilometres (FTK) in 1989 to 50 million tons and 300 billion FTKs in 2014 respectively. Baxter (2011) notes that the range of 'air eligible' products grows rapidly as more firms seek time compression in their supply chains by using airfreight.

However, from IATA's forecasts, the current weak global economic climate will affect air cargo performance, with advanced economies slowing down and emerging economies performing well below their potential. ICAO notes that the industry is plagued by low margins, reflecting the intense competition in the industry. The rapid development of technology, increased global competition and higher customer demands have put pressure on firms to improve their services. Such competition involves price, product and service attributes. All firms in competitively structured chains from seller to buyer are integral to the chain's operation and its ability to deliver superior customer value.

Airlines use freight not just to supplement passenger operations and maximize capacity, but also to extend their control of physical and information flows along the entire air logistics chain. They offer ground services such as transit storage, packaging/unpacking, and transit inventory management through collaborations with logistics service providers (LSPs). This allows them to focus on their core competencies, while competing with the integrators (ISPs) such as Fedex and UPS, who dominate the freight market by supplementing air services with extensive ground transport, time-definite door-to-door delivery, continuous tracking and logistics expertise to support just-in-time inventory strategies. The challenge from the ISPs has led to strategic responses from the LSPs, such as partnerships with airlines and couriers (e.g., CARGO 2000 initiative). These horizontal collaborations pit one transport chain against another, and those players who manage cost well and synergize on their partners' strengths improve market share.

As airlines seek to increase market share and profit, they need to plan routes, frequencies and prices based on demand forecast and fleet capacity, and assess how much value is offered to customers. This value, determined by price and service levels, is crucial and must be accounted for to sustain market and supply chain position. Determining the value that LSPs add to the final service, relative to competition, is necessary in pricing products, as customer demands increase and integrators continue to contain cost and offer competitive prices by controlling complete supply chains.

In this paper, we discuss techniques to provide the routes, flight frequencies and prices charged by the cargo airlines to capitalize on demand for various routes. The remainder of the paper is organized as follows. Section 2 reviews the literature. In Section 3, models are formulated and solved for finding the flight routes, frequencies, prices and service levels. A numerical example with the final outcomes is given in Section 4. Section 5 provides managerial insights and implications for routing, scheduling and pricing. Section 6 concludes the paper and outlines directions for future research.

2. LITERATURE REVIEW

Designing novel routing algorithms for better transport and logistics network design has generated much interest among researchers. Lederer et al. (1998) first considered different airline network strategies, and designed profit maximizing frequencies based on cost optimized networks. The inspiration for solving hub-and-spoke network problems using integer programming originated from O'Kelly (1987) while Louveaux (1986) studied stochastic facility location problems involving demand, production costs, transportation cost and price for several private and public sector applications. Powell et al. (1994) further studied stochastic dynamic networks with random arc capacities and proposed

approximation techniques to evaluate the recourse functions. Campbell (1996) and Santoso et al. (2005) then applied stochasticity on demand, transportation costs, supply and capacity for industrial supply chain planning. Recently, Yang (2009) abstracted stochastic uncertainty in demand to solve hub location and routing problems with a 2-level model simultaneously. Derigs et al. (2009) extended this by simultaneously considering flight selection, aircraft rotation planning, and cargo routing to maximize profit. Further, Campbell and O'Kelly (2012) reviewed hub location models.

The need to competitively price products, using service levels, as industries transition from producing physical products to providing services as products, has led to value added services, which have to be accounted (Dixit 1979). However, previous literature primarily focused on a single-echelon, unlike this paper's two-echelon framework. Moreover, the relatively recent concept of supply chain design is important to analyse as competition among supply chains, not firms, decides a firm's market share. Many papers consider supply chain contract design using player cooperation (cf. Pasternack 1985; Cachon et al. 2005). Service level was introduced by Iyer (1998), who considered price and service-based competition in terms of service value and disutility of travel in a 1-manufacturer, 2-retailers supply chain. Tsay et al. (2000) analyzed a linear demand function to measure the competitive intensity of price and service, and characterized how competition dynamics affect behaviour and performance under decentralization. Wei et al. (2013) consider a 1-supplier, 2-retailer game optimized for price, capacity allocation and ordering for a service supply chain. Lin (2013) uses build-to-order strategies to design a supply chain network. Wu (2012) and Bian et al. (2015) consider a 2-manufacturer, 1-retailer game and determine the equilibrium point for price and service level. Xiao et al. (2013) consider a supplier-retailer Stackelberg game to coordinate price and service level decisions under vendor-managed inventory.

While some papers discuss vertical collaboration in supply chains, other papers tackle horizontal collaboration, which is gaining traction in industry. Ireland et al. (2002) exhaustively review alliance management issues while Schmoltzi et al. (2011) provide an overview of the motives, structure and performance attributes of horizontal cooperation and identify distinctive types of cooperation by analytical classification. Pomponi et al. (2015) note that the small size of LSPs, environmental concerns, and low load factors engender such collaboration. Cheung et al. (2015) apply system dynamics to model interactions between collaborators and state that such collaborations may fail when information sharing risks increase, inspite of strong incentives to collaborate horizontally. Adenzo et al. (2014) consider horizontal cooperation only in the final delivery process to overcome such risks and apply the GRASP metaheuristic to find cost savings when planning joint deliveries with collaborators. Krajewska et al. (2008) perform joint routing-scheduling for collaborations using cooperative game theory for profit sharing.

Notwithstanding this, research on competition between supply chains considering service level is scant. McGuire et al. (1983) employ a game-theoretic approach to determine the equilibrium channel structure under different market conditions for a 2-manufacturer, 1-retailer problem, with competition between integrated and decentralized channels. Boyaci et al. (2004) consider a 2-wholesaler, 1-retailer chain and formulated a model in which each supply chain's market share is influenced only by service strategies, and not pricing. Moreover, not many works discuss the joint frequency-hub location-routing-pricing problem, especially with respect to the demand enhancing services of the players. This is more valuable for cargo airlines, given their constraints and competition from the integrators. Javid et al. (2015) present a location-inventory-pricing model for a network with price-sensitive demand and capacity constraints. Shah et al. (2012) apply airline schedule competition to find costs and frequency using a non-spatial approach for freight operations. Next, Zhang et al. (2007) compare the profitability of the airline-LSP alliance to an ISP. However, most of these papers omit multiple variables in their analysis such as routing/frequencies, and avoid quantifying aspects such as service level.

Thus, this paper seeks to help airlines price their freight services given a knowledge of the LSP's service level and price to increase market share. We first solve an MILP to find the best routes considering demand-distance products. We then solve a 3-player non-cooperative game between a cargo airline (CA), an LSP serving the CA, and an ISP. We find the best price, service level and frequencies, by considering the LSP service level and the level of intermodal integration between the CA and LSP.

3. MODEL DEVELOPMENT
We consider 3 players: CA, LSP, and ISP. The LSP represents two like-minded players, each operating at the origin and destination ports to support the CA on ground services. The study first solves the routing problem whereby the CA decides on which routes to ply to manage the operating costs that depend on the distance travelled. Next, we solve a Stackelberg game to find the optimal price and service level for each player under equilibrium and find strategic insights that the CA and LSP can use to maximize profit.

Route Planning
Freight demand is seasonal. The CA's route-wise demand is assumed to obey a discrete distribution. We assume that the hub location decision is strategic, and does not vary with demand. The flight network design is tactical and is adjusted periodically based on demand. Following Yang (2009), we have one stage which determines the number and location of hubs, while another stage constructs a service network by finding the optimal transport routes and flow allocation, based on the hub locations decided earlier.

We consider a network of N nodes and route demands $D_{il}(S)$, where S is the realized demand scenario for a route (either low, middle or high) with origin i and destination l. We take d_{il} to be the distance between nodes i and l. λ_{il} corresponds to the CA's fixed cost per tonne-kilometre without going through a hub. For simplicity, we consider $\lambda_{il} = \lambda$ for all $i,l \in N$. H_j is hub j's setup cost and λ_{ijkl} is the unit transport cost to move from origin i to destination l through hubs j and k. The binary decision variables $x_j = 1$ when node j is a hub; $y_{il}(S) = 1$ when the direct arc i-l is chosen by the CA for freight transport; and $y_{ijkl}(S) = 1$ when the indirect arc i-j-k-l, with j and k as hubs, is chosen. $\alpha_{ij}(S) \in [0,1]$ and $\beta_{jk}(S) \in [0,1]$ are transportation discounts due to the economies of traffic when transporting from node to hub and from hub to hub respectively. The determination of x_k gives the hub setup investment decision, while $y_{il}(S)$ and $y_{ijkl}(S)$ yield the tactical flight route decisions. Once x_j is chosen, the second stage decisions $y_{il}(S)$ and $y_{ijkl}(S)$ change for different realizations of S. When scenario S is realized, $D_{il}(S)d_{il}$ and $\lambda_{ijkl}(S)$ become known and $y_{il}(S)$ and $y_{ijkl}(S)$ can be found. $RD_{ijkl}(S)$ is the realizable demand along the indirect arc i-j-k-l. This formulation is similar to Yang (2009), who also considers the maximum number of arc segments in a route to be 3.

Following Yang's (2009) model, we focus on i) cost minimization using the distance-demand product $D_{il}(S)d_{il}$, and ii) calculating an extractable demand $E_{il}(S)$ for each route i-l. $E_{il}(S)$ is calculated as a ratio of FTKs logged by a CA compared to an ISP for a particular route. As CAs undertake newer routes to spread their network and improve profit, CAs must watch the routes monopolised by the ISPs who offer lower prices and attractive services, which is difficult for the CA to match.

The formulation for this model is provided as follows:
Min $\Sigma_{k \in N} H_{k} * x_k + \Sigma_S \Sigma_{i \in N} \Sigma_{l \in N} E_{il}(S)D_{il}(S)\lambda d_{il}y_{il}(S) + \Sigma_S \Sigma_{i \in N} \Sigma_{j \in N} \Sigma_{k \in N} \Sigma_{l \in N} RD_{il}(S)\lambda_{ijkl}(S)y_{ijkl}(S)$

where $RD_{ijkl}(S) = D_{ij}(S)E_{ij}(S) + D_{jk}(S)E_{jk}(S) + D_{kl}(S)E_{kl}(S)$
$\lambda_{ijkl}(S) = \lambda(\alpha(S)d_{ij} + \beta(S)d_{jk} + \alpha(S)d_{kl})$

$$\text{s.t. } y_{il} + \Sigma_{j \in N} \Sigma_{k \in N} y_{ijkl}(S) = 1 \quad \text{for all } i,l \in N; i \neq l \tag{1}$$
$$\Sigma_{i \in N} y_{ij}(S) + \Sigma_{i \in N} y_{ji}(S) \leq H_j(1-x_j) \quad \text{for all } j \in N; i \neq j \tag{2}$$
$$\Sigma_{k \in N} y_{jjki}(S) + \Sigma_{k \in N} y_{ikjj}(S) \geq 2x_j \quad \text{for all } i,j \in N; i \neq j \tag{3}$$
$$Y_{jjkk}(S) \geq x_j + x_k - 1 \quad \text{for all } j, k \in N; j \neq k \tag{4}$$

$$\sum_{i \in N} \sum_{l \in N} \sum_{k \in N} (y_{ijkl}(S) + y_{ikjl}(S)) - \sum_{i \in N} \sum_{l \in N} y_{ijjl}(S) \leq H_j x_j \quad \text{for all } j \in N;\ i \neq k \tag{5}$$

$$H_j(\sum_{i \in N} \sum_{l \in N} \sum_{k \in N} (y_{ijkl}(S) + y_{ikjl}(S)) - \sum_{i \in N} \sum_{l \in N} y_{ijjl}(S)) \geq x_j \quad \text{for all } j \in N;\ i \neq k \neq j \tag{6}$$

$$E_{ij}(S) + E_{jk}(S) + E_{kl}(S) \leq 1 \tag{7}$$

$$\text{with} \quad x_j,\ y_{il},\ y_{ijkl} \in \{0,1\}.$$

The constraints ensure that non-logical routes are eliminated from the search space by the MILP solver in GAMS Distribution 24.7.1. Constraint 1 ensures that all demand at an origin is transported to its destination. Constraint 2 ensures that if node j is a hub, then the direct flights between nodes *i* and *j* are represented as y_{jjji}, y_{ijjj}, y_{iijj}, or y_{jjii}, and not y_{ij} or y_{ji}. Constraint 3 requires that only non-stop and one-hub-stop services are allowed if either the origin or destination is a hub. Constraint 4 requires that only direct services are allowed when both origin and destination are hubs. Constraint 5 requires that no hub-connected services are allowed to stop at node k, if node k is not a hub. Constraint 6 states that at least one among all flights when stopping at a hub must stop at node j, if node j is a hub. Constraint 7 ensures that the net extractable demand is within the capacity limits of the freighters. When plying along indirect arcs, CAs must plan for sufficient freight volume through the hubs they pass to ensure profitability.

Pricing and Scheduling for CA, LSP and ISP
In the second part of our model, we solve a non-cooperative Stackelberg game of 3 players: CA, LSP, and ISP. We assume that the CA is a follower to the ISP and LSP i.e. it sets an offer price to customers by optimizing profit, after knowing the service levels and prices charged by the LSP and ISP. We focus on the LSP's demand enhancing capability to determine an optimal operating frequency along a particular route by measuring $y_{il}(S)$ and $y_{ijkl}(S)$ from the first part of the model to find the route and corresponding distance d_{il} to be travelled by the CA and ISP separately. We assume that each route between nodes i and l has a base demand of M and that the ISP's and CA's products are correlated by parameter $\delta \in [0,1]$. The greater the δ, the more similar are the products, and the greater is the competition. Also, δ affects the demand functions through the price and service levels of each player. T_m denotes the unit transport cost of player m.

Now, consider the linear demand equations for the CA, LSP and ISP. P_m and SL_m refer to the price and service level offered to the market by player m, where m = CA, LSP, ISP.

$$D_{CA} = (M - P_{CA} + \delta P_{ISP} - \delta SL_{ISP} + SL_{LSP}) \tag{8}$$

$$D_{ISP} = (M - P_{ISP} + \delta P_{CA} - \delta SL_{PSP} + SL_{ISP}) \tag{9}$$

Thus the profit function for each player is:

$$\Pi_{CA} = (P_{CA} - P_{LSP}f_{CA})(M - P_{CA} + \delta P_{ISP} - \delta SL_{ISP} + SL_{LSP}) - f_{CA}T_{CA}d_{il} - g(\mu) \tag{10}$$

$$\Pi_{LSP} = (P_{LSP}f_{CA}/2)(M - P_{CA} + \delta P_{ISP} - \delta SL_{ISP} + SL_{LSP}) - R(SL_{LSP})/2 \tag{11}$$

$$\Pi_{ISP} = P_{ISP}(M - P_{ISP} + \delta P_{CA} - \delta SL_{PSP} + SL_{ISP}) - f_{ISP}T_{ISP}d_{ij} - R(SL_{ISP}) \tag{12}$$

We assume that the two LSPs at the origin and destination have identical profit functions; the CA pays the LSP on a per-flight basis; and that the unit operating cost for an ISP and CA differs as an ISP controls an entire supply chain, whereas the CA controls only air transfer services. For comparison, we add a term called strategic intermodal integration for the CA, because the ISP's costs in integrating different modes of its supply chain, are to be borne by smooth integration between the CA's cargo bays and LSP's resources. These ISP costs are already reflected in T_{ISP} and we assume perfect intermodal integration for them. The function R gives the cost of providing service level SL_i by player i, with Δ as the cost of service coefficient. To reflect the diminishing returns effect of the additional service, we use a quadratic service cost function. Similarly, the intermodal integration cost borne by the CA-LSP alliance is bi-quadratic to emphasize the dependence on the LSP's price and service offering. Frequency f_i for player i is calculated as the product's total demand divided by freight capacity (CF).

$$R(SL_i) = (\Delta/2)SL_i^2 \tag{13}$$

$$g(\mu) = (P_{LSP}SL_{LSP})^2 \tag{14}$$

$$f_i = D_i/CF, \quad i = CA, ISP \tag{15}$$

In this Stackelberg game, the CA sets its prices based on previously set values of the LSP's and ISP's service levels and prices. This is done by optimizing the CA's profit with respect to the LSP's service level and price, yielding the following first-order conditions:

$$\partial \Pi_{CA}/ \partial P_{LSP} = -(M-P_{CA}+\delta P_{ISP}-\delta SL_{ISP}+SL_{LSP})^2 + 2P_{LSP}SL^2_{LSP} \tag{16}$$

$$\partial \Pi_{CA}/\partial SL_{LSP}=P_{CA}-(P_{LSP}/CF)(M-P_{CA}+\delta P_{ISP}-\delta SL_{ISP}+SL_{LSP})-2SL_{LSP}P^2_{LSP} \tag{17}$$

The Hessian of Π_{CA} with respect to P_{LSP} and SL_{LSP} is negative definite as the diagonal elements $\partial^2 \Pi_{CA}/ \partial P^2_{LSP}$ and $\partial^2 \Pi_{CA}/ \partial SL^2_{LSP}$ are negative while the determinant is positive. Hence the profit function Π_{CA} is jointly concave in P_{LSP} and SL_{LSP}. We obtain the CA's equilibrium response by setting eqns (16) and (17) to 0 yielding optimal solutions as:

$$P^*_{CA}=M+ \delta P_{ISP}-\delta SL_{ISP} + ((2P_{LSP}CF)^{0.5}-1)SL_{LSP} \tag{18}$$

$$S^*_{LSP}= \frac{((M+ \delta P_{ISP}-\delta S_{ISP})CF- \Delta\, d_{il})}{(((2P_{LSP}CF)0.5-1)(CF+2P_{LSP})-2P_{LSP}(1+CF*P_{LSP}))} \tag{19}$$

Substituting in the profit functions for the ISP and LSP, we obtain

$$\Pi^*_{LSP} = (P^2_{LSP}-(\Delta/4))SL^2_{LSP} \tag{20}$$

$$\Pi^*_{ISP} = \frac{\Delta SL(ISP)*((\delta+1)M+(\delta^2-1)(P_{ISP}-SL_{ISP}-\delta SL_{LSP}(2P_{LSP}CF)0.5}{1-\delta^2+\delta*CF*k} \tag{21}$$

where $k = \dfrac{\delta(2P_{LSP}CF)^{0.5}}{(((2P_{LSP}CF)0.5-1)(CF+2P_{LSP})-2P_{LSP}(1+CF*P_{LSP}))}$.

As Π_{LSP} and Π_{ISP} are both concave in P_{LSP} and SL_{LSP}, we apply first order conditions on these functions with respect to these variables, to yield the optimal values for P_{LSP}, P_{ISP} and SL_{ISP} and plug them in the model's equations to get the required solutions. Note that the solution to P^*_{LSP} is a polynomial of degree 7, yielding only 3 real roots, and only 1 positive and profitable root for the model. SL_{ISP} and P_{ISP} are hence easily obtained as

$$SL^*_{ISP}=\frac{M(1-\delta^2+\delta*CF*k)-\left(\frac{\lambda_{CA}d_{il}}{CF}\right)(1-\delta^2+\delta*CF*k*(\delta*CF-1))}{2\Delta-(1-\delta^2+\delta*CF*k)} \tag{22}$$

$$P^*_{ISP}=\frac{T_{ISP}d_{il}}{CF} + \frac{\Delta SL_{LSP}}{1-\delta^2+\delta*CF*k} \tag{23}$$

$$\Pi_{CA}=SL_{LSP}*((2P_{LSP}CF)^{0.5}*(P_{CA}-\frac{T_{CA}d_{il}}{CF}))+(P_{LSP}SL_{LSP})^2. \tag{24}$$

4. NUMERICAL EXAMPLE

Flight Route Planning: We take $H_j=0.9$ billion Rs, 5 airports (Mumbai, Bangalore, Chennai, Delhi, Kolkata) carrying 88% of India's total domestic freight, $\lambda=50$ Rs per tonne-kilometre, demand levels as high (120%), medium (100%), and low (80%) with probabilities of 0.25, 0.58, and 0.17 respectively, as per historical data. Campbell et al. (2012) suggest that α and β can reasonably lie in [0.6, 0.8] and [0.7, 0.9] respectively.

Table 1: Flight route planning results

Demand level	Probability	Description	Direct flights	Flights through Mumbai hub
120%	0.25	High	5	15
100%	0.58	Medium	6	14
80%	0.17	low	9	11
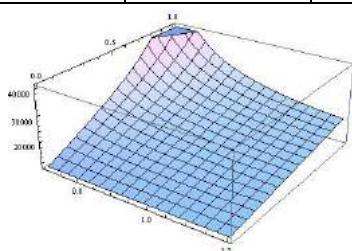
Variation of SL_{LSP} with Δ and δ
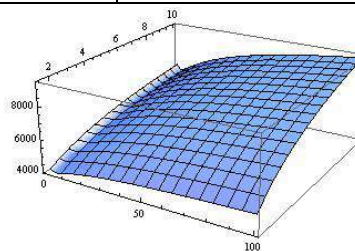
Variation of P_{LSP} with CF and Δ
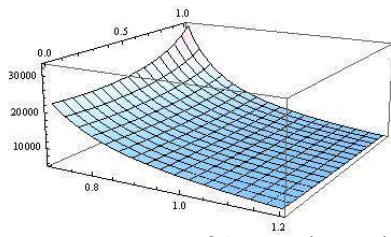
Variation of SL$_{ISP}$ with Δ and δ
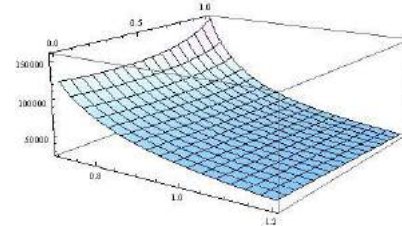
Variation of P$_{ISP}$ with Δ and δ
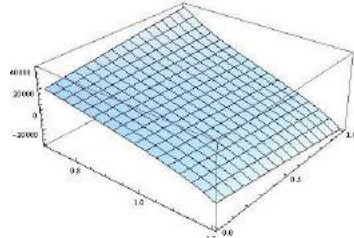
Variation of P$_{CA}$ with Δ and δ
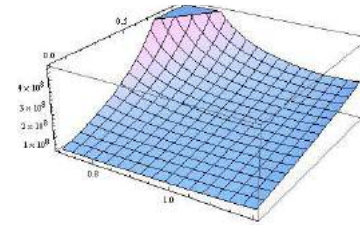
Variation of Π_{LSP} with Δ and δ

Variation of Π_{CA} with Δ and δ

Variation of Π_{ISP} with Δ and δ
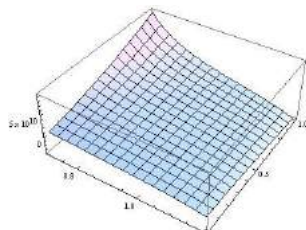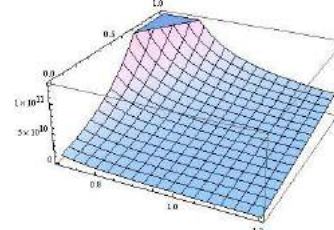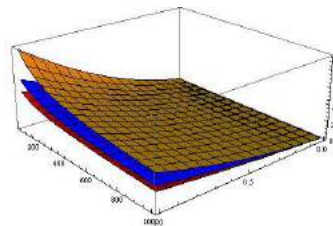
Variation of f$_{ISP}$ with CF $\in$ [100, 1000] and δ for Δ = 0.8(orange), 1.2 (blue), and 2(red)
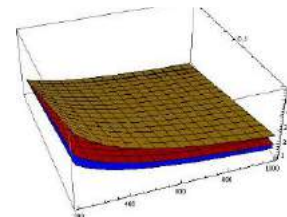
Variation of f$_{CA}$ with CF $\in$ [100, 1000] and δ for Δ = 0.8(orange), 1.2 (blue), and 2(red)

Figure 1: Variation of outputs to parameters

Table 1 shows Mumbai as a hub, as the Mumbai handles the highest freight volume in India. The final cost is 3.298 billion Rs. Plots in Figure 1 correspond to inputs M=50000 tons, CF=100, d_{ij}=100 km, T$_{CA}$=1000 Rs, T$_{ISP}$=4000 Rs, $\Delta \in$ [0.7, 1.2] and $\delta \in$ [0,1].

Optimal Pricing and Frequency Estimation: The CA's price is 25% that of the ISP's maximum price. The greater the intermodal integration, the greater the LSP's service requirement and the greater is the CA's cost. The greater the correlation δ between products, the greater are the LSP's and ISP's service levels. The lower the LSP's price offered to the CA, the lower is its service level. The LSP's service level and price increase as the CA's fleet is more utilized, implying larger freight quantities being transported by air and lower operating frequency, leading to more utilization of the LSPs' ground resources to deal with the extra freight. The CA's and ISP's profit functions are similar, suggesting that the CA should reduce its dependence on the LSP to improve costs and profit. The LSP benefits more from the alliance than the CA. Keeping δ high yields higher profit to the ISP compared to the CA. Players should keep Δ within the interval [0.7, 1.2], else the prices and service levels become negative and operations become infeasible. Flight frequency increases as fleet capacity decreases for the CA and ISP.

5. MANAGERIAL INSIGHTS AND IMPLICATIONS
Freight Hub Location and Routing

Considering demand-distance products in reducing hub and routing costs is justified as cost is always calculated on a per FTK basis. Routes depend not only on demand, but also on other factors such as fuel and crew cost incurred for that route. Computing the extractable demand allows a CA to quantify its ability to attract sufficient demand to offset cost and protect profit margins. This value is critical in knowing how penetrable a particular route is for a new entrant. Clearly, a lower demand situation leads to more direct flights, presumably to reduce fixed costs and time delays. In high demand cases, it is advantageous to rely on the economics of the hub-and-spoke. An in-depth analysis may calculate extractable demand as a ratio of average service levels and prices offered by the CA-LSP alliance versus the ISP. This can better predict the CA's route penetration ability, market saturation effects or monopoly control in markets.

Optimal Pricing and Frequency Estimation
Equilibrium strategies for all players in the air freight competition game are identified. Both decentralized and integrated management approaches appear to be profitable under different market conditions. This partially explains the co-existence of ISPs and CA-LSP collaborations in the freight industry. There exists a synergistic effect where one player's attempts to game the market through product offers invites competitive responses from other players as well. The price and service level are indicative of demand trajectories. Service levels increase with competition, which is consistent with practice. Our model also shows the dependence of frequency on price and service level. More product differentiation reduces stress on fleets. Cost of services coefficient Δ should be low to reduce costs, especially in high competition markets, for better profitability.

The difference in ISP and CA prices comes from controlling freight functions in-house, which explains why several airlines have started building in-house freight divisions, while outsourcing some aspects to LSPs. Similar profits for the CA and ISP indicate that as competition increases, controlling functions in-house is a better strategy to reduce cost. CAs also have passenger operations, which can help reduce cost through scale economies. LSPs should improve services to sustain demand from CAs as they benefit from such collaborations; else they will lose out to in-house CA units. LSPs outnumber CAs, hence their margins are low and their services are slowly becoming redundant.

CONCLUSION
This paper proposes a two-stage model to determine an optimal hub location-routing-pricing-scheduling strategy for CAs competing with ISPs. The routing problem considers extractable demand and demand-distance products to decide optimal routes. The pricing model captures LSP's service level impact on final prices and service levels offered by CAs, ISPs and LSPs. Managerial insights into each player's strategy are presented. Results suggest that the ISP's monopoly is resilient to a CA-LSP alliance (see Figure 1). Of the world's ten largest air freight carriers by market share, six are in-house cargo units (Emirates SkyCargo, SIA Cargo), while the top three are ISPs (FedEx, UPS, DHL).

In future, cooperative game scenarios with oligopolistic models could be studied. A more integrated approach to routing-hub location-pricing-scheduling with faster algorithms is of great interest to airlines. Emphasis on how airlines can synergize their passenger and freight operations to capture more value is also important. Horizontal collaboration, as highlighted by Cruijssen et al. (2007) improves profitability and service quality. LSPs consider the estimation and distribution of cost savings as impediments to such collaborations, hence such research is important. Optimal alliance formation amongst LSPs/airlines or hybrid vertical-horizontal supply chain alliances is crucial, given the presence of current passenger and freight alliances such as the Value Alliance, SkyTeam Cargo and WOW AirFreight Alliance. Finally, Bahinipati et al. (2009) have used an AHP-FLM approach to obtain a collaboration intensity index in a semiconductor manufacturer's supply chain to measure the success of horizontal collaboration. We could replicate this.

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Section 6: Sustainability and green logistics

INSTITUTIONAL PRESSURE, ORGANIZATIONAL VALUES AND CORPORATE ENVIRONMENTAL STRATEGY

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Abstract
Purpose of this paper:
Environmental management has been researching extensively in the last two decades. Scholars increasingly tout institutional theory as an important perspective for studies on environmental management. However institutional theory is not enough to understand the different reaction while companies facing similar institutional pressure in the industry. Toward environmental management, companies can take different strategies based on the managerial perceptions of environmental risks and market opportunities. Researchers have classified corporate environmental strategy along a continuum that rangers from reactive environmental strategy to proactive environmental strategy (Aragón-Correa and Sharma, 2003; González-Benito and González-Benito, 2005). At one end of the continuum, companies with reactive environmental strategy are typical of companies that only implement the minimal compulsory changes to meet regulations and take defensive posture to control the environmental protection investment. At other end of the continuum, companies with proactive environmental strategy are typical of companies that voluntarily take measures to reduce their impact on the natural environment and recognize the possible competitive advantage associated with investing in environmental management. Thus, it is necessary for scholars to investigate the potential moderators in the process of a firm's experiencing, interpreting, and managing institutional pressures (Heugens and Lander, 2009).

Exploring the moderating effect of organizational value (culture) may help provide more implications. A firm exerts discretion by following its own rules and values rather than passively submitting to conventions prevailing in its organizational field (Greening and Gray, 1994). The organizational field refers to "those organizations that, in the aggregate, constitute a recognized area of institutional life: key suppliers, resource and product consumers, regulatory agencies, and other organizations that produce similar services or products" (DiMaggio and Powell, 1983, p. 148). Thus, institutional pressures and organizational value may work together and interact with each other to affect innovation adoption. For instance, firms may react differently to the same levels of perceived institutional pressures to adopt GSCM due to the differences in their organizational values. However, to date, no research has empirically investigated the effects of institutional factors on environmental management strategy and the interaction effect of institutional pressures and organizational value. Such a void leaves a significant gap between theoretical and empirical research.

Design/methodology/approach:
We collect survey data from the manufacturing companies in China, and use structural equation modelling and hierarchical regression analysis for data analysis.

Findings:
The results of a survey of 250 firms suggest that the institutional pressures have effects on proactive environmental strategy. In addition, organizational culture (i.e., flexibility orientation and control orientation) plays different roles in the relationships between the dimensions of institutional pressures and corporate environmental strategy.
Value:
This paper therefore enrich environment sustainability research by examining the external pressure factors' effects on firms' environmental strategy, Also it lends support to the interaction effects of pressure and organizational culture on firms' proactive

environmental strategy. The study also offers practitioners and policy-makers guidelines for promoting proactive environmental strategy.

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REVERSE SUPPLY CHAIN RELATION TO CIRCULAR ECONOMY

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ABSTRACT

Most of the focus in logistics and supply chain research has been on forward logistics, but the reverse supply chain (RSC) has been studied for more than a decade. Meanwhile, the Circular Economy (CE) has gathered a lot of attention in recent years from management sciences as well as companies offering a practical alternative to the current linear economic model. The purpose of this paper is to analyze the relationship of these two concepts of RSC and CE, especially in terms of value creation. The study also suggests how to develop a sustainable business model by following RSC and CE concepts. The paper indicates future research questions and hypotheses for these topics.

KEYWORDS: Reverse Supply Chain, Circular Economy, Value creation

INTRODUCTION

The 20th century has witnessed by far the fastest development of the industrial revolution as well as the most serious damage to the environment and natural resources. People have already been aware of the linear growth mode for decades, a concept that has resulted in continuous over-exploitation, over-production, and over-consumption, ultimately leading to excessive waste (e.g., Bocken et al., 2014). Today, global resource crises and environmental problems are reality. Sustainability and ecological issues are a global economic concern on a daily basis. There are nowadays many trends and initiatives for sustainability and environmental friendly businesses. This study focuses on the comparison of two sustainable, friendly operational concepts: the reverse supply chain (RSC) and the circular economy (CE). A supply chain in its classical form is defined as forward supply chain, which is a combination of processes to fulfill customers' requests and includes all possible entities like suppliers, manufacturers, transporters, warehouses, retailers, and customers themselves (Govindan et al., 2015). The classic forward supply chain does not feel any responsibility for end-of-life (EOL) products. Then the reverse supply chain tries to account for EOL products in the most environmentally friendly manner possible (Schenkel et al., 2015). RSC management entails the effective and efficient management of a series of activities to return products, parts or materials from the customer with the aim of recovering their value (Schenkel et al., 2015). These activities include reverse logistics and recovery options such as remanufacturing, refurbishing or recycling. At the same time, the principle of a circular economy is reduction, reuse, recycling, low consumption and high efficiency as its basic character, which

is the answer for the sustainable economy mode (Genovese et al., 2015). The idea of a circular economy is reducing the resource used by produce and also the creation of self-sustaining production systems in which materials are used over and over again. The main difference in RSC and CE is the core idea of business behind. RSC focuses on utilizing a product or its materials after usage. RSCs do not focus on designing products in a sustainable way as in the beginning. In practice, RSC might be a totally different value chain than a forward supply chain. That is still reality, especially in many consumer product chains. A CE focuses a brand new way of thinking about the entire business environment and value chain, where all material resources are planned to be used again and energy consumption during production and delivery is minimized. All value chain members should change their operational model in CEs.

Our contribution narrows the gap between logistics and business research, in the field of environmentally friendly and sustainable business operations and supply chain management by increasing the understanding of the relationship between RSC and CE concepts. This study focuses especially on the value creation and business model perspectives of the RSC and CE concepts. Furthermore, our systematic approach allows us to discuss important trends and develop a comprehensive agenda for future research. The paper begins with the methodology and subsequently delves into the value creation chapters or RSCs and CEs. The next chapter develops ideas for the future of sustainable business models and value creation. The last chapter offers a concluding discussion, discusses the limitations of the study and offers suggestions for future extension of the research.

METHODOLOGY

The findings in this working paper are mostly based on the review of selected literature. The majority of the available literature concerning CE is based on Chinese research and industries (Lieder and Rashid, 2016). This study focuses on the latest literature from western economies; Chinese articles are not used. Additionally, experiences from different industries, observations through visits, documents and other reports have been used to enrich the findings of this study. The phenomenon of CE is as yet a quite rare topic for logistic and supply chain academics, despite there being a lot of literature available on logistics supporting environment friendly industries. RSC is already a widely studied topic and is one of the most popular fields of research in supply chain management (SCM) studies today (Govindan and Soleimani, 2016). The value creation perspective needs more attention in RSC studies. The analysis in this paper is based on the value creation identification and analysis method for the understanding of value determinants in the RSC and CE concepts (Hemilä et al., 2015). The study seeks to answer the research question: "Which kind of sustainable business models and value creation methods ensure competitiveness in the future?". Synthesis of this study suggests concepts for sustainable business models in the future.

REVERSE SUPPLY CHAIN CONCEPT AND VALUE CREATION

Traditionally supply chain is understood as a forward supply and logistics. A widely used SCOR model has included return flow as one of the six supply-chain processes (SSC, 2005). However, the SCOR model does not have specific environmentally friendly or sustainable conceptualization included in the reference model. As the research and practitioners' focus have turned towards sustainability, the concept of RSC was introduced but initially the focus was on tactical and operational aspects of trying to minimize costs and comply with legislation (Schenkel et al., 2015). RSC is defined today as "The process of planning, implementing, and controlling the efficient, cost-effective flow of raw materials, in-process inventory, finished goods and related information from the standpoint of consumption to the point of origin for the purpose of recapturing

value or proper disposal" (Govindan et al., 2015). Reverse logistics, in general forms, start from end-users where used products are collected from customers (return products) and then attempts to manage EOL products through different decisions are undertaken including recycling (to have more raw materials or raw parts), remanufacturing (to resell them to second markets or if possible, to first customers), repairing (to sell in the second markets through repairing), and finally, disposing of some used parts. (Govindan et al., 2015). A closed loop supply chain (CLSC) constitutes the integration of the original forward supply chain with the reverse supply chain for product returns (Schenkel et al., 2015). Schenkel et al. (2015) have ipointed out that most studies that explicitly deal with the idea of value creation have focused on forward supply chains. With more firms showing an interest in RSCs and CLSCs, Schenkel et al. (2015) suggest it is time for research to move away from technical and operational issues toward the strategic impact of reverse supply chains as a means to create value. They have created views for economic, environmental, customer and information value within RSCs. They conclude that future research may focus on how and which specific RSC activities create multiple values. A previous study by Hemilä et al. (2015) focused on customer value, where emotional and symbolic value determinants play a dominant role. The customer is finally "who pays the bill", and in that manner, this study suggests that RSC value creation should focus on what the customer gets in RSC processes and how to provide value for customer. Is there some value for a customer when return flow is managed well or when materials are re-used? This study indicates that practitioners cannot clearly show value for customers in an RSC context. The earning logic of the RSC value chain is crucial for successful business. Environmental value is clear to identify, but is that something that someone is willing to pay? Value creation in RSC can be linked to other strategic fields such as the strategy for sustainability or product and service orientation (Schenkel et al., 2015). RSC operations should be linked to other value chain activities for ensuring strategic value proposition, e.g., the selling of re-usable materials, re-manufacturing, etc.

THE CIRCULAR ECONOMY CONCEPT AND VALUE CREATION

The concept of circular economy (CE) is to an increasing extent treated as a solution to a series of challenges such as waste generation, resource scarcity and sustenance of economic benefits (Lieder and Rashid, 2016). Since the first use of the concept of the circular economy, the terminology around the "circular economy" has been diverging rather than converging and the terms closed loop and circular economy are often used in parallel (Bocken et al., 2016). Some scholars use RSC and closed loop chains as synonyms. The principles underlining CE suggest that, by assuming the planet as a closed system, the amount of resources depleted in a period is equal to the amount of waste generated in the same period (Genovese et al., 2015). Material use is of two types: biological (renewable) materials, designed for reuse and ultimate return to the biosphere; and technical (non-renewable) materials, designed to move back and forth between production and consumption with minimal loss in quality or value (Lacy and Rutqvist, 2015). Companies in a CE are primarily focused on value creation based on management of resources in the markets, as opposed to management of resources solely in production. Ultimately, the circular economy results in zero-waste value chains powered via regenerative (renewable) energy, and natural resources are used in connected loops rather than consumed and discarded in linear flows (Lacy and Rutqvist, 2015). Planing (2015) has defined three main arguments for why the circular economy ideas among corporate managers changed dramatically in recent years. First, increasingly volatile commodity prices have fueled the need to safeguard resource supplies for manufacturing corporations. Second, information technology enables new business models that weren't thinkable a few years ago. Third, and maybe most fundamentally, we are in the beginning of a pervasive shift in consumer behavior that increasingly leads

to a performance over ownership mentality. In this study, we use Hemilä et al. (2014; 2015) value determinants and, in accordance with their value categorization Planing's first argument is creating functional value (resource efficient manufacturing/operational processes), economic value (cost efficiency). Information technology, Planing's second argument, is providing more efficient information sharing and change in operational models (digitalization). Value provided with ICT has enormous potential in many industries. However, information technology's link to the CE value is not clear. Planing's third argument for customer behavioral change for ownership ideology is a really big issue in value creation and today a basis for many service business initiatives too. From the logistics and supply chain perspectives, Planing's third argument has an enormous effect on operations as well for supply chain value. While RSC could be an individual company effort, CE requires all stakeholders to share same ideology. Only a comprehensive framework unique to the concept of CE that is jointly supported by all stakeholders is able to support successful CE implementation (Lieder and Rashid, 2016). A huge challenge from the customer value creation standpoint is the required change in people's mindset in order to steer focus toward the performance of products and their fitness for use rather than thinking in terms of new or second-hand products (Lieder and Rashid, 2016). Emotional and symbolic value determinants have been seen today to be the most influential factors in human decision making (Hemilä et al., 2015). Some customers are always willing to buy new and even luxury products, despite their not usually being the most sustainable and environmentally friendly choices.

THE FUTURE OF SUSTAINABLE BUSINESS MODELS AND VALUE CREATION
Emotional and symbolic value creation determinants are essential for decision making, and for successful management, decision makers should identify and analyze them (Hemilä et al. 2015). The Hemilä et al. 2014 study focused on value determinants, where symbolic value is believed to be 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). We argue that to create unique value (whether functional, economic, emotional or symbolic) for customers, entire product-service offerings should be redesigned and maintained until the end of a product's life or the recycling or re-use time of its materials. The more radical the technical or product innovation, the more challenging it is and the greater the likelihood that changes are required to the traditional business model (Bocken et al., 2016). The reverse supply chain is then the economic activity to realize product return flow in practice. All stakeholders should be integrated on the sustainable operation mode. From environmental- and sustainability-focused points of view, it is not enough just to focus on logistics and supply chain activities, i.e., RSC, but the entire business should be redefined towards CE. The move to a circular economy model is a radical change, which will require a new way of thinking and doing business. Disruptive business models are needed in order to move towards the CE model, and on the other hand, there is an evident need to base new business models on an in-depth understanding of stakeholders and customer value creation (Antikainen et al., 2015; Hemilä et al., 2015).

According Planing (2015), the transition to the circular economy entails four fundamental building blocks: 1) materials and product design, 2) new business models, 3) global reverse networks, and 4) enabling conditions. In forward chain the materials and product design are separate process from RSC, while in CE product should be designed with taking care of EOL. Planing has argued that the

starting point for CE is more efficient and longer use of current products, and based on this, reverse networks come into place to recover either the product itself or its components and materials. In that way, Planing is combining RSC and CE concepts. Surely, it is a way towards CE, but our study indicates reverse network only is not still a CE, but rather an RSC approach. The second building block, a new business model, is definitely a crucial contributor to CE operations and business. Business model innovation offers a potential approach to deliver the required change through re-conceptualizing the purpose of the firm and the value creating logic, and rethinking perceptions of value (Bocken et al., 2014). Actually, in our study, we have noticed business models to be the most important component of the movement towards CEs. Planing (2014) suggests that business models actually combine all other building blocks. Planing's third (global reverse networks) and fourth (enabling conditions) building blocks are surely important, but can be seen as basic features of the business environment in CEs. In CEs, customer behavior moves away from a linear mode. Sustainability and environmentally friendly ideas for customers have led to a situation where customers are not willing to own anymore, but rather pay-per-use or allow for access instead of ownership (Planing, 2014). Recent customer value research has indicated that a clear understanding of customer value is the starting point for new business models and it is recommend to focus on the value proposition design when aiming towards a CE. The management and value creation of the return chain in CE should include the alignment in profit-share along the supply chain. Otherwise supply chain (return chain) partners cannot have profitable businesses. Lieder and Rashid (2016) have developed a comprehensive framework for CEs based in three main elements pertaining to their relationships: 1) resource scarcity, 2) environmental impact and 3) economic benefits. From our study perspective, the most important factor is the economic benefits, which include business models. Surely nations and governmental bodies can economize force towards a CE, but wide and global implementation requires economic benefits to be achieved for companies and economical entities.
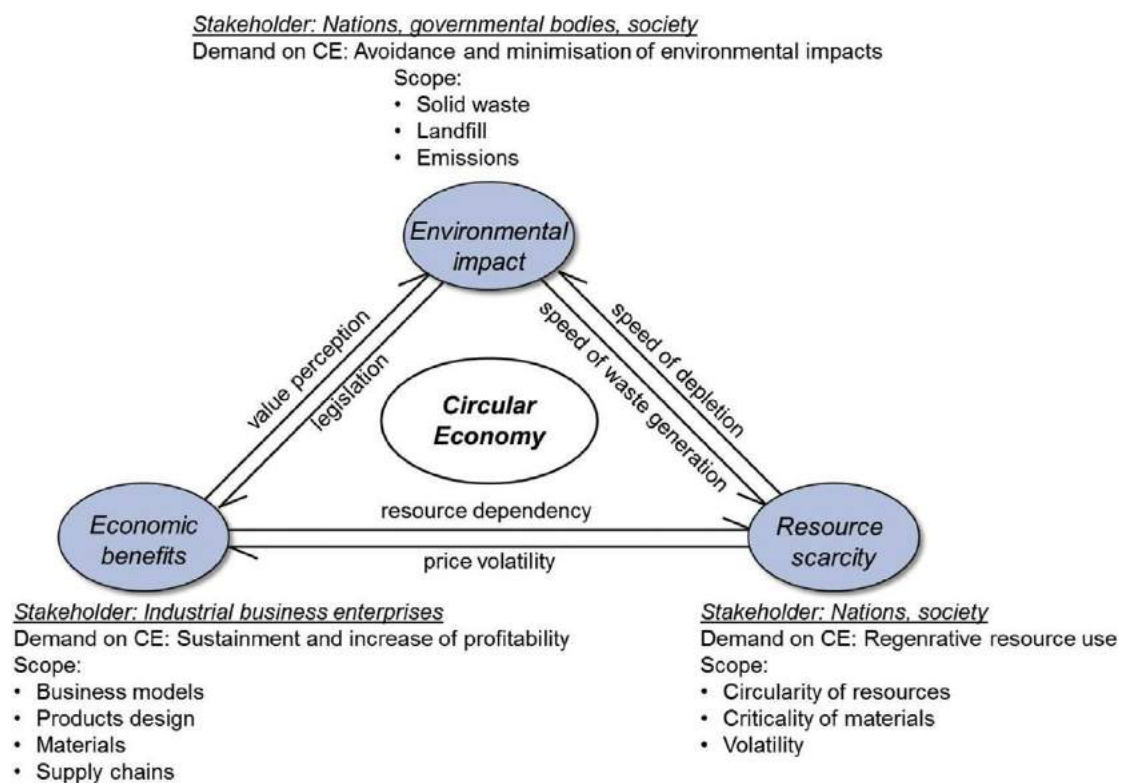
Figure 1. A comprehensive CE framework (Adopted from Lieder and Rashid, 2016).

The last viewpoint this study indicates is required competencies for successful CEs. The CE business model is very close to service business model, which is a structured configuration of people, technology and shared information that interacts with other service systems to create value. Companies should decide what their own role is in the value chain, how one creates value, and the kind of competencies that are needed to ensure value creation (Hemilä, 2015). Supply management professionals will need the skills and capabilities to understand and interpret CE and RSC market dynamics, analyze complex supply options and risks, and develop innovative value-acquisition strategies that integrate with and support business and functional strategies (Hemilä, 2015). Diversity among employees can create better performance while changing business and operational setups. New, fresh ideas and sustainable mindsets are needed when moving towards CE.

CONCLUSIONS
Reverse supply chain (RSC) management entails the effective and efficient management of a series of activities to return products, parts or materials from the customer with the aim of recovering their value (Defee et al., 2009). These activities include reverse logistics and recovery options such as remanufacturing, refurbishing or recycling. The concept of circular economy (CE) is a solution to a series of challenges such as waste generation, resource scarcity and sustenance of economic benefits (Lieder and Rashid, 2016). At the industrial level, multidisciplinary approaches involving business perspectives, technological developments and policies need to be considered (Lieder and Rashid, 2016). Future developments for CE will require more extensive work in the area of social awareness and new business models as primary triggers for wider implementation of the concept. Without doubt, the CE and even RSC business models provide huge opportunities for companies, customers and the environment.

Research limitations/implications
This study compares the RSC and CE concepts, without the practical evidence from case studies, which is a limitation of this study. The focus of the study is on western economies despite an abundance of literature being available on Asiana and especially on the Chinese economy; this fact in itself is another limitation of this study. In future research, more practical evidence is needed of how to develop a CE business model with an efficient reverse supply chain.

Practical implications
The managerial contribution of our study lies in the relevance of findings for practitioners, who are increasingly pressured to engage in RSC and CE activities. This paper provides for practitioners a better understanding of the development and movement towards CE. Further, it analyses how to transform a business mindset from a traditional economic model towards circular economy systems and create value for customers within it. This study indicates that it is critical for success for companies to develop cross-functional operations that link design, R&D, manufacturing, distribution, reverse logistics and marketing together. New competencies might be required, for example, in engineering, logistics and customer relationship management.

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MODELING CARBON FOOTPRINT OF THE REVERSE LOGISTICS OF DISPOSING WASTE OF UPHOLSTERY INDUSTRY

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ABSTRACT

Owing to the rising awareness of the need to protect the environment, reverse logistics is being promoted to improve ecological sustainability of production. An upholstery company generates a lot of waste at the start of a new interior decoration because it needs to destroy the existing decoration. However, the reverse logistics of the upholstery sector are still unclear. This study models the carbon footprints of disposing upholstery waste based on studies from Benjaafar et al. (2013), Pishvaee et al. (2009) and Tascione et al. (2014). Modeling the carbon footprint of disposing upholstery waste can help companies aware of the environmental impact of disposing of waste, and how to improve it through reverse logistics. This study further performed a preliminary qualitative analysis from the interviews to upholstery companies, and gathers factors of that contribute to carbon footprints before and after the adoption of reverse logistics.

Key words: Upholstery, interior decoration, waste management, reverse logistics, carbon footprint, linear programming.

INTRODUCTION

Reverse logistics has recently become popular to encourage the sustainable production of goods. Over-use of natural resources, a common result of advancing economic development, leads to gradual destruction of the ecological environment. Therefore, environmental awareness and conservation are becoming increasingly important.

Manufacturers are increasingly implementing green supply chains that extend the in-plant green manufacturing processes to up- and down-stream cooperating companies. Therefore, reverse logistics, based on the green supply chain, that can reserve available resources for their sources is discussed in industry (Wang, 2011).

Upholstery companies need to implement reverse logistics in order to minimize energy consumption. World Organization for Economic Co-operation and

Development (OECD) reported in "Sustainable building environment: Challenges and Policy" in 2013 that the construction of buildings creates 40% of all waste. Over 40% of greenhouse gas emissions come from constructing the houses or mansions (Lien et al. 2014). Therefore, our building technologies need to evolve to satisfy the demands of climate change predictions, while simultaneously reducing their contribution to CO_2 emissions (Gill Seyfang, 2010).

Carbon footprint helps a company to understand the importance of reverse logistics in protecting the environment. Therefore, a company should better understand the reverse logistics of green building materials in implementing carbon emission reductions.

To minimizing carbon emissions in reverse logistics, manufacturers should price as well as calculate the carbon footprint. By pricing the carbon footprint, a company can understand the cost of carbon to the environment. At the Climate Summit held in Paris in December 2015, 195 countries gathered to try to reduce greenhouse gas emissions (mainly carbon dioxide) and form the first climate agreement, the Paris Agreement. This agreement comes into effect in 2020, and makes 'carbon pricing' the top priority for protecting the environment.

In summary, this study calculates the carbon footprint of reverse logistics using the Benjaafar (2013), Pishvaee (2009) and Tascione (2014) models as references, and develops a model through probed carbon emissions of reverse logistics of the upholstery sector.

LITERATURE REVIEW

1. Reverse logistics

Environmental protection is a major worldwide trend because of disasters from global warming. People dispose of garbage through recycling, landfill or incineration. The key point of reverse logistics is how to reuse or remanufacture the value-retaining parts of garbage to ensure sustainable environment protection.

The main method of implementing a green supply chain strategy is reverse logistics, which is defined as "the process of planning, implementing and controlling the efficient, cost-effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal" (Daga, 2004). The aim of reverse logistics is to protect the environment and save resources (Xu et al. 2011).

Cruz-Rivera and Ertel (2009) concluded that through reverse logistics, a company not only increases the value of recycled resources from a broken product, but lowers the cost of discarding it. The company can re-manufacture a product using the recycled resources, and thus save manufacturing cost directly. The saving

cost encourages manufacturers to proceed with recycling. The completed supply chain consists of forward and reverse logistics (Fig. 2-1) (Sasikumar and Kannan, 2008b, 2009).
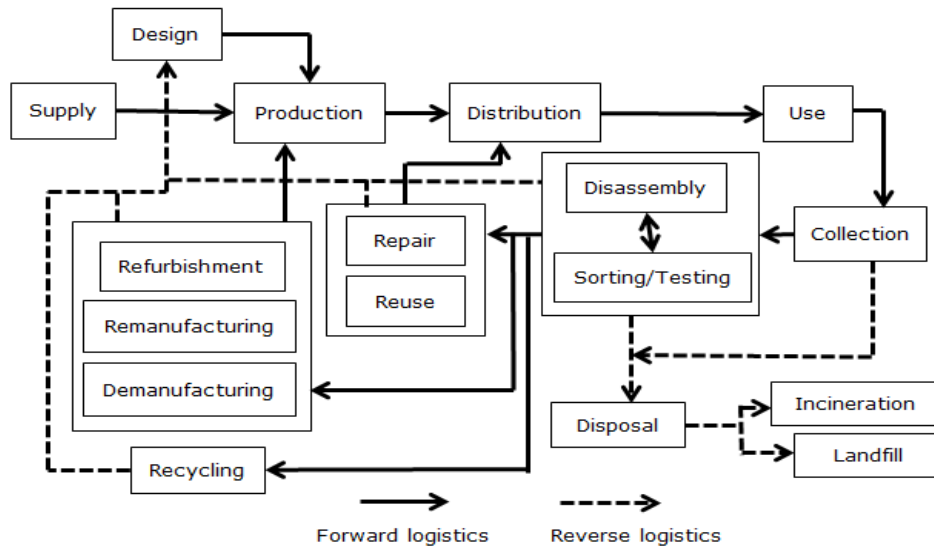
Fig.2-1 A framework of a completed supply chain

2. Interior upholstery materials

The use of reverse logistics to manage the supply chain of interior upholstery materials reduces the level of construction environmental hazards by reducing the amount of disposal or reusable parts from the deconstruction of old or broken materials. For instance, in Taiwan, existing interior upholstery needs to be removed before setting up new upholstery, generating a lot of waste if the company simply disposes of the removing upholstery. Construction waste is divided into nine categories (Table 2-1).

Table 2-1 Categories of recycling interior upholstery materials

Categories of recycling	Recycling Usage
Waste woods (board, sawdust)	Pulpwood, oil absorbent material, wood, pulp additives, organic fertilizers, soil mixture for cultivation.
Glass fragments	Glass products, ceramic tiles products, concrete products.
Iron	Steel-making, iron ingots, iron products, cast iron.
Pure metal material (copper, zinc, aluminum, tin)	Pure waste metal (copper, zinc, aluminum, tin) products.
Plastics	Plastic materials, iron and steel plant auxiliary fuel, plastic decompose materials.
Rubber	Upholstery, asphalt concrete additives, rubber,

	oil refining materials and auxiliary fuel.
Mixture of construction	Construction engineering materials, engineering landfill and road engineering ingredients, engineering landfill materials, aggregate and construction materials, concrete additive materials, tile materials, and materials generated through construction work such as metal shaving, shards of glass, plastic and sawdust.
Calcium silicate	Calcium silicate filler.
Gypsum board	Re-use purpose: gypsum board materials.

The Construction and Planning Agency (2000) reports that the annual construction wastes (excluding public constructions) of northern Taiwan occupies 48% of the annual wastes. Taiwan has more than 70,000 constructions annually, generating (including waste soil and mixture) about 18 million tons of wastes, but it has insufficient capacity and locations for storing waste.

Additionally, 85% of construction mixtures can be recycled, but Taiwan has ineffective control and management of recycling. Recycling construction material instead of throwing it away is increasingly popular worldwide, but has not been widely applied in Taiwan.

3. Carbon footprint

According to the International Energy Agency report from, in Taiwan released 248.7 megatonnes of carbon emissions in 2013, making it 22nd in the world, and 10.63 tonnes per person, ranking 11th in Asia (Environmental Protection Administration, 2014). Although Taiwan is working to reduce carbon emission, it remains behind many other countries.

Studies have discussed the impact of pollution on the environment through the carbon footprint, whose origin can be traced to the "ecological footprint" (Wackernagel et al. 1996). The ecological footprint is the calculation of the amount of natural resources that a person needs, and how much waste is generated for disposal by people in the world (Industrial Development Bureau, 2015).

Owing to the global warming crisis, reducing greenhouse gas emissions, particularly of carbon dioxide produced by petrochemical fuel, has become a main purpose. Pricing carbon can help people to understand the cost, because the cost can increase people's awareness of inductionless pollution. According to Christine Lagarde, Managing Director of the International Monetary Fund, "Carbon pricing is effective in reducing emissions that cause climate change, is straightforward to administer, can raise valuable revenues for broader fiscal reforms, and can help

address local pollution as well as global climate change" (Dana, 2015).

The carbon footprint can be calculated directly from actual carbon emissions, or indirectly from energy consumptions or emissions of carbon. Carbon footprint can be determined from gas emissions in the air by using the Global Warming Potential (GWP) factors (The Intergovernmental Panel on Climate Change (IPCC), 1990).

The carbon footprint calculation is based on previous methods (Table 2-2). This study presented a model based on the models and parameters developed by Benjaafar et al. (2013), Pishvaee et al. (2009) and Tascione et al. (2014), because not every model is always feasible in this study. The parameters used by the model are capacity, distance, carbon emissions during transportation (including number of trucks).

Table 2-2 Categories of carbon footprint calculation

Benjaafar et al. (2013), and Pishvaee et al. (2009) form a model from a case study.	The parameters include: 1.Cost of transportation 2.Capacity 3.Distance 4.Fixed cost 5.Fixed carbon emissions 6.Number of trucks 7.Carbon emissions of during transportation 8.Capacity of trucks
Tascione et al., 2014, formulated linear programming model with a single impact category	The parameters include: 1.Maximum unit(s) of waste fractions that the destination can accept 2.Unit(s) of environmental impact to treat/disposal of one unit of waste fraction 3.Distance from the waste collection center to the place of destination 4.Unit(s) of environmental impact to transfer one unit of waste over one unit of distance

METHOD

This study models the carbon footprints of disposing upholstery waste based on studies from Benjaafar et al. (2013), Pishvaee et al. (2009) and Tascione et al. (2014). The objective function, decision variables and constraints of the formulating model are discussed in the next section.

DISCUSSION

The proposed formula of this model is to calculate the minimized carbon footprints of disposing upholstery in reverse logistic based on a real case in Taiwan. The first term of the proposed formula is the sum of the carbon emission of the demolition companies; the second term is the sum of transportation carbon emission between customers and the contracted demolition companies; the third and fourth terms are the sum of transportation carbon emission between customers and recovery/recycling centers (i), and between customers and landfill/incineration houses (m); the fifth and sixth terms are the sum of carbon emission of recovery/recycling centers (i) and landfill/incineration houses (m). The formula is as followings and the decision variables have described on Table 3-1.

Minimizing the carbon footprints

$$= \sum_{j \in J} F_j \times X_{aj} + \sum_{j \in J} \sum_{a \in A} (d_{aj} \times \alpha_{aj} \times N_{aj})$$

$$+ \sum_{a \in A} \sum_{i \in I} (d_{ai} \times \alpha_{ai} \times N_{ai}) + \sum_{a \in A} \sum_{m \in M} (d_{am} \times \alpha_{am} \times N_{am}) + \sum_{i \in I} F_i \times V_{ji}$$

$$+ \sum_{m \in M} F_m \times T_{jm}$$

Table 3-1 Decision variables

$W_i = 1$	$Y_i : \begin{cases} if \ recovery/recycling \ center \ is \ opened \ at \ location \ i \\ \qquad 0 \quad otherwise \end{cases}$
$Y_j = 1$	$Y_i : \begin{cases} if \ demolition \ company \ is \ opened \ at \ location \ j \\ \qquad 0 \quad otherwise \end{cases}$
$Z_m = 1$	$Y_i : \begin{cases} if \ landfill/incineration \ house \ is \ opened \ at \ location \ m \\ \qquad 0 \quad otherwise \end{cases}$
V_{ji}	Quantity of new products produced by recovery/recycling center(i) (ton/hr)
X_{aj}	Quantity of upholstery waste generated by demolishing (j) (ton/hr)
T_{jm}	Quantity of irrecyclable products disposed by landfill/incineration house (m) (ton/hr)

The constraints of the proposed model have described on Table 3-2. Eqs. (1) restrict the total carbon emissions less than or equal to the carbon cap; Eqs. (2) to (3) confirm the flow balance at recovery/recycling center (i), and landfill/incineration house (m) in reverse logistics; Eqs. (4) to (5) represent capacity constraints on facilities; Finally Eqs. (6) and (7) enforced binary and non-negative restrictions on corresponding decision variable.

Minimizing the carbon footprints

Table3-2 constraints of the formulating model

$$\sum_{j \in J} \sum_{a \in A} (d_{aj} \times \alpha_{aj} \times N_{aj})$$ $$+ \sum_{a \in A} \sum_{i \in I} (d_{ai} \times \alpha_{ai} \times N_{ai}) + \sum_{a \in A} \sum_{m \in M} (d_{am} \times \alpha_{am} \times N_{am}) \leq CO_2$$	(1)
$$\sum_{i \in I} V_{ji} - (1-s) \sum_{j \in J} X_{aj} = 0$$	(2)
$$\sum_{m \in M} T_{jm} - s \sum_{j \in J} X_{aj} = 0$$	(3)
$$\sum_{j \in J} V_{ji} \leq cwr_i \times W_i \quad \forall i \in I$$	(4)
$$\sum_{j \in J} T_{jm} \leq cz_m \times Z_m \quad \forall m \in M$$	(5)
$W_i, Y_j, Z_m \in \{0,1\} \quad \forall i \in I, j \in J, m \in M$	(6)
$X_{aj}, V_{ji}, T_{jm}, N_{aj}, N_{ai}, N_{am} \geq 0 \quad \forall i \in I, j \in J, m \in M$	(7)

CONCLUSION

This study further applies actual manufacturer data to verify the results of this model. The data of carbon emission factors are obtained by preliminary qualitative interview. The proposed model is verified by analyzing carbon emission factors in the reverse logistics program. Furthermore, the key behavioral indicators (KBI) can also be developed for further applications. The model incorporates a mechanism for timely reduction of carbon emissions. Modeling the carbon footprint of disposing upholstery waste can help companies aware of the environmental impact of disposing of waste, and how to improve it through reverse logistics.

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GREEN INTELLECTUAL CAPITAL, GREEN DYNAMIC CAPABILITY AND PERFORMANCE : EVIDENCE FROM MANUFACTURING FIRMS IN TAIWAN

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ABSTRACT

Purpose:

The purpose of this paper is to comprehensively conceptualize a holistic structural model of green intellectual capital, green dynamic capabilities and firm performance to apply both natural resource-based view and dynamic capabilities in elaborating sources of firms' competitive advantages.

Design/methodology/approach:

This study collected both subjective questionnaires data and objective secondly data from 170 manufacturing firms in Taiwan, and then used Squares Structural Equation Modelling (SEM) to examine the causal relationships among green intellectual capital, green dynamic capability, and firm performance.

Findings:

The empirical results of this study partially supported the proposed relationships among green intellectual capital, green dynamic capability and firm performance. The direct effect of green intellectual capital on firm performance did not revealed significant, however, the indirect effects from green intellectual capital through green dynamic capability to impact on firm performance is significant. Specifically, this empirical model verified the proposed fully-mediated effects of green dynamic capabilities. Therefore, the empirical findings suggest that top managers should enforce and improve the green intellectual capital and green dynamic capability to acquire and maintain competitive advantage.

Value:

This research identifies and describes the causal effects and paths that facilitate firm performance from establishing green intellectual capital and green dynamic capability. By delving into the relationships among green intellectual capital and green dynamic capability, and firm performance, the research explains the detail and differences of green capital and green dynamics. Ultimately, it is the necessary mediating roles of green dynamic capabilities that make firm outperform rivals.

1. INTRODUCTION

In the last decades, climate change, environmental awareness, and green consumptions have raised more and more concerns on the environmental green management issues for business, government and consumers (Shang, Lu, and Li, 2010; Shang et al, 2010; Albino and Berardi, 2012; Lirn et al. 2014). Many multinational corporates actively participated in "Carbon Disclosure Project, CDP", such as Timberland (Dauncey, 2013), Wal-Mart (Huckabee, 2008), Dell computer and British retailer Tesco (Johansen, 2015).

Driven by an export-oriented trade policy, the manufacturing sector has always been at the center of Taiwan's economic development. Earlier most manufacturers in Taiwan treated investing resources in environmental initiatives is pointless and expensive, however, strict environmental regulations and prevalent environmentalism have changed the competitive rules in practices. Environmental challenges could also become green opportunities that stimulate firms to adopt environmental innovations to enhance green images and competitive advantages (Porter and van der Linde, 1995). The key is that companies not only ensure themselves to react to the green challenges, but also prosper from these emergent green opportunities. Therefore, more manufacturers are adopting various green initiatives—the voluntary incorporation of environmental and social issues into a company's business strategies and attempting to meet the requirements and expectations of a range of company's stakeholders(Ioannou and Serafeim, 2015). Concurrently the environmental management literature has grown considerably; the natural resource-based view (NRBV) of the firm was one of prominent theory that has explored the implementation and effects of green practices such as eco-design, cleaner production, green purchasing, and green logistics, on financial, operational and environmental performances. NRBV adapted from RBV which is focus on steady-state firm resources, here we adopted the term "green intellectual capital" revised from original intellectual capital, and defined it as the bundle of all kinds of intangible assets, knowledge, and capabilities concerned environmental management, and green competencies (Chen, 2008; Dzinkowski, 2000; Stewart, 1994). Extant empirical study showed that green intellectual capital had positive effects on firms' competitive advantages (Chen, 2008).

The rapid rising of green force and the emergence of green opportunities have intensified global competition that firms can't just hold still. Companies need appropriate strategies to respond rapidly and flexibly in order to survive in this troubling time within international marketplace (Buckley and Casson, 1998). Meanwhile, valuable firm-specific dynamic capability is treasured highly to enable firms to develop innovative products or reconfigure business processes to adapt to an ever-changing competitive environment, and hence sustain a firm's competitive advantage (Teece and Pisano, 1994; Teece et al., 1997; Wilson and Daniel, 2007; Bueno et al., 2008; Ambrosini and Bowman, 2009; Bi et al., 2013; Pan et al., 2015). Here this study is set under environmentalism drivers, this kind of firm-specific dynamic capability is called "green dynamic capability" adapted from Teece et al. (1997) and Chen (2012) that is "The capability of a company that synthesize and reconfigure internal and external resources to cope with a volatile and dynamic market in a timely manner". The purpose of this paper therefore is to comprehensively conceptualize a structural model of green intellectual capital, green dynamic capabilities and corporate performance hypothesizing cause and effect, and mediating relationships. Adopting a more holistic framework such as this offers potentially important insights for managers into how firms successfully establish, configure, and leverage resources and capabilities, ultimately leading to more sustainable competitive advantages.

2. THEORETICAL BACKGROUD AND HYPOTHESES

The natural-resource-based view (NRBV) of a firm (Hart 1995) is an adaptation of the resource-based view (RBV) of the firm which argues that resources and capabilities are valuable, rare, non-substitutable, and inimitable form the basis of sustainable competitive advantages (Barney 1991). Although RBV is good at explaining how a firm can use its intangible resources to implement valuable strategy that sources performance, it failed to fully explain how and why some firms outperform others in rapidly changing environments (Carlos, 2011; Eisenhardt and Martin, 2000). Thus, Teece originated the theory of "dynamic capabilities" which derived from RBV and complement with RBV, is a set of learned processes and activities that enable a company to produce a superior performance. One key implication of the dynamic capabilities perspective is that firms are not only competing on exploitation of existing resources and organizational capabilities, but also competing on renewing and development of organizational capabilities to fit the volatile environment (Teece and Pisano 1994; Teece et al. 1997, Winter 2003). In this study, we adopted a notion, 'green dynamic capabilities', which is modified from Teece et al. (1997) and Chen and Chang(2013) to define it as "the ability of a firm to exploit its existing resources and knowledge to renew and develop its green organizational capabilities to react to the dynamic market". This study applies the NRBV and 'green dynamic capabilities' "of a firm to explore the influences of green capital and green dynamic capabilities on firms' performance and investigates the mediation role of green dynamic capabilities in manufacturing companies listed in Taiwan stock exchange.

Green Intellectual Capital and Firm Performance

For a long time the term "intellectual capital" has been used as a synonym for intangible or knowledge assets since the work of Stewart (1991). It has been called "capital" because of its economic roots- the economist Galbraith described it in 1969 as a process of value creation and as a bundle of assets at the same time. The definition of intellectual capital is a set of intangible knowledge assets that generates firm performance and value creation (Gogan and Draghici, 2013), therefore we can tie intellectual capital to the resource-based view (RBV). Due to the rising awareness of environmental protections and green consumption, the academy had proposed the corresponding concept of "Green Intellectual Capital" that enables firms to maintain sustainable competitive advantages in this environmentalism era (Chen, 2008; Huang and Kung, 2011). Green intellectual capital is essential to firms' sustainable strategies (Epstein, 2008). Like intellectual capital that has been described as multidimensional construct comprising human, structural and relational capitals (De Castro and Lopez-Saez, 2008; McPhail, 2009; Diez *et al*., 2010; Gogan and Draghici, 2013; Lu and Hung, 2010; Sydler *et al*., 2014), hence, this study suggests that green intellectual capital is comprised of green human capital, green structural capital and green relational capitals that are necessary to fulfil the goal of sustainable competitive advantage. Human capital embedded in individual employees rather than in organization (Nieves and Haller, 2014) and it will reduce because of strategic human resources leave. Therefore, green human capital is the summation of employees' knowledge, skills, capabilities, experience, attitude, creativities, and commitments, etc. about environmental protection and green innovation. Structural capital on the other hand, is embedded in organizations and it remains in a firm even employees leave (Aminu and Mahmood, 2015). Structural capital includes both organizational and technological elements that pursue the integration and coordination of activities within a firm (De Castro and Lopez-Saez, 2008). Hence, this study refer to Chen's (2008) defines the "green structural capital", as the stock of patents, copy rights, and trademarks, management

systems and processes, organizational culture, and computer networks etc. about environmental protection and green innovation within a company. Lastly, relational capital generates value from relationships between the focal firm and its key stakeholders such as customers, suppliers, and partners (Sydler *et al*., 2014). Particularly, relational capital results in customer loyalty and satisfaction (Yildiz *et al*., 2014), network with suppliers, distributors and reputation, attitude and brand recognition in marketplaces (Sydler *et al*., 2014). Jaradat et al. (2012) has established significant relationship between the intellectual capital and competitive advantage in taxation service firms. Roos and Roos (1997) contended intellectual capital is the most significant source of organizational routines, processes as well as core competences and capabilities that generate performance. Moreover, several empirical studies established that there is positive significant relationship between intellectual capital and performance (Abdullah and Sofian, 2012; Chen *et al*., 2014; Santos-Rodriues *et al*., 2010; Lu *et al*., 2014). Consequently, the present study proposed the following hypothesis:

Hypothesis 1: Green intellectual capital is positively associated with firm performance

Green Dynamic Capability and Firm Performance

Nowadays, many organizations are facing fast changing and highly volatile environments. Therefore, dynamic capabilities have gained particular attention by scholars in strategic management research (Teece, Pisano & Shuen 1997; Winter 2003). However, the diversified definitions and interpretations have been proposed (Barreto 2010; Eisenhardt &Martin 2000; Zahra, et al., 2006), and still exist differences. According to Zollo and Winter (2002) dynamic capabilities can be defined as "a stable pattern of collective activity through which the organization systematically generates and modifies its operating routines in pursuit of improved effectiveness". Makkonen *et al*., (2014) argued that a novel combination of new knowledge and a firm's existing resources into new operational capabilities constitutes the fundamental of dynamic capabilities. It is still divergent options toward the measurement dimensions of dynamic capabilities, for example Li and Liu (2014) categorized dynamic capabilities into three dimensions- strategic sense-making, timely decision-making and change implementation capacity, Villar *et al*. (2014) proposed two dimensions of knowledge management dynamic capabilities- external integration and internal development, Tseng and Lee (2014) claimed sensing and integrating capabilities, and Denford (2013) classified dynamic capabilities into eight dimensions- creating, integrating, reconfiguring, replicating, developing, assimilating, synthesizing and imitating etc. This study used the more comprehensive categorization by Pavlou and Sawy (2011) and retained the spirits of Teece (1997), green dynamic capabilities that comprise three basic dimensions (i.e., green monitoring, green learning, and green integrating). Similarly, it has been suggested that the novel combination of existing knowledge assets and firm resources into new operational capabilities constitutes the fundamental of higher firm performance (Jiao *et al*., 2013; Makkonen *et al*., 2014; Pavlou and Sawy, 2011). Thus, under growing green pressures, superior performance relies on the firm's ability to integrate, build and reconfigure such intangible resources (Wu, 2007). Accordingly, the present study proposed the following hypothesis:

Hypothesis 2: Green dynamic capability is positively associated with firm performance

Green Intellectual Capital and Green Dynamic Capability

Recently, the business environment, which is characterized by phenomena such as globalization, hyper-competitiveness, fast technological innovations, as well as rapid changes in environmentalism pressures, firms need to develop and implement competitive strategies that will yield dynamic capabilities, competences and then sustained competitive advantage (Marr *et al*., 2004). Tseng and Lee (2014) argued that the firm's own stock of inherent resources that are helpful to develop idiosyncratic competitive advantages has become an urgent need. Stahle and Hong (2002) stated that intellectual capital was created for updating understanding of the competitive edge of firms in rapidly changing environments.

According to the conception of green dynamic capabilities in this study, the incremental and radical innovation capabilities are relevant to operationalize green dynamic capabilities as mechanisms mediating the contribution of intellectual capital to the performance of firms. From this perspective green intellectual capital may be expected to be an antecedent of green dynamic capabilities of firms. From another perspective, green dynamic capabilities may be conceived as an organizational process that activates the intangible resources of firms. More precisely, green dynamic capabilities may be considered as a generative mechanism through which green intellectual capital is refreshed to further contribute to the firm performance. Subramaniam and Youndt(2005) argued that inherent differences in the key attributes of human, structural, and relational capital cause a particular reinforcing or transforming influence on incremental and radical dynamic capabilities. This leads to expect that the contribution of green intellectual capital to the firm performance. Thus, we expect intellectual capital to enhance the green dynamic capabilities and thereby influence firm performance, hypothesis described as follows,

Hypothesis 3 Green Intellectual Capital is positively associated with Green Dynamic Capability
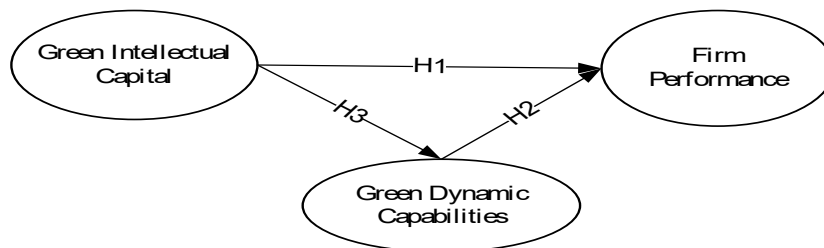
Figure 1 Conceptual Framework

3. METHODOLOGY AND MEASUREMENT

Data, sample, and analytic method

Based on the postulated hypotheses (in figure 1), the questionnaire is then designed as an instrument of collecting subjective data. The corresponding financial data was downloaded from market observation post system established by Taiwan Stock Exchange. To insure content validity of the scale used, the questionnaire items were developed from literature reviews and modified to fit the context of the environmentalism when it is necessary. The reasons why this study select manufacturing firms as research target is because production cost advantages and industrial upgrade policy made the manufacturing sector become crucial part of Taiwan's economic development. Each item was measured

on a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). To achieve the desired balance and randomness in the questionnaire, several items were written in appropriate negation wordings and all questionnaire items were randomly reordered to reduce the potential ceiling and floor effect, which might cause monotonous responses to the measures of a particular construct. Furthermore, to ensure that the question items could be understood and measured validly, pretest was conducted with a small group. The sample of questionnaire survey was randomly selected from 1,200 main manufacturing firms listed in Taiwan Stock Exchange. The respondents of the questionnaires are CEOs or spokespersons who are familiar with firm's environmental strategies. One thousand and two hundred questionnaires were sent to the selected companies. There are 170 valid questionnaires, and the effective response rate is 14.17 %.

Structural equation modelling (SEM) was used for hypotheses testing. The data were analyzed in two steps recommended by Anderson and Gerbing (1988). First, the measurement model was estimated using confirmatory factor analysis (CFA) to examine the validity and reliability of the constructs. Secondly, the research model was tested by the simultaneous estimation of the measurement and theoretical (structural) models. Before testing the hypothesis and relationships between the constructs in the structural model, the measurement model with a satisfactory level of validity and reliability must be demonstrated. AMOS 20.0 and SPSS 20 were used to assess the construct reliability and validity. Using the data collected from the questionnaires, the standardized factor loadings, correlations, and goodness-of-fit statistics, were obtained and validated.

The Measurement of the Constructs

The definitions and measurements of the constructs in this study are stated in the following:

Green Intellectual Capital

Despite continuing differences in definitions and conceptualizations, the field is starting to see a consensus is emerging regarding what intellectual capital encompasses (Bontis et al, 2002). Generally the measurements of intellectual capital have been revisited by different line of research and reconcile components of intellectual capital to consist of three basic and strongly interrelated components :(1) Human capital;(2) Structural capital; and (3) Relational capital (Kaplan and Norton, 1992; Saint-Onge, 1996; Edvinsson and Malone, 1997;Stewart, 1997; Sveiby, 1997; Bontis, 2001; Meritum, 2002; Warden, 2003). Here we summarized above definitions and revised it as the accumulation of intangible assets, knowledge, capabilities, and relationships, etc. regarding environmental management and innovation in both the individual level and the organization level within a company. Items for measuring Green Intellectual Capital (GIC) were mainly adapted from extant literatures, for example Chang and Chen (2012), Huang and Kung (2011), and Chen (2008). The green human capital comprises five items: (1) Competitive environmental employees' productivity and contribution; (2) Better employees' environmental competence; (3) Better qualities of environmental product/service; (4) Better team work regarding environmental management issues (Bontis, 1999; Edvinsson and Malone, 1997; Johnson, 1999; Roos and Roos, 1997; Stewart, 1994). Second, items adapted to measure green structural capital are five: (1) superior management system of environmental protection; (2) Higher Ratio of R&D investments in environmental projects; (3)Actively spread environmental management value; (4) Establish Environmental Knowledge management system. The last, items adapted to measure green relational capital are five

: (1) Offer green products/services; (2) Customers' satisfaction regarding organizational environmental practices; (3) Close environmental cooperation with suppliers; (4) Loyal customers regarding environmental strategies; (5) Solid Environmental cooperation relationships with strategic partners (Bontis, 1999; Capello, 2002; Capello and Faggian, 2005; Johnson, 1999).

Green Dynamic Capabilities

In this study, we adopted and modified and integrated from Teece et al. (1997), Chen and Chang (2013), Nieves and Haller (2014), and defined "green dynamic capabilities" as "the ability of a company to exploit its existing resources and knowledge to renew and develop its green organizational capabilities to react to the dynamic market". For most researchers have reached the consensus in three dimensions "integration, " "learning," and "monitoring", thus this study also follow the same classification. The measurement of green dynamic capability comprises ten items: (1) Fast monitor the environment to identify new green opportunities; (2) Periodically review to identify and develop new green knowledge; (3) Develop new green technology; (4) Assimilate, learn, generate, combine, share, transform, and apply new green knowledge; (5) Integrate and manage specialized green knowledge; (6) Coordinate employees to develop green technology; (7) Allocate resources to develop green innovation; (8) Appropriate routines to assimilate new information and knowledge; (9) Manage to successfully interconnect members' activities; (10) Effective in transforming existing information into new knowledge

Each item was measured on a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). To achieve the desired balance and randomness in the questionnaire, half of the items were written in appropriate negation wordings and all questionnaire items were randomly reordered to reduce the potential ceiling and floor effect, which might cause monotonous responses to the measures of a particular construct.

4. EMPIRICAL RESULTS

Sample characteristics

170 valid questionnaires were used for analysis after screening invalid ones by using reverse questions and identifying illogical answer patterns. Table 1 presents the sample characteristics of the respondents.

Table 4.1 Sample characteristics

Demographics	Percentage	Demographics	Percentage
Industry	Electronics (52%) Non-Electronics (48%)	Established	5-10 yrs(3%) 10-15 yrs(8%)
Ownerships	Foreign Branch (2%) Local Firms (95%) Joint Venture (3%)	No. of Employees	15-20 yrs(16%) Above 20 yrs(73%) Below 50(3%)
Business Volume	~1 B (16%) 1.1B~2.0B(21%) 2.2B~3.0B(11%) 3.3B~4.0B(10%) 4.4B~5.0B(3%) 5.5B~10B (10%) 6.10B~50B (23%) 7.50B~ (6%)		51-100(9%) 101-200(13%) 201-400(21%) 401-600(13%) 601-800(7%) 801-1000(7%) 1001-2000 人(12%) 2001~ (15%)

Environmental Certifications	Yes (68%)	Environmental Certifications	No (32%)

Source: this study

The Results of the Measurement Model

Measurement model tests using AMOS 20 software to assess the reliability, convergent validity, and discriminant validity of the latent constructs between green intellectual capital and green dynamic capabilities. Table 1 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 0.882 to 0.943, exceeding the acceptable threshold value (0.7) suggested by Nunnally and Bernstein (1994). Composite reliability of every construct used in this study ranged from 0.891 to 0.945, 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 0.634 to 0.813, 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 (λ)	CR	AVE	α
Green Intellectual Human		0.891	0.674	0.882
Productivity and contribution	0.89			
Environmental competence	0.88			
Better Product/Services	0.84			
Environmental Teamwork	0.65			
Green Intellectual Structural		0.897	0.744	0.879
Superior management system	0.87			
Environmental investments	0.82			
Environmental share value	0.87			
Knowledge management	0.78			
Green Intellectual Relational		0.945	0.813	0.943
Loyalty customers	0.86			
Suppliers' cooperation	0.92			
Partners' cooperation	0.91			
Green Monitoring Capabilities		0.886	0.723	0.880
Monitor & identify	0.72			
Periodically review	0.80			
Development new	0.88			
Allocate resources	0.83			
Green Learning Capabilities		0.891	0.748	0.898
Learn &generate	0.84			
Transforming	0.93			
Assimilate new information	0.82			
Green Integration Capabilities		0.904	0.758	0.884
Integrate & manage	0.82			
Coordinate& develop	0.84			
Interconnect activities	0.88			

Goodness-of-fit: χ2/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 goodnes-of-fit measures, model-fit indices ($\chi 2/df$ =1.932, RMSEA=.074, AGFI=.808, CFI=.950, NFI=.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.

Empirical results of structural model

This study applied structural equation modelling (SEM) to verify the hypotheses and adopted AMOS 20 to obtain the empirical results (Table 2). The hypotheses testing results show that partial hypotheses (H2 and H3) postulated in our study are supported and H1 is supported shown in Figure 2. The hypothesized positive relationship between green intellectual capital and green dynamic capabilities (H3) was supported (γ_{11} = .852, p < .001). Hypothesis H1, which predicted a positive relationship between green intellectual capital and firm performance, was not supported (γ_{21} = -.235). Hypothesis H2, which predicted green dynamic capabilities lead to positive firm performance was also supported ($\beta 21$ = .260, p < .05). The predicted relationships, standardized path loadings, and hypotheses test outcomes are provided in Table 3. In addition, since H3 is supported in this study, we find out green dynamic capabilities as a mediator which influenced by green intellectual capital and then in turn have impacts on the firm performance. That is by the empirical results, we prove that green dynamic capabilities mediating the relationships between green intellectual capital and firms' firm performance.

The mediation model in this study is used to clarify the mechanism which underlies specific relationships among green intellectual capital and firm performance via green dynamic capabilities, known as mediators. Based on the above research results, we suggest that organization should pay more attention to their resources allocations to stimulate and cultivate green dynamic capabilities, and then the overall firm performance will increase automatically.

Table 3 the results of the structural model and Hypothesis Testing

Hypothesis	Predicted Relationships	St. Path Coefficients	Significant/Outcome
H1: GIC➔ FP	+	-0.235	H1 is not supported
H2: GDC➔FP	+	0.260*	H2 is supported
H3 :GIC➔GDC	+	0.852***	H3 is supported

Note: * p < 0.05; ** p < 0.01; *** p < 0.001
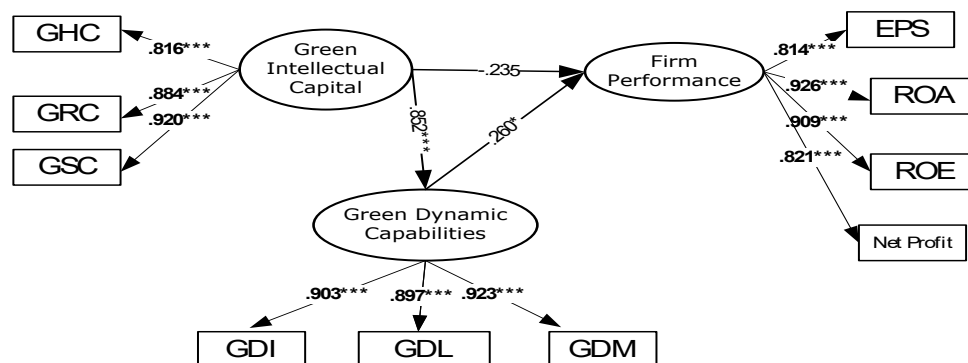
Figure 2. The results of the structural model.
Note: * *p* < 0.05; ** *p* < 0.01; *** *p* < 0.001

5. CONCLUSIONS AND IMPLICATIONS

In the context of increasing social and environmental pressures from a variety of sources for last several decades, environmental policies and regulations have been implemented to deal with serious climate change problems that resulted from the increasing industrial activities in the world (Chen, 2011;Shang, Lu, and Li, 2010; Lirn et al. 2014). We summarize the literature and establish a research framework of green intellectual capital, green dynamic capabilities and firm performance to apply both natural resource-based view and dynamic capabilities in elaborating sources of firms' performance. The empirical results show that green intellectual capital positively relates to green dynamic capabilities, and then in turns green dynamic capabilities positively relate to firms' performance. In addition, we find out that the green dynamic capabilities fully mediated the relationship between green intellectual capitals to firms' performance. This finding is consistent with previous studies (Vermeulen, 2013; Aminu and Mahmood, 2015). Superior firm performance depends on energetic green dynamic capabilities which rooted in good green intellectual capitals.

The contributions of this study including firstly, bridging the empirical gap requested to support the dynamic capabilities theoretical approach and the RBV as a whole. Secondly the originality of the paper stems from the consideration of the mediating role of green dynamic capabilities in the mechanisms by which intellectual capital contributes to the performance. Third, although many previous researches argues that firms complied with sustainability have profited significantly and positive impacts on corporate reputation and image from stakeholders that affect the survival of companies in the long run (Pedersen, 2006; Wolf, 2014), we are the pioneer research to deal with objective financial performance rather than subjective perceived ones which are common used by extant research.

In conclusion, top managers should always display a willingness to reinforce their green intellectual capital and dynamic capabilities, thus contributing to the acquisition and maintenance of a long-term superior firm performance. This research was limited to an evaluation of green intellectual capital, green dynamic capabilities and firm performance of manufacturing firm which listed in Taiwan Stock market; the empirical results are just derived from a particular national industry in the Taiwan area. However, the manufacturing industry is a global business and future studies could usefully embrace the same scope of investigation while including other countries in the research.

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A MEASUREMENT MODEL FOR EVALUATING CORPORATE SUSTAINABILITY PRACTICE IMPLEMENTATION

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Abstract
Purpose of this paper:
The research point outs that sustainability significantly influences the nature of firms' strategies and operations. An ever-greater number of companies are recognizing that sustainability has become part of their business strategies and the basis for corporate social responsibility (CSR) in response to strict legal and stakeholder requirements. However, studies regarding integrating sustainability into business strategies have fragmented into various areas of research like environmental management, cleaner production, environmental product, and/or green supply chains. Furthermore, a comprehensive measurement model for examining the level of corporate sustainability practice implementation has been sparse. As such, this study aims to identify and validate a measurement model for evaluating corporate sustainability practice implementation.

Design/methodology/approach:
This study first aims to identify constructs of corporate sustainability practice drawing upon literature review on the fields of environment management, cleaner production, environmental/green product, and green/sustainable supply chains. Second, based on survey and statistics techniques, we use manufacturing firms in Taiwan as the sample base to empirically validate the constructs and the measurement items of a firm's corporate sustainability practice.

Findings:
Drawing upon intensive literature review, we first identify five constructs: environmental management systems (EMS), environmental institutional management (EIM), environmental supply chain collaboration (ESCC), environmental operations management (EOM), and environmental product (EP). Moreover, a total of 233 survey respondents as a sample size are used for further examining the measurement items of each construct proposed by this study. The test results support the first-order model for the corporate sustainability practice implementation constructs. It is also found that corporate sustainability practice implementation can be conceptualized as a second-order multidimensional construct consisting of EMS, EIM, ESCC, EOM, and EP. In sum, the findings show that both the first-order and second-order models of corporate sustainability practice are reliable and valid.

Value:
This study is the first research which reviews various fields of literature associated with sustainability and identifies a comprehensive measurement model empirically rather descriptively, providing identified constructs and measurement scales for examining the level of corporate sustainability practice implementation.

Research limitations/implications (if applicable):
The proposed measurement model guides future empirical research related to companies' sustainability assessments and decisions not just in an unbalanced viewpoint but from a holistic perspective. This therefore helps researchers gain new and further insights for understanding the effects of firms' real environmental commitments and effort on their performance.

Practical implications (if applicable):
The expected results may offer guidelines for companies to re-examine or re-think the complex and multiple links between their sustainability impacts, their business strategies and operations, and their green resource investment and allocation, which thereby assists top executives with their business management transformations and more realistic and successful sustainability practice development.

INTRODUCTION

As institutional forces increase, the effective management of sustainability becomes increasingly important to a corporate to be legitimate and competitive (Aragón-Correa et al. 2008). Already, many companies such as IBM, HP, Foxconn, or Nike have committed to green initiatives internally and externally to gain the desired business performance (Huang and Wu 2010; Seuring and Müller 2008). Given "sustainability" is itself multi-dimensional, so-called a triple-bottom-line principle, it represent the necessity and a critical strategic consideration for practitioners to integrate the environmental, economic, and social goals under a balanced system. Thus, here corporate sustainability practice implementation is viewed as a company's organizational changes towards greener its business, operations, and management systems for increasing environmental, economic, and social benefits.

Currently, when discussing environmental sustainable issues, the relevant literature is fragmented into various areas of research like environmental management, cleaner production, environmental product, and/or green supply chains. These studies use different perspectives and focuses to address corporate sustainability, resulting in a firm's sustainability practice ranging from a functional to an enterprise strategy(Banerjee 2001), from environmental reactivity to proactivity (Aragón-Correa et al. 2008), and from internal focus to supply chains (Seuring and Müller 2008). It is clear the diversity of viewpoints and inclusive discussion challenge managers' decisions and assessment on corporate sustainability practice. Furthermore, a comprehensive measurement model for examining the level of corporate sustainability practice implementation has been sparse. To our best knowledge, Zhu et al. (2008) have developed a measurement model with a specific focus on green supply chain management practices implementation. Other researchers commonly address corporate sustainability as the different constructed terms and thus evaluate it at a narrower and specific rather a broad and comprehensive way.

As such, this study aims to identify and validate a measurement model for evaluating corporate sustainability practice implementation. By doing so, this study firstly contribute to theory by reviewing the relevant literature related to environmental sustainability for identifying a valid and comprehensive measurement model. Second, it therefore provides an effective analytical tool for managers to fully assess their green efforts for better decision-making.

LITERATURE REVIEW

Nowadays, evidence shows that environmental proactivity emerges and becomes a provider of resources and capabilities for competitiveness (Molina-Azorín et al. 2009). Additionally, to achieve sustainability, Pane Haden et al. (2009) suggest an enterprise may achieve sustainability and competitiveness via continuous learning and development and by embracing environmental requirements that are fully integrated with the goals

and strategies of the organization. In this study, corporate sustainability practice can be viewed as a firm's evolving way of strategic organizational changes towards greener its business, operations, and management systems for increasing environmental, economic, and social benefits.

In the environment management literature, there are four perspectives commonly used to address corporate sustainability. First is natural-resource-based view of the firm, in which the author note competitive advantages and sustainability might be rooted in an organization's resources and capabilities and its relationship to the natural environment (Hart 1995). Second, it is the stakeholder management view of the firm, in which a stakeholder theory suggests that any group or individual who can express interest and influence the environmental practices of an organization via direct pressure or by conveying information (Henriques and Sadorsky 1999). Third, it is the managerial discretion perspective of the firm, in which managerial interpretations of environmental issues influence the level of top managers' social responsibility and their commitments to the natural environment (Sharma 2000). Finally, the environmental operations management viewpoint of the firm is commonly discussed. Environmental operations management perspective is that an manufacturing organization may integrate environmental principles into operations decision-making process for strengthening business performance and manufacturing competitiveness (Kleindorfer et al. 2005).

By committing to these green initiatives internally and externally, organizations have become increasingly aware of life cycle analysis (LCA) and design for environment (DfE) approach in the design phase, environmentally-friendly materials at source, cleaner production technologies in the operations phase, eco-packaging/distribution, recycling/re-use of materials, and/or reverse logistics so that environmental impacts such as waste and emissions and energy/resource consuming are reduced (Kleindorfer et al. 2005; Simpson and Power 2005). Academically, the concept of green/environmental product is widely addressed and is viewed as an effective strategy to respond to customer and institutional pressures.

Over the last decades, increasing attention from studies regarding a broad business process perspective to the interface between an organization's environmental strategy and SCM has been observed (Seuring and Müller 2008). Accordingly, a few terms like green supply chain management (GSCM), environmental supply chain management (ESCM), closed-loop supply chains (CLSC), or sustainable supply chain management (SSCM)(Fabbe-Costes et al. 2011), have emerged to address the environmental and societal performance of corporate operations within SC characteristics at an integrated level. The two points are commonly addressed in environmental issues: supply chain collaboration (Vachon and Klassen 2008) and supply chain relationship (Simpson and Power 2005) in a sustainability context.

METHODOLOGY

This study first aims to identify constructs of corporate sustainability practice drawing upon literature review on the fields of environment management, cleaner production, environmental/green product, and green/sustainable supply chains. Second, based on survey and statistics techniques, we use manufacturing firms in Taiwan as the sample base to empirically validate the constructs and the measurement items of a firm's corporate sustainability practice.

Instrument construction

There are seven main constructs are identified and measurement scales of research constructs are developed based on the previous studies in the literature review section. The main constructs are environmental management systems (EMS), environmental institutional management (EIM), executive's social attitude (ESA), environmental operations management (EOM), environmental product (EP), environmental supply chain

collaboration (ESCC), and environmental supply chain relationship (ESCR). Constructs were measured using the multiple-item scales, drawn from pre-validated measures in the literature in regard to environmental management, green/environmental new product development, green/sustainable SCM, sustainable operations management, and SCM, and reworded to relate specifically to the context of corporate sustainability. All items were measured on a five-point Likert scale (1=strongly disagree, 5=strongly agree).

Data collection

We conduct a mailing survey among Taiwanese companies and a number of 233 qualified samples is for further analysis. The sample characteristics in terms of geographic dispersion, annual revenues, and respondent's job title are presented. Geographical classification of the surveyed companies includes local (30.9%), Asian region (36.91%), and global (32.19%). The annual revenues (in US million dollars) of surveyed firms are (1) less than or equal to 170: 57.51% and (2) greater than or equal to 170: 42.49%. The types of respondent's job title are vice president or above, environmental-related department manager, and senior manager, 12.45%, 31.76%, and 55.79%, respectively.

RESULTS

Scale validation

The first scale validation is assessed the construct validity for the seven measurement scales via confirmation factor analysis (CFA). A summary of descriptive statistics, reliability testing, and convergent validity is showed in Table 1.

	# of items	Mean	S.D.	α	CR	AVE
EMS	3	3.73	0.83	0.81	0.81	0.58
EIM	5	3.59	0.94	0.87	0.87	0.57
ESA	3	3.74	0.83	0.84	0.84	0.64
EOM	3	3.89	0.76	0.78	0.81	0.60
EP	7	3.43	0.93	0.93	0.93	0.67
ESCC	4	3.80	0.87	0.81	0.81	0.52
ESCR	4	3.46	0.93	0.92	0.92	0.73

Table 1 Summary of scale validation results

Cronbach α values and CR (composite reliability) values for all the seven constructs of corporate sustainability practice are greater than 0.7, suggesting the existence of internal consistency and strong reliability. The values of factor loading of all measurement items are showed in Figure 1 and 2. They all are above or close to 0.7 threshold. Further, the values of average variance extracted (AVE) of all constructs surpass the recommended 0.5 (Fornell and Larcker 1981). It is note that measures support convergent validity.

Testing first- and second-order models

The first-order model for testing the corporate sustainability practice construct (see Figure 1) implies that EMS, EIM, ESA, EOM, EP, ESCC, and ESCR are correlated but not governed by a common latent factor. Five common model-fit measures are used to estimate the measurement model fit: chi-square normalized by degree of freedom (χ^2/df), comparative fit index (CFI), non-normed fit index (NNFI), standardized root mean-square residual (SRMR), and root mean square error of approximation (RMSEA). All the model-fit indices exceed their respective common acceptance levels (value of 0.9) suggested by the previous literature (Hair et al. 2006). Therefore, it may be concluded

that the measurement model has good fit with the data gathered (χ^2/df = 696.625/356 = 1.956, CFI = 0.932, NNFI = 0.923, RMSEA = 0.064, SRMR = 0.049).
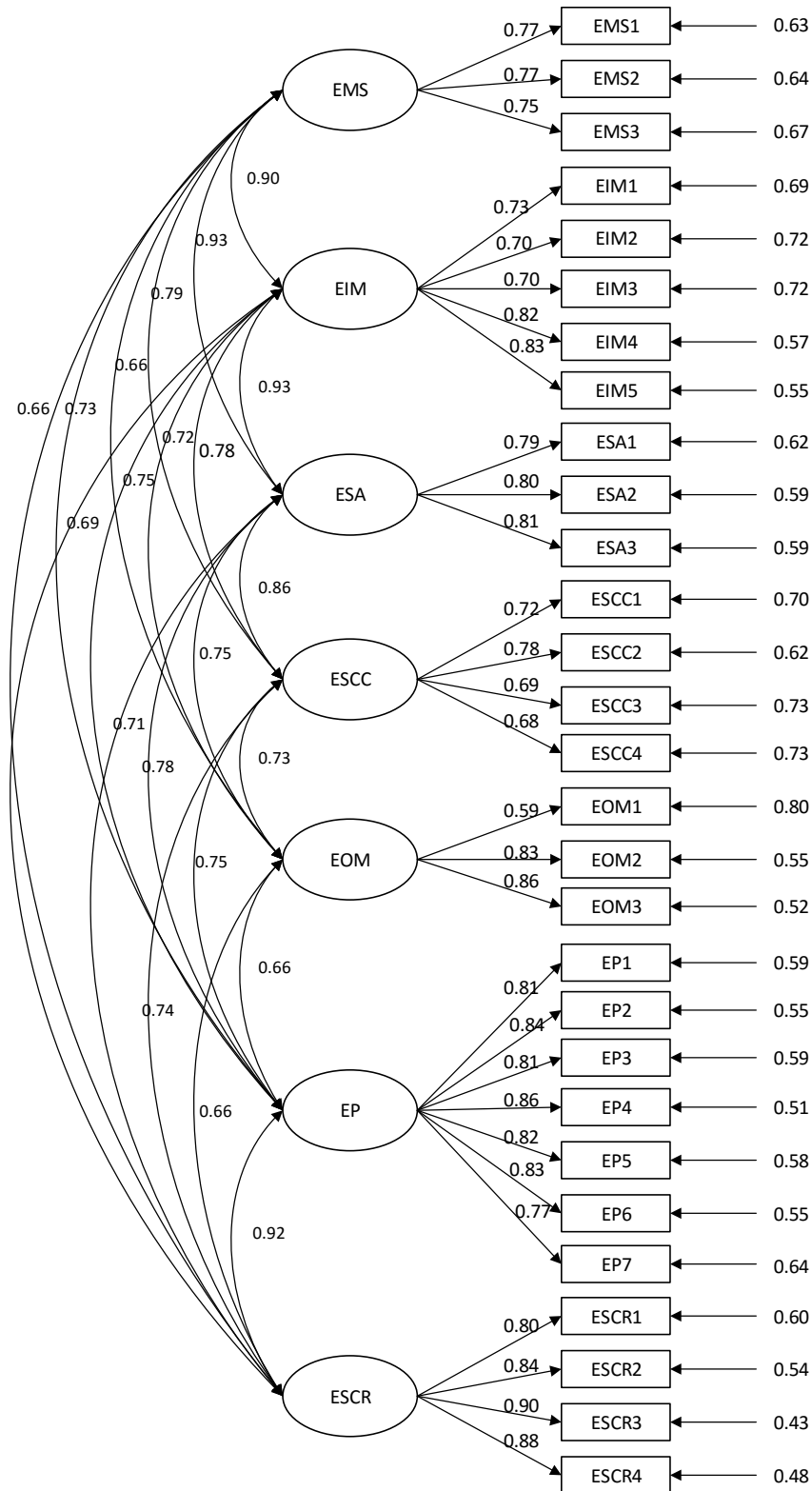
χ^2/df=696.625/356=1.956 (P<0.001) CFI=0.932 NNFI=0.923 RMSEA=0.064 SRMR=0.049

Figure 1 The results of first-order measurement model

The test results of the second-order model are showed as Figure 2. In the second-order model, all the model-fit indices except NNFI and SRMR exceed their respective common acceptance threshold, as suggested by Hair et al. (2006). NNFI is close to the recommended 0.9 cut-off, while SRMS is closed to the acceptance value of 0.05. As such, it may be concluded that the measurement model has good fit with the obtained data (χ^2/df = 840.030/369 = 2.277, CFI = 0.906, NNFI = 0.897, RMSEA = 0.074, SRMR = 0.065).
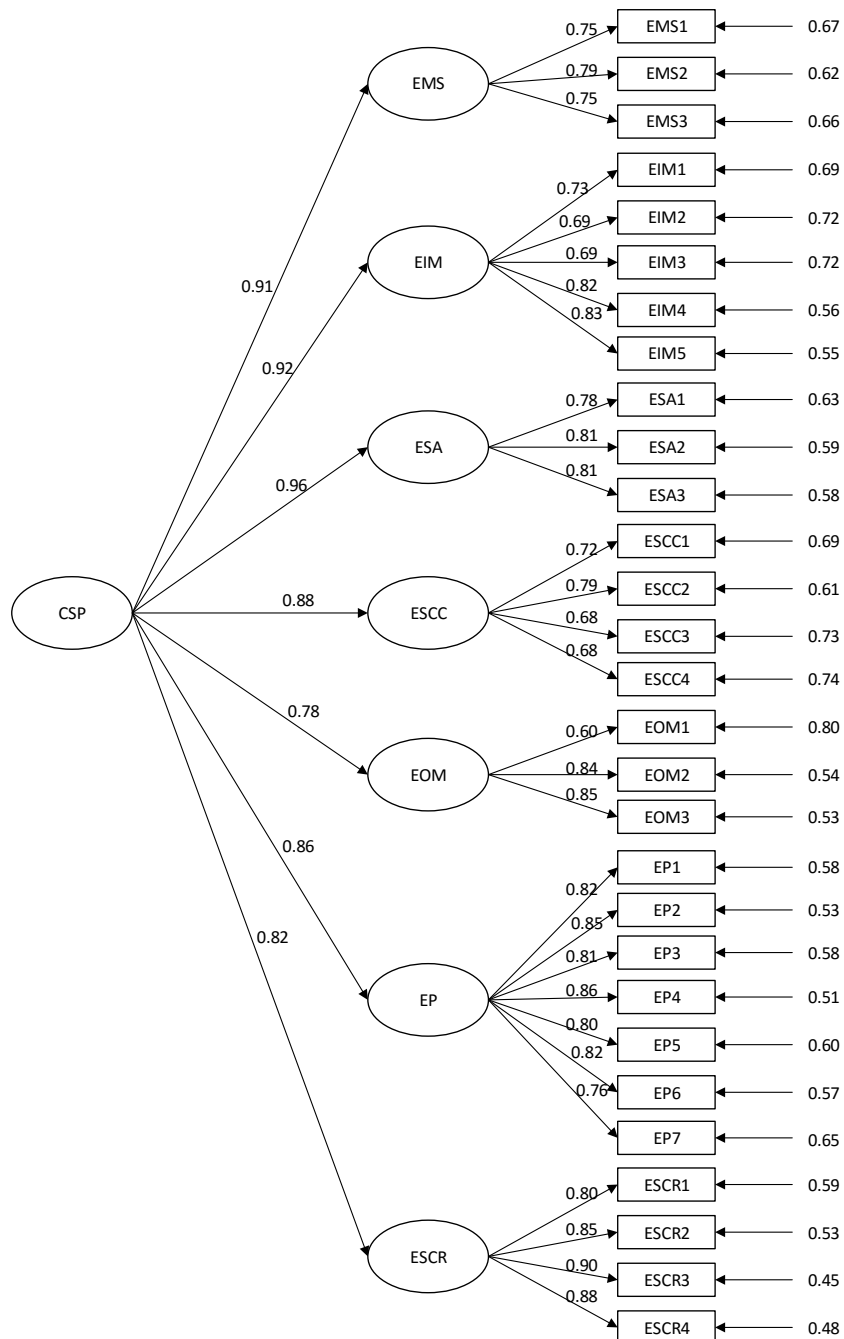
X^2/df=840.03/369=2.277 (P<0.001) CFI=0.906 NNFI=0.897 RMSEA=0.074 SRMR=0.065

Figure 2 The results of second-order measurement model

DISCUSSION AND CONCLUSION

Drawing upon intensive literature review, we first identify seven constructs: environmental management systems (EMS), environmental institutional management (EIM), executive's social attitude (ESA), environmental operations management (EOM), environmental product (EP), environmental supply chain collaboration (ESCC), and environmental supply chain relationship (ESCR). Moreover, a total of 233 survey respondents as a sample size are used for further examining the measurement items of each construct proposed by this study. The test results support the first-order model for the corporate sustainability practice implementation constructs. It is also found that corporate sustainability practice implementation can be conceptualized as a second-order multi-dimensional construct consisting of EMS, EIM, ESA, EOM, EP, ESCC, and ESCR. In sum, the findings show that both the first-order and second-order models of corporate sustainability practice are reliable and valid.

This study is the first research which reviews various fields of literature associated with sustainability and identifies a comprehensive measurement model empirically rather descriptively, providing identified constructs and measurement scales for examining the level of corporate sustainability practice implementation.

The proposed measurement model guides future empirical research related to companies' sustainability assessments and decisions not just in an unbalanced viewpoint but from a holistic perspective. This therefore helps researchers gain new and further insights for understanding the effects of firms' real environmental commitments and effort on their performance. The expected results may offer guidelines for companies to re-examine or re-think the complex and multiple links between their sustainability impacts, their business strategies and operations, and their green resource investment and allocation, which thereby assists top executives with their business management transformations and more realistic and successful sustainability practice development.

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SOCIAL RESPONSIBLE GOVERNANCE MECHANISMS AND FIRM PERFORMANCE - EVIDENCE FROM APPAREL SUPPLY CHAINS

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ABSTRACT

Aim/Purpose: This study develops a model of social responsible governance mechanisms and investigates the relationships between governance mechanisms and firm performance in the context of apparel supply chains.

Design/Methodology/Approach: A survey methodology is adopted and a total of 267 responses are collected from Bangladesh garment manufacturers. A covariance based partial least square structural equation-modelling (PLS-SEM) method is employed to confirm the measurement items of the model and to test the hypothesised relationship between governance mechanisms and firm performance.

Findings: The results of factor analysis confirm that the social, environmental and economic criteria reflect supplier selection construct, and supplier assessment and collaboration forms the supplier development construct. The results of the structural model evaluation indicate that there is a significant positive relationship between supplier selection construct with environmental and social performance, whereas, supplier development construct has a positive effect on all three performances-environmental, social and economic performance.

Originality/Value: To our knowledge, This study is the first empirical research to examine the impact of both supplier selection and supplier development mechanisms on firm performance.

Research Limitations/ Implications: This study is conducted in the context of Bangladesh apparel industry, so the results may not be generalised to other industries. Therefore, future research can validate the model with other industry sector samples or other country samples.

Practical Implications: The findings of this study will assist apparel manufacturers in implementing social responsibility, and retailers to understand the social responsible needs of manufacturers. It also provides guidelines for organisations like Bangladesh garment Manufacturers association (BGMEA) to develop standards for auditing Bangladesh garment manufacturing facilities.

Keywords: Social responsibility, social responsible supply chains, governance mechanisms, apparel industry.

Paper Category: Research paper

1. INTRODUCTION

In a globalised era, large organisations are sourcing from the low-cost suppliers. This gives an opportunity for large multinationals to maximise profits by exploiting complex supply chains, misusing regulations and compromising labour conditions. In particular, many well-known clothing and footwear manufacturers and retailers are known to have abused human rights by operating sweatshops in third world countries (Park-Poaps & Rees, 2009). Clothing industry is one of the most labour intensive industries and employs around 75 million people worldwide with an export value of $483 billion in 2014 (Clean Cloth, 2015; WTO, 2015). Bangladesh is the world leader in clothing exports after China with a share of 5.1 per cent (value of 25 billion dollars) in 2014 (WTO, 2015). The apparel industry in Bangladesh has nation's merchandise export share of 80.9 per cent and employs over 4 million workers (WTO, 2015). This industry is considered as a catalyst for the nation's development (BGMEA, 2015). However, the recent incidents such as the collapse of Rana Plaza with a death toll of more than 1130 and fire in

Tazreen factory with 112 people killed, raised concerns not only on Bangladesh apparel industry but also on clothing industry globally. As a result, many multinational buying companies are now under pressure to consider corporate social responsibility (CSR) related policies at their supplier and subcontractor facilities (Eriksson & Sevensson, 2015). Supplier code of conduct is a common form of governance mechanism to ensure socially responsible business practises throughout the supply chain (Pedersen & Andersen, 2006). However, it is not easy to implement code of conduct due to cultural differences, inappropriate incentive structure and supply chain complexity (Awaysheh & Klassen, 2010). Literature suggests that the supplier assessment and collaboration as an effective form of social responsible governance mechanisms (Gimenez & Tachizawa, 2012). But implementation of each mechanism in silo will not be adequate to develop sustainable supply chain (Lu, Lee & Cheng, 2012). According to Lund-Thomsen and Lindgreeen (2013), compliance based (code of conduct) and cooperative based (assessment and collaboration) mechanisms are needed to implement social responsibility in supply chain. Against this background, the aim of this study is to examine social responsible governance mechanisms and investigate the relationships between governance mechanisms and firm performance.

2. LITERATURE REVIEW

An extensive literature review is performed to develop a conceptual framework and to propose hypothesis that can address the research objective. Figure 1 illustrates proposed higher level conceptual framework that is explained in this section.
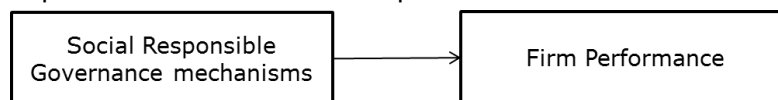
Figure 1 Conceptual Framework

In literature, CSR refers to an approach to build trusted relationships among stakeholders (McWilliams & Siegel, 2001; Waddock, 2004). To implement CSR in supply chains and to promote continuous relationship, effective governance mechanisms should be used (Vurro, Russo & Perrini, 2009; Burkert et al., 2012). Cox (2004) identifies supplier selection, supply chain sourcing, supplier development and supply chain management as governance mechanisms to manage retailer-manufacturer relationship. From the literature it is evident that supplier selection and development practices are associated with each other and must be examined together to understand the social responsibility implementation in supply chains and their impact on firm performance (see for example, Kwong, Ip & Chan 2002; Park et al. 2010; Gualandris, Ruggero & Matteo, 2014). Previous studies suggest that the socially responsible supply chains can deliver benefits in the reduction of resource usage and environmental wastes, enhancement of working conditions and stakeholder welfare, and development of community and corporate image (Ye at al., 2013). In addition to social and environmental performance improvements, firms have realised the financial benefits in terms of increase in revenue, decrease in costs and improvement in customer satisfaction. In this study, we examine social, environmental and economic forms of performance to measure firm performance.

Supplier selection is the first stage of establishing relationship among supplier and buyer. Over the years, researchers s have used several criteria in the decision making process of selecting suppliers (Handfield et al., 2002; Humphreys et al., 2006; Lu, Lee & Cheng, 2007; Tsai and Hung 2009; Kannan et al. 2013; Govindan et al., 2013). Earlier, criteria such as price, quality and delivery performance used to be the main criteria employed to select suppliers (Weber, Current & Benton, 1991; Dickson 1996; Kwong, Ip & Chan, 2002). These criteria are primarily economic in nature. Due to the importance given to the sustainability aspects in the recent time, social and environmental criteria have gained greater attention in the decision-making process of the supplier selection analysis (Baskaran, Subramanian & Rahman, 2012). Previous studies have identified a significant positive relationship between supplier selection mechanism and firm performance (Ittner et al., 1999; Xu et al., 2013). Orlitzky, Schmidt and Rynes (2003) meta-analysis demonstrates that there is a positive relation

between social responsibility and firm performance. According to Gallear, Ghobadianb and Chena (2012), inclusion of social aspects in supplier selection mechanism will enhance the firm performance. Based on the above discussion we hypothesise the following hypothesis between supplier selection and firm performance.

H1: Supplier selection is positively related to firm performance

- *H1a: supplier selection is positively related to social performance*
- *H1b: supplier selection is positively related to environmental performance*
- *H1c: supplier selection is positively related to economic performance*

A number of studies have highlighted the importance of supplier development mechanism in integrating social responsibility in supply chain (Andersen & Skjoett-Larsen, 2009; Vurro, Russo & Perrini, 2009). Supplier development mechanism enhances trust among supply chain members, reduces the number of contracts, develops supplier capabilities, and eliminates opportunistic behaviour (Krause, Scannell & Calantone, 2000; Wathne & Heide, 2000; Yu et al., 2006). Research identifies assessment, feedback of evaluation, education/ training, and capital investment dimensions of the supplier development mechanism (Krause & Ellram, 1997; Humphreys et al., 2004; Lu et al., 2012). Further, the dimensions of supplier development mechanism can be grouped into evaluation and collaboration (Park et al., 2010). Several studies have attempted to identify the relationship of supplier development mechanism and firm performance (Sucky & Durst, 2013). Gallear, Ghobadianb and Chena (2012) demonstrate that collaboration among supply chain partners along with evaluation improves firm performance. So we hypothesise that there is a positive relationship between supplier development and firm performance.

H2: Supplier development is positively related to firm performance

- *H2a: supplier development is positively related to social performance*
- *H2b: supplier development is positively related to environmental performance*
- *H2c: supplier development is positively related to economic performance*

Drawing from the literature, a theoretical framework is developed with five first-order (lower) independent constructs such as social criteria (SSO), environmental criteria (SEN), economic criteria (SEC), supplier assessment (SA), and supplier collaboration (SC) reflective of several indicators which in turn forms two second-order (higher) independent constructs supplier selection(SS) and supplier development (SD). On the other hand there, are three dependent variables social performance (SOP), economic performance (ECP), and environmental performance (ENP) reflective of several items. The causal relationship between independent governance mechanisms and dependent firm performance is tested by the proposed hypothesis and the detailed model is as shown in Figure 2.
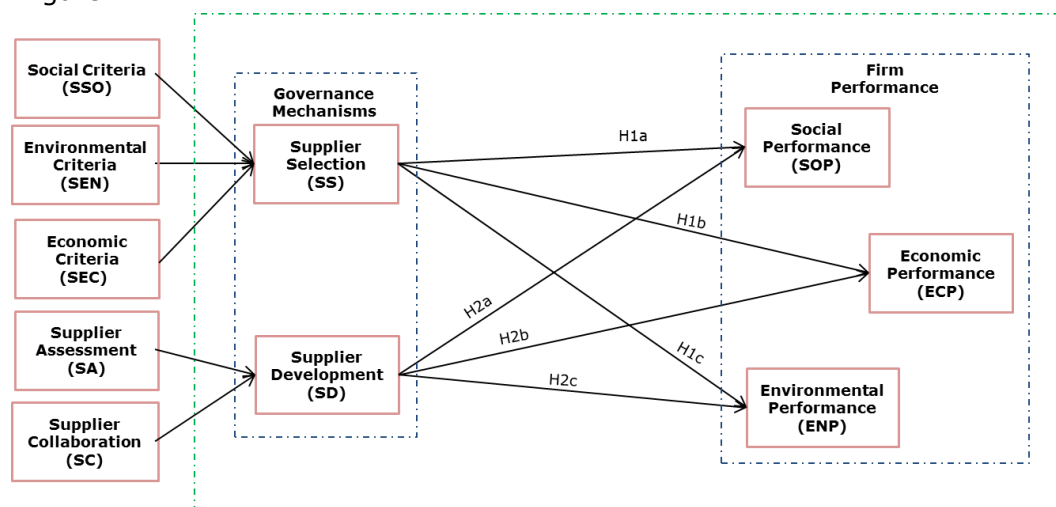
Figure 2 Proposed Conceptual Framework

3. RESEARCH METHODOLOGY

A structured questionnaire is used to collect data from the Bangladesh apparel manufacturers to understand the importance of governance mechanisms in implementing social responsibility at their facilities. The survey questionnaire consists of two parts: Part A aims to gather information on respondent and organisation profile; Part B comprises of items measuring five independent and three dependent constructs. The items of the questionnaire are either adopted from previous studies or developed through extensive literature review. The items related to the supplier development, economic performance and environmental performance are adopted from existing scales. Items to measure supplier selection and social performance are developed through literature review. The questionnaire is pre-tested with two senior academics, experts in apparel supply chains and three senior executives from Bangladesh garment industry. Based on their feedback few items under supplier selection construct are reworded to make it appropriate and items related to building safety are added to supplier selection construct. To finalise the survey questionnaire, a pilot study was conducted. Responses from a sample of 20 respondents are collected and analysed for reliability. Results of pilot study indicate that the reliability coefficient (cronbach alpha) of all the eight first-order constructs is greater than 0.7, resulting in a reliable questionnaire (Hair et al., 2014). The final questionnaire is distributed using drop and collect method and a total of 267 usable questionnaires are collected for analysis. Data analysis was performed in three stages: data screening, validation of the measurement model and evaluation of the structural model (Hair, Ringle & Sarstedt, 2013). In this research, Partial Least Squares structural equation model (PLS-SEM) is used to examine the impact of supplier selection and supplier development mechanisms on the firm performance.

4. ANALYSIS & RESULTS

Data screening is performed to identify missing values in data. The drop-and-collect procedure employed in this study along with the participatory information sheet emphasising on the importance of answering all questions ensured that there are no missing values. So all the 267 responses collected are considered for further analysis.

4.1 Demographic Profile

It is identified that the majority of the survey respondents are senior managers (64.04 percent) with considerable experience in supply chain, operations and production departments. The results also indicate that 60.67 percent respondents have an experience of 5 years and over in the garment manufacturing industry. This demonstrates that the respondents are informative and knowledgeable to answer the survey questionnaire. Majority of the companies that respondents represent are Bangladeshi owned (55.05 percent organisations) and medium sized organisations with 5000-10000 dozens production capacity per month (64.42 percent organisations). It is also observed that most of the manufacturers (89.14 percent organisations) receive orders directly from retailers or buying houses indicating that these organisations are tier 1 suppliers and the manager's perceptions reflect on the relationship with the retailers. All the organisations represented in the sample are practicing in fire safety workplace procedures demonstrating that they exhibit knowledge and interest towards social responsible practices.

4.2 Measurement model (Outer model)

It is identified that the hypothesised conceptual model is a reflective-formative (Type II) hierarchical component model. In this study, the proposed conceptual framework is validated in two stages: evaluation of the measurement model and structural model evaluation. Further, measurement model is evaluated by validating items of reflective model and then by testing the weights of reflective constructs forming higher constructs.

4.2.1 Reflective measurement model

First, confirmatory factor analysis (CFA) is performed using SmartPLS, a statistical software tool to statistically assess the relationship between the measures and the eight first-order constructs. To conduct CFA, indicator reliability, internal consistency, convergent validity, and discriminant validity criteria must be met (Hair et al., 2014).

Indicator Reliability

Researchers (e.g. Hair, Ringle & Sarstedt, 2013) suggest that item loadings should be at least 0.7 or more in order to achieve item reliability of approximately 0.5. However, if an item loading is between 0.5 and 0.7 and does not affect the reliability of the construct then the item can be included (Hair et al., 2014). Following these criteria, 8 items from five independent variables and three items from dependent variables are deleted. Retained items loadings of the measurement model are obtained by conducting final round of CFA. Final revised model is shown in Figure 3 with factor loading. It is identified that the indicator loadings of the final model are above the threshold value of 0.7, except item SC-2 (training). Item SC-2 is retained in the analysis as the deletion of the item does not affect the reliability of the construct. All the items of the final model show strong evidence for reliability of the measurement items.
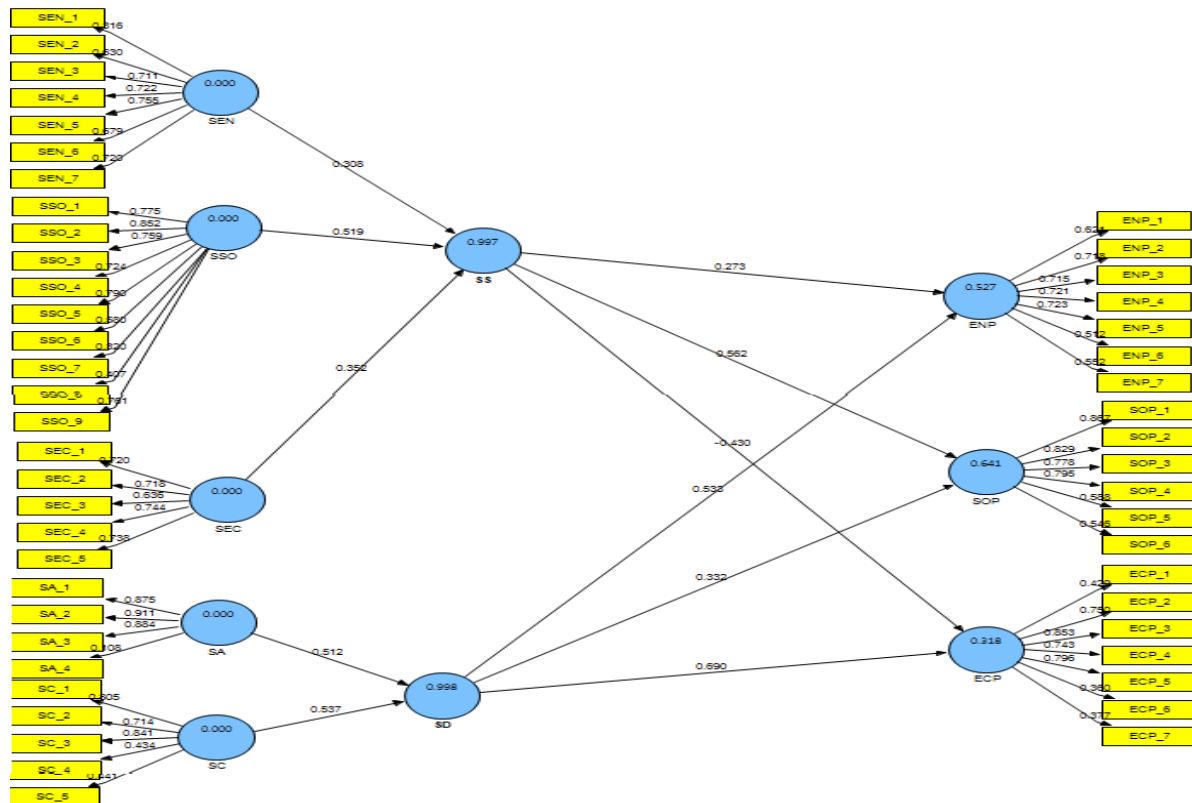
Figure 3 Final Structural Model- Model Estimates

Internal consistency

The most appropriate technique to measure internal consistency of a construct is composite reliability. Composite reliability presents the degree to which the indicators measure the latent construct. All first-order constructs display composite reliability between 0.837 and 0.920 (see Table 1), which is well above the threshold value of 0.7 (Hair et al., 2014).

Convergent Validity

Convergent validity of the constructs is assessed using Average Variance Extracted (AVE) (Fornell & Larcker, 1981). Sufficient convergent validity is achieved when AVE value of a construct is at least 0.5 (Fornell & Larcker, 1981). Table 1 shows that the AVE for all constructs are within the range of 0.562 and 0.794, fulfilling the 0.5 threshold, demonstrating convergent validity.

Variable	Indicator	Loadings	Indicator Reliability	Composite Reliability	AVE	Cronbachs Alpha
ECP	ECP_2	0.782	0.611	0.883	0.653	0.826
	ECP_3	0.847	0.717			

	ECP_4	0.780	0.609			
	ECP_5	0.822	0.676			
ENP	ENP_2	0.763	0.582	0.842	0.572	0.758
	ENP_3	0.724	0.524			
	ENP_4	0.734	0.539			
	ENP_5	0.803	0.645			
SA	SA_1	0.874	0.763	0.920	0.794	0.870
	SA_2	0.911	0.830			
	SA_3	0.888	0.788			
SC	SC_1	0.863	0.745	0.853	0.662	0.739
	SC_2	0.678	0.460			
	SC_3	0.883	0.780			
SEC	SEC_1	0.736	0.542	0.837	0.562	0.741
	SEC_2	0.783	0.612			
	SEC_4	0.746	0.557			
	SEC_5	0.733	0.538			
SEN	SEN_3	0.711	0.505	0.850	0.656	0.754
	SEN_5	0.831	0.690			
	SEN_7	0.879	0.774			
SOP	SOP_1	0.877	0.769	0.908	0.713	0.866
	SOP_2	0.854	0.730			
	SOP_3	0.802	0.643			
	SOP_4	0.843	0.710			
SSO	SSO_1	0.759	0.577	0.913	0.638	0.886
	SSO_2	0.872	0.760			
	SSO_3	0.778	0.606			
	SSO_4	0.757	0.573			
	SSO_5	0.823	0.677			
	SSO_9	0.798	0.636			

Table 1 Measurement Model- Quality Criteria

Discriminant Validity
The two criteria used to measure discriminant validity are cross loadings examination and Fornell-Larcker criterion. Results of cross-loadings examination exhibit that the loadings of measurement items are high on their theoretically intended constructs. Second, a Fornell-Larcker criterion is presented in Table 2. Results show that the square root of AVE as the diagonal elements is larger than the off-diagonal correlations in rows and columns. Hence, the discriminant validity at the construct level is supported.

	ECP	ENP	SA	SC	SEC	SEN	SOP	SSO
ECP	0.808							
ENP	0.377	0.757						
SA	0.325	0.573	0.891					
SC	0.504	0.651	0.805	0.813				
SEC	0.022	0.497	0.605	0.413	0.750			
SEN	0.029	0.361	0.126	0.152	0.410	0.810		
SOP	0.011	0.581	0.642	0.445	0.672	0.227	0.844	
SSO	-0.273	0.335	0.414	0.167	0.732	0.462	0.656	0.799

Table 2 Fornell-Larcker Matrix for Discriminant Validity

4.2.2 Formative Hierarchical Component Model
Internal validity and multicollinearity are the two important measures of higher-order component model.

Internal Validity
The magnitude of the path coefficient is above threshold value of 0.1, which is consistent with the underlying theory. Bootstrapping procedure is applied for estimating the significance of the path coefficients. It is observed that critical t-value (see Table 3) is well above threshold value of 1.96 (Hair, Ringle & Sarstedt, 2011). The results

demonstrate that the first-order constructs (SSO, SEN, SEC, SA, and SC) are forming second-order variables (SS and SD).

Second-order construct	Path	Path Coefficient	t- stat	p-value	Significant
Supplier development	SA -> SD	0.556	21.486	0.000	Yes
	SC -> SD	0.482	26.231	0.000	Yes
Supplier selection	SEC -> SS	0.354	16.928	0.000	Yes
	SEN -> SS	0.175	5.286	0.000	Yes
	SSO -> SS	0.614	18.581	0.000	Yes

Table 3 Results for Formative Second-Order Constructs

Multicollinearity

Multicollinearity is evaluated by calculating the variance inflation factor (VIF). Hair et al. (2014) suggests that VIF above 5.00 and tolerance levels below 0.20 in the predictor constructs implies high collinearity. Results indicate that all the VIF values range between 2.33 and 1.438 and tolerance levels are above 0.4 exhibiting no collinearity (See Table 4). All the above explained results demonstrate that the proposed measurement model is valid.

	Tolerance Value	VIF
ECP	0.695	1.438
ENP	0.549	1.820
SOP	0.429	2.332

Table 4 Tolerance and VIF values of dependent variables

4.3 Structural model

This study uses the repeated-indicator approach to estimate the construct scores of the second-order variables. Computed second order variable scores are used to estimate the path coefficients of dependent variables. The size of path coefficients and coefficient determination (R^2) are shown in Figure 3. The t-values obtained from bootstrapping procedure are used to evaluate the statistical significance of each path coefficient. Results from the bootstrapping procedure are detailed in Table 5. The results support that proposed hypothesis H1a, H1b, H2a, H2b and H2c (β=0.54, 0.226, 0.355, 0.548, and 0.579 respectively) at a significance level of *p* <0.05 with coefficients greater than 0.1. However, H1c coefficient is significant at *p* <0.05 but the negative path coefficient (β=-0.387) does not support hypothesis.

Hypothesis	Path	Coefficient	t- stat	p-value	Significant
H1a	Relationship between supplier selection and social performance	0.540	5.692	0.000	Yes
H1b	Relationship between supplier selection and environmental performance	0.226	2.498	0.013	Yes
H1c	Relationship between supplier selection and economic performance	-0.387	3.962	0.000	No
H2a	Relationship between supplier development and social performance	0.355	2.422	0.016	Yes
H2b	Relationship between supplier development and environmental performance	0.548	8.770	0.000	Yes
H2c	Relationship between supplier development and economic performance	0.579	5.832	0.000	Yes

Table 5 Bootstrapping Results for Structural Model Evaluation
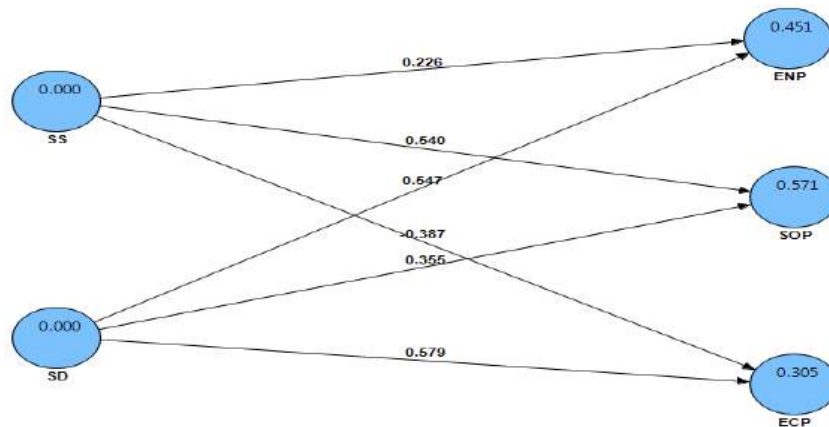
Figure 2 Structural Model- Impact of Governance Mechanisms on Firm Performance

5. FINDINGS & DISCUSSION

In this research, multi-item scale for supplier selection with first-order social, environmental and economic selection constructs is developed. Results demonstrate that the social, environmental and economic constructs form the supplier selection variable. These results are consistent with prior social responsible supplier selection studies (Govindan, Kannan & Shankar, 2014). CFA results of the supplier development variable are consistent with the earlier studies (Gimenez & Sierra, 2013). The results of this study also operationalize the social performance constructs from literature.

This study provides an empirical support for the positive relationship between both supplier selection and development mechanisms with environmental and social performance. Integration of social responsibility at Bangladesh garment manufacturing facilities results in significant improvement of environmental and social performance creating a win-win scenario. However, the impact of supplier selection on economic performance is less clear. Specifically, the integration of social and environmental aspects in selection criteria has a negative impact on economic performance. These results are in contrast to Green Jr et al. (2012) and Zhu and Sarkis (2007) finding of green purchasing positively affects economic performance. The differences in results may be attributed due to the differences in unit of analysis. Zhu and Sarkis (2007) studied the relationship between the firm's supplier environmental aspects and firm's performance. However, in this study we consider the relationship between the implemented environmental and social criteria of the firm and firm performance. Implementation of social and environmental aspects could incur financial costs to the firm thus affecting economic performance negatively.

The results exhibit supplier development construct has a positive impact on economic, social and environmental performances. From earlier studies Kannan and Tan (2002), supplier assessment factor of information sharing and feedback has a significant impact on economic performance of market share, return on assets and competitive position. The positive impact of supplier assessment and collaboration on environmental performance is consistent with the findings of several studies. Vachon and Klassen (2008) conclude that there is a positive relation between environmental collaboration of training, joint efforts, investment and awareness items with environmental performance of reduction in wastes and air emissions. Most recently, Gimenez and Sierra (2013) conclude that supplier assessment and collaboration has a significant impact on environmental performance. On the other hand, only recently social aspects gained attention in research. There is no empirical research on supplier governance mechanisms and its impact on social performance. However, Lund-Thomsen and Lindgreen (2014) proposed retailer collaborative and assessment strategies would help manufacturer to build capabilities, upgrade the worker conditions and improve social performance.

Results of this study empirically proved that there is a positive relationship between supplier development mechanism and social performance.

6. CONCLUSION

This study investigates the social responsible governance mechanisms and its impact on firm performance. This study operationalizes social responsible supplier selection and performance constructs from literature and adopts the measurement scale of supplier development and environmental and economic performance from prior measurement scales in literature. The results of the positive relationship between selection and development with environmental and social performance drive the manufacturers to implement social responsibility. However, the negative impact of supplier selection on economic performance can be explained by the financial resources required for social responsible investments. The results of this study provide an in-depth understanding on the importance of social responsible governance mechanisms and it impact on firm performance. This study provides a framework for retail mangers with important constructs to consider during the implementation of social responsibility at manufacturing facilities. Manufacturers are provided with guidelines on formulating policies and developing programmes to adhere social responsible practices. It also provides guidelines for organisations like BGMEA to develop standards based on the needs of retailer-manufacturer dyadic relationship. The inclusion of several aspects of standards like 'Alliance for Bangladesh worker and safety' and 'Accord on Fire and Building Safety in Bangladesh' in items to measure the variables helps to test the relevancy of the standards to the manufacturer.

Though the study had several practical implications, there are several limitations. To better understand the social responsible investments impact on economic performance research need to consider a long-term view. The results of this study are in the context of Bangladesh apparel industry, raising the issue of generalizability. The results of this study only test the causal relationship between governance mechanisms and firm performance. It is also possible that the enhanced firm performance might drive the firms to implement social responsible governance mechanisms. Future research need to focus on addressing the above mentioned research limitations. In future, research need to take the time factor into analysis. Proposed model need to be tested using samples from different industry context. Considering actual performance measures will give an opportunity to compare the relationship of objective or subjective performance measures with independent variables. Future research need to focus on to develop and test a model on recursive relationship of firm performance to drive the implementation of governance mechanisms.

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Rest of the references will be provided upon request

WASTE NOT, WANT NOT: MANAGING PERISHABLES IN SMALL AND MEDIUM RETAIL ENTERPRISES

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Abstract
Purpose of this paper:
Recent literature indicates that around one third of perishable products finish as waste (Mena et al., 2014): 60% of this waste can be classified as avoidable (EC, 2010) suggesting logistics and operational inefficiencies along the supply chain. In developed countries perishable products are predominantly wasted in wholesale and retail (Gustavsson et al., 2011) due to customer demand uncertainty the errors and delays in the supply chain (Fernie and Sparks, 2014). While research on logistics of large retail supply chains is well documented, research on retail small and medium enterprises' (SMEs) capabilities to prevent and manage waste of perishable products is in its infancy (c.f. Ellegaard, 2008) and needs further exploration.
In our study, we investigate the retail logistics practice of small food retailers, the factors that contribute to perishable products waste and the barriers and opportunities of SMEs in retail logistics to preserve product quality and participate in reverse logistics flows.

Design/methodology/approach:
As research on waste of perishable products for SMEs is scattered, we focus on identifying key variables that contribute to the creation of avoidable waste. Secondly we identify patterns of waste creation at the retail level and its possibilities for value added recovery. We use explorative case studies (Eisenhardt, 1989) and compare four SMEs and one large retailer that operate in a developed market. To get insights into specificities of SMEs that affect retail logistics practice, we select two types of food retailers: specialised (e.g. greengrocers and bakers) and general (e.g. convenience store that sells perishable products as a part of the assortment)

Findings:
Our preliminary findings indicate that there is a difference between large retailers and SME retailers in factors that contribute to the waste creation, as well as opportunities for value added recovery of products. While more factors appear to affect waste creation and management at large retailers, a small number of specific factors appears to affect SMEs. Similarly, large retailers utilise a range of practices to reduce risks of product perishability and short shelf life, manage demand, and manage reverse logistics practices. Retail SMEs on the other hand have limited options to address waste creation and value added recovery. However, our findings show that specialist SMEs could successfully minimize waste and even create possibilities for value added recovery of perishable products. Data indicates that business orientation of the SME, the buyer-supplier relationship, and an extent of adoption of lean principles in retail coupled with SME resources, product specific regulations and support from local authorities for waste management or partnerships with other organizations determine extent of successful preservation of a product quality and value added recovery.

Value:
Our contribution to the SCM academic literature is threefold: first, we identify major factors that contribute to the generation waste of perishable products in retail environment; second, we identify possibilities for value added recovery for perishable products and third, we present opportunities and challenges for SME retailers to manage or participate in activities of value added recovery. Our findings contribute to theory by filling a gap in the literature that considers product quality preservation and value added recovery in the context of retail logistics and SMEs.

Research limitations/implications (if applicable):
Our findings are limited to insights from five case studies of retail companies that operate within a developed market. To improve on generalisability, we intend to increase the number of cases and include data obtained from the suppliers and organizations involved in reverse logistics flows (e.g. local authorities, charities, etc.).

Practical implications (if applicable):
With this paper, we contribute to the improvement of retail logistics and operations in SMEs which constitute over 99% of business activities in UK (Rhodes, 2015). Our findings will help retail managers and owners to better understand the possibilities for value added recovery, investigate a range of logistics and retail strategies suitable for the specificities of SME environment and, ultimately, improve their profitability and sustainability.

Key words: product quality preservation, value added recovery, retail logistics

INTRODUCTION

Recent literature indicates that around one third of food products are wasted (Gustavsson et al., 2011), despite raising concerns about food security (Papargyropoulou et al., 2014), and the environmental impact that results from food production, processing and consumption (Mena et al., 2011). Additionally, research conducted in UK shows that more than 80% of food and drink waste (measured by weight) is possibly avoidable (EC, 2010), which indicates managerial, technical or organizational challenges in food supply chains (c.f. Apte, 2010). In developed countries most food waste occurs after processing, i.e. in distribution and retail channels. While food logistics is well documented in large retail systems, there is a lack of empirical research on food logistics in small and medium enterprises (SMEs) (Bernon and Cullen, 2007). Moreover, research findings into SMEs are segmented by the type of SME (Ellegaard 2008) or region of data collection (Bourlakis et al., 2014; Vlajic, 2016). To the best of our knowledge, there is no research that empirically investigates the retail logistics practice of small food retailers, the factors that contribute to perishable products waste and the barriers and opportunities of SMEs in retail logistics to preserve product quality and participate in reverse logistics flows.

The paper is structured to provide a theoretical background on circular supply chains in the context of perishable products and the position and role of SME retailers. There follows a description of the methodology used in our investigation, presentation of key findings and a discussion of issues arising from the cross-case analysis. We conclude with remarks and suggestions for further research.

A FRAMEWORK FOR MANAGING PERISHABLE PRODUCTS IN CIRCULAR SUPPLY CHAINS

In this section, we describe the research framework for managing circular flows of perishable products (Figure 1). The framework combines the work of Carter and Ellram (1998) and Rahman, (2012). Generally, the supply chain consists of suppliers, producers, distribution centres (wholesalers or warehouses) and retail outlets, as well as raw materials, work-in-process inventory and finished products that flow between facilities (Simchi-Levi et al., 2008). This flow is considered as forward logistics flow, where production and physical movement of the product and the means of creating the

exchange are *value adding (VA)* processes (Christopher, 2011). Supply chains consist of primary and supporting supply chain members (Lambert and Cooper, 2000): VA processes are performed by the primary members, while supporting members provide resources, knowledge, utilities or assets to the primary members of the supply chains. In our framework we refer to the supporting members as secondary markets, such as governmental bodies, energy companies, local authorities responsible for waste collection, food banks and charities.

Alongside the forward logistics flow there is the reverse logistics flow, which is "the movement of product or materials in the opposite direction for the purpose of creating or recapturing value, or for proper disposal", (Tibben-Lembke and Rogers, 2002, p. 271).
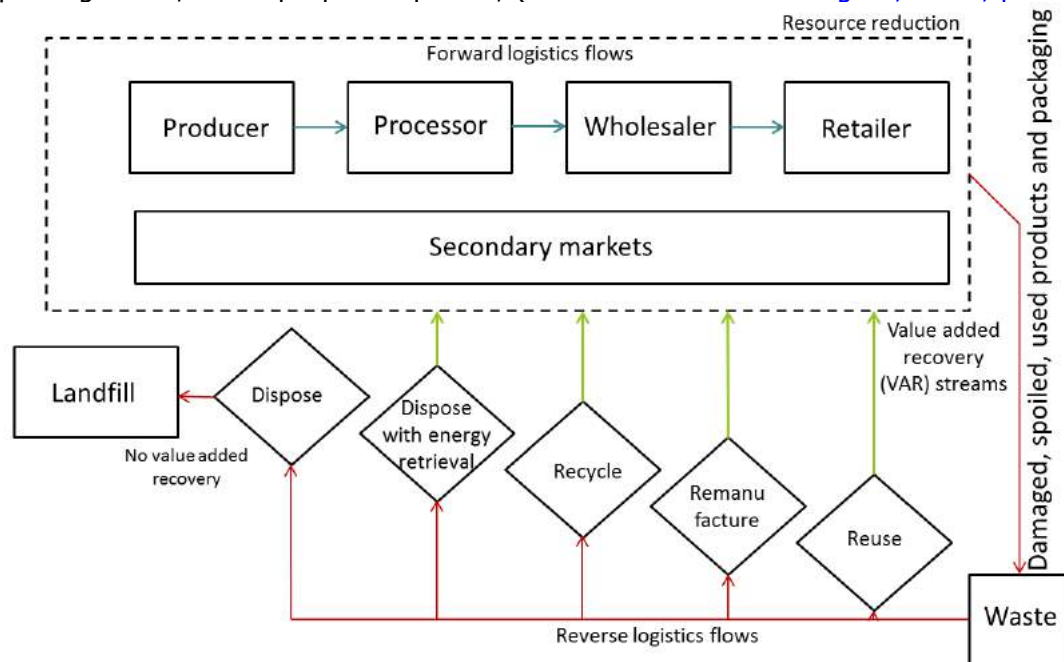
Figure 1. Framework for managing perishable products in circular supply chains

Damaged, spoiled, used products, packaging and other types of waste, as well as logistics units are all to be found in the reverse logistics flow. Waste generation occurs throughout the supply chain due to various *internal* factors (e.g. company's organization, planning and control, resources, information system or relationship with the suppliers), and *external* factors (e.g. environmental, legal, technological, market, etc.), (c.f. Vlajic et al., 2012). In our framework, we focus on the waste related to food and its packaging.

In their early work on reverse logistics, Carter and Ellram (1998) proposed the reverse logistics hierarchy, which consists of five processes: reduce, reuse, recycle, dispose with energy retrieval and dispose in landfill. They state that *resource reduction* is the ultimate goal in the reverse logistics process, as it minimizes materials "used in a product and minimisation of waste and energy achieved through the design of more environmentally efficient products" (p. 91). This view is broadly the same as that introduced by the European Parliamentary Council in 2008 (EPC, 2008). In the latter framework, these processes are seen as waste prevention, i.e. processes that avoid waste generation (Papargyropoulou et al., 2014). *Prevention* of food waste considers good manufacturing and logistics practice aimed to preserve food quality and safety, such as maintenance of the cold chain, use of protective packaging where needed, and proper product handling (van der Vorst et al., 2005). Prevention also considers tackling sources of food loss and waste related to product risks, demand uncertainty, consumer behaviour, ordering, inventory management and sale policies, supply chain operations or variety of external factors (Vlajic et al., 2012).

Carter and Ellram (1998) state that the after resource reduction, maximal recovery value can be obtained in reverse logistics flow, i.e. by reuse, recycling and disposal with energy recovery and in the last resort disposal. Later research added re-manufacturing, as a process distinct from reuse. Rahman, (2012) defines *reuse* as a "process in which

recovered product is used again for a purpose similar to the one for which it was originally designed", *remanufacturing*, as a "process of reducing a product into its constituent parts", i.e. it requires disassembly and *recycling* as the process of collecting and disassembling used products, components and materials, separating them into categories and processing them into recycled materials. Recycled materials do not retain functionality of used parts of products.

In the context of food supply chains, typical example of *reuse* occurs when food surplus is redistributed to day centres and night shelters for homeless people (Cherrett et al., 2015). These activities are supported by various organizations at national, regional and local levels, such as FareShare. *Re-manufacturing* of food products is often considered together with recycling. In our view, use of fresh food as a resource for production of animal or pet food requires separation of good quality and spoiled fractions of products (Stenmarck et al., 2011), which corresponds to the definition of the re-manufacturing. *Recycling* of the food waste typically considers transformation to composts, while *disposal with energy recovery* typically considers anaerobic digestion (Papargyropoulou et al., 2014) or incineration (Stenmarck et al., 2011). The distinction between recycling and disposal with energy recovery is sometimes blurred, as some methods (e.g. in-vessel tunnelling) produce both, recycled material and energy (DAERA, 2013).

Waste products in reverse logistics flows are part of value added recovery (VAR) streams, i.e. streams that pass through re-use, re-manufacturing, recycling or disposal with energy recovery processes. Depending on the type of the product and type of the supply chain, the destination of the VAR stream can be different (Tibben-Lembke and Rogers, 2002; de Brito and Dekker, 2003): products might return to the original suppliers, or to some supply chain member, or they might be delivered to one of supporting members, i.e. on the secondary market, such as second-hand shops, charities, or energy companies.

RETAILERS' POSITION IN CIRCULAR FLOWS OF FOOD SUPPLY CHAINS

Within the food supply chain retailers take a specific position: they are at the end of the forward logistics flow, and as such they are impacted by disturbances in material flows and activities of other supply chain members (Fernie and Sparks, 2014). A considerable body of literature indicates that large retailers are powerful, focal companies of their supply chains (Coe and Hess, 2005; Fernie and Sparks, 2014), with a commitment to waste prevention and reduction, as well as involvement into reverse flows (McKinnon and Edwards, 2014). On the other hand, the majority of authors agree that SMEs are not competitive due to smaller variety and volume of products, higher capital and transaction costs, a reactive nature in the company's strategies, and the presence of limited resources (Arend and Wisner, 2005; Thun et al., 2011). Cagliano et al., (2001) suggests that small firms have less insight into actual costs of their operations, as well as poorer and incomplete understanding of operations combined with management practice based on local and contingency factors. However, SMEs are often characterized by informal exchanges of information between employees (Roebuck et al., 1995), knowledge of local markets, knowledge-based advantages (Arend and Wisner, 2005) and flexible organizational structure (Vaaland and Heide, 2007), which indicate SMEs' advantages over larger enterprises. Bourlakis et al. (2014) found that a company's performance relates to its size: in comparison with small and medium enterprises, micro companies do better on gross profit margin but worse on waste, flexibility in extra volume orders and delivery of products according to the specification. It is also noticeable that the majority of research is focused on manufacturing SMEs (see work of Cagliano et al., 2001, Ellegaard, 2008), while there is considerably less research focused on service and retail SMEs. Ellegaard, (2008) even concluded that findings related to the manufacturing SMEs might not be applicable to service or retail oriented SMEs.

Based on the reviewed literature, it is inconclusive how retail SMEs manage return flows, i.e. what is extent of their participation in VAR. In our study, we investigate the retail logistics practice of retail SMEs to identify major factors that contribute to perishable products waste, as well as possibilities for waste prevention and VAR.

METHODOLOGY

In this study, we apply multiple case study methodology. This methodology is based on the replication strategy (Yin, 2014), which is allows strengthening the precision, validity, stability and trustworthiness of the findings (Miles et al., 2014). An explorative approach is better suited to identify patterns (Eisenhardt, 1989) relevant for waste creation, its prevention and management of VAR flows.

Selection of the companies was based on the hygiene rating score by the Food Standards Agency (FSA) (http://ratings.food.gov.uk). The FSA assesses three elements: hygiene of food handling (storing, cooling, etc.), the condition of the structure of the buildings (the cleanliness, lightning, layout, etc.) and management of the business (recording data, ensuring food safety, etc.). The higher score implies better hygiene policy. Data collection about their supply chain was based on snowball sampling, which benefits inductive, theory building analysis (Miles et al., 2014).

Our investigation is based on five case studies of food retailers (Table 1). The unit of analysis is a company. In all cases we considered both packed and unpacked fresh products. To distinguish differences in opportunities, barriers and practices between different retailers, we compare large supermarket with high hygiene score and range of employed practices on product quality preservation and VAR processes, and retail SMEs. To address the challenges small retailers face, we selected stores with higher and lower hygiene rating scores. To capture specificities of retail SMEs in retail logistics, we select specialised and general type of retail SMEs. Key retail logistics tasks are related to management of storage facilities, inventory, transportation, unitization and packaging and communications (Fernie and Sparks, 2014).

Following instruction of Yin (2014), the case study protocol comprised of the following parts: general (project information, data about the company, interviewee), key retail logistics tasks, products and their estimated quantities and causes of product waste, as well as the retailer's strategies to manage perishable products and waste.

Case	Type of retail outlet	Function of interviewee	Waste level	Hygiene rating	Data collection
1	Specialized, grocery shop	Owner, store and purchasing manager	Low	4	I, F/O
2	Specialized, grocery shop	Owner, store and purchasing manager	Low-medium	3	I, F/O
3	Specialized, bakery	Store manager, main baker	Low	4	I, F/O
4	General, convenience shop	Owner, store and purchasing manager	Low-medium	4	I, F/O
5	Supermarket	Corporate Affairs Manager	Low	5	I, F/O

Legend: I – interview; F – Field visit; O – observation

Table 1 – Cases selected and data collection

Data collection is based on semi-structured interviews with the company managers. All interviewees were required to have experience in the food retail industry. Interviews were scheduled in 2015 and 2016, each lasted between 1 and 4 hours. Ten interviews were conducted with retailers, with ten field visits and observations. Where agreed, interviews were recorded and transcribed otherwise interviewers made detailed notes during the conversation. To validate data, in addition to interviews we noted personal observations during the field visit, consulted public and company documentation for additional insights, and conducted interviews with suppliers and local authorities responsible for waste collection.

FINDINGS AND DISCUSSION

Due to constraints of space we present cross-case analysis and key findings related to the main factors that contribute to the waste generation and main strategies retailers use in circular supply chains (Table 2). In analysis of factors that contribute to waste generation, we considered the product characteristics, internal and external factors.

In line with findings in Mena et al. (2014), our research showed the common denominator among food waste factors regardless of the size and type of retailer is related to the 'supply chain' – in particular demand characteristics, such as customers' preference for fresh food, uncertainty of demand or returns from customers. However, the relevance of other supply chain factors is not the same for all retailers: while large companies focus on sources of food waste that arise from complexity of their supply chain and organization of logistics operations, retail SMEs are affected by the operational faults in the supply chain, as well as by policies set by suppliers. This is very apparent in Case 4, where the retail SME is conditioned by the supplier's demand of minimum order size and a no return policy while experiencing low demand for food products.

Analysis of product and company factors, as well as external factors, indicates that waste generation at large retailers is affected by a larger number of factors, while retail SMEs are affected by the smaller number of specific factors, such as lack of resources for maintenance of the cold chain (Cases 1 and 2) or lack of support for waste collection (Cases 2 and 3) or waste separation (Case 4) by the local authorities. Root cause analysis shows that location, layout and accessibility of the outlet, as well as outsourcing of waste collection are important factors that might act as sources of waste generation in retail SMEs, and as barriers or opportunities for product quality preservation and VAR.

In analysis of retail SMEs waste prevention and VAR strategies, we compared large retailers and retail SMEs, and then specialist and general types of retail SMEs (Table 2).

Principles and Strategies	Case 1	Case 2	Case 3	Case 4	Case 5
Estimated waste prevention	++*	++*	+++*	++*	++++*
▪ Adequate resources			⊕⊕	⊕⊕	⊕⊕
▪ Innovative packaging solutions					⊕⊕
▪ Operational planning and control/measurement[#]	⊕⊕⊕*	⊕⊕	⊕⊕⊕	⊕	⊕⊕⊕⊕*[#]
▪ Collaboration with the suppliers					⊕⊕
▪ Demand management: customer information, communication, education		⊕			⊕⊕⊕
▪ Promotion	⊕	⊕*	⊕[n]*	⊕*	⊕*
Estimated value added recovery	++++*	++++	++++*	+++	+++*
Reuse (re-distribution)	+	++	++	+	++
▪ Returns to the supplier	⊕	⊕	⊕	⊕[n]	
▪ Re-distribution		⊕[n]	⊕[n]		⊕⊕*
Re-manufacturing	+++	+	++		+
▪ Pet-food					⊕*
▪ Prepared food	⊕⊕	⊕	⊕		
▪ Ready meals	⊕⊕*				
▪ Ingredients			⊕		
Recycling	+	+	++	+	
▪ in-vessel composting	⊕	⊕	⊕	⊕	
▪ transformation to raw materials		⊕[n]	⊕*		
Disposal with energy recovery	+	+	+	+	+
▪ Anaerobic digestion					⊕*
▪ in-vessel composting	⊕	⊕	⊕	⊕	

* - Strategies identified by interviewees as the most used in retail SMEs for value adding recovery
+ - Estimated extent of the strategy used; ⊕ - The strategy; **n** - Strategies introduced in 2016

Table 2. The key principles and strategies used in food waste minimisation and VA retrieval

The large retailer (Case 5) deploys a range of principles and strategies, focusing on both, waste prevention and VAR strategies. This is not surprising, as the large retailers

typically have sufficient resources and power to tackle internal and external waste sources by ensuring control of the chain (Fearne et al., 2005), investing in packaging, information technology and labelling solutions (Thun et al., 2011), as well as tracing systems that enables visibility and monitoring of food waste (Stenmarck et al., 2011). In the case 5, for example, the large retailer had not only invested in innovative packaging solutions that would extent product shelf-life, but also in media and expert groups that shape demand. The retail SMEs (Cases 1 to 4) on the other hand tend to focus on a smaller number of selected strategies deployed to tackle specific, internal waste sources related to consumer behaviour, purchasing conditions or product quality/freshness. Application of these strategies is under control of the shop managers. We formulate following proposition: *Retail SMEs engage less with waste prevention and VAR than the large retailer*.

Food waste prevention is associated with creation and preservation of the product quality along the chain. Food supply chains are controlled by the powerful supermarkets which coordinate and monitor forward logistics flows (Hingley, 2005). Independent retail SMEs are typically involved into looser collaborative supply chains, as many of food chains are based on informal relationships between buyers and suppliers (Ilbery and Maye, 2005; Trienekens and Zuurbier, 2008). Thus, they are very much impacted by the strategies and disturbances occurred in the supply part of the chain and prevention is localised to their own company. Retail SMEs are not able to invest into innovative packaging solutions, and they do not practice demand management. These strategies require significant financial resources, technology, time and personnel, which is limited for small retailers (c.f. Bourlakis et al., 2014). Moreover, they have low purchasing power and influence on the supplier's strategies and other supply chain members (Thun et al., 2011). In such a situation, retail SMEs (cases 1 to 4) have limited options: a) they practice lean approach to purchasing, e.g. small, but frequent orders, fast inventory rotation and early detection of spoiled/damaged products and their separation from the batch (Cases 1 and 2), and minimal inventory (Cases 1, 3 and 4) b) they utilise product specific VAR activities suitable for small economy of scale operations. We formulate following proposition: *Retail SMEs engage into VAR activities more than in waste prevention*.

Finally, it is interesting to observe differences between retail logistics of a specialist and general types of retail SMEs: specialist retail SMEs appear to deploy more strategies for VAR than the general ones. Specialist stores appear to be more opportunities for re-manufacturing, at their site: for example, slightly bruised fruits are removed and used for preparation of fruit salads (Case 1), vegetables that started losing freshness are wrapped and packed (Case 2), bread is transformed to crisps or bread-crumbs (Case 3). Additionally, surplus of fresh products are donated to shelters or charities that prepare and distribute meals to vulnerable people (Cases 2 and 3). Contrary to specialist shops, convenience shop (Case 4) has fewer opportunities for VAR: it appears that there is lack of space, time and knowledge about possibilities for product transformation. We formulate following proposition: *Specialist retail SMEs engage more into VAR activities then general stores*.

CONCLUSION

Food supply chains are characterized by specific logistics activities and return flows. While a rich body of literature exists on topics related to managing perishable food products for large food companies, empirical research on return flows in food supply chains from the aspect of retail SMEs is under-researched.

Our preliminary findings indicate that a common denominator in waste generation for retailers is their supply chain, in particular the uncertainty of customer demand. Analysis of other factors showed that there is a difference between large retailers and SME retailers in factors that contribute to the waste creation, as well as opportunities for VAR of products. While more factors appear to affect waste creation and management at large retailers, a small number of specific factors appear to affect SMEs.

The analysis of waste prevention and VAR activities shows that large retailers utilise a range of practices to reduce risks of product perishability and short shelf life, manage

demand, and manage reverse logistics practices. Retail SMEs on the other hand use specific strategies to participate in VAR, while coping with multiple constraints when addressing waste generation. However, our findings show that specialist SMEs minimize waste successfully by combining lean principles in purchasing and specific VAR activities for perishable products.

Our contribution to the SCM academic literature is threefold: first, we identify major factors that contribute to the waste generation of perishable products in the retail environment; second, we identify possibilities for VAR of perishable products by retail SMEs and third, we provide insight into opportunities and challenges for SME retailers to manage or participate in VAR. Moreover, though Ilomaki and Melanen (2001) found that micro and small enterprises are not interested in waste management due to lack of time and knowledge, and the small impact it has on their businesses, we found that small food retailers in UK consider waste prevention and management an integral part of their business strategy. Thus, our findings contribute to current theory by presenting data that fills a gap in the literature that considers product quality preservation and VAR in the context of retail logistics and SMEs. Previously, this kind of study has rarely been supported by empirical data (Bernon and Cullen, 2007).

With this paper, we contribute to the improvement of retail logistics and operations in SMEs which constitute over 99% of business activities in UK (Rhodes, 2015). Our findings will help retail managers and owners to better understand the possibilities for VAR, and to investigate a range of logistics and retail strategies suitable for the specificities of the SME environment, and ultimately improve their profitability and sustainability.

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AN EXPLORATORY STUDY ON THE ENVIRONMENTAL IMPACT OF LOGISTICS CLUSTERS

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ABSTRACT

Purpose - The development of logistics clusters (LC) is a step towards economic growth as it leads to a well-established physical infrastructure, the enhanced availability of logistics-related facilities, and value-added services (Sheffi, 2012). Research into LC has been mainly on their development and impact on economic growth, with little attention being paid to the social and environmental impacts. Although the impact of logistics operations on the environment has been discussed widely in the literature, research on the environmental implications of LC has not received attention. Drawing on Relational View (Dyer and Singh, 1998), this paper investigates the possible environmental implications for companies operating within a logistics cluster. It also explores the interactions between those companies and whether or not firms located within the cluster can positively or negatively affect the overall environmental performance.

Design/ methodology/approach – Based on the Relational View (RV) Theory, this research proposes a conceptual framework, which explores the link between LC and environmental performance. RV has been considered in this research as a suitable lens because of its relevance, and simplicity of application due to its unique enablers that allow firms to achieve mutual benefits that cannot be achieved individually. This paper presents an exploratory research that has been carried out through semi-structured interviews with five companies located in two logistics clusters in Saudi Arabia.

Findings – It is found that companies tend to establish collaborative relationships, share knowledge and resources with partners (e.g. sharing transportation and warehousing facilities), but with a limited view on the environmental aspect. Results have also shown that companies are interested in sharing more resources in order to improve their capabilities and operational efficiencies.

Research limitations/implications – This exploratory study contributes to the body of knowledge on LC, specifically on the environmental aspect of the sustainability by developing a conceptual framework based on RV Theory. Our study attempts to fill the academic gaps concerning the empirical investigation of environmental performance in the LC context.

Practical/ Policy Impact - Our study provides valuable insights on how LC companies share tangible and intangible resources which can be adopted to reduce the environmental impact. The study also provides directions to academics and practitioners, particularly, the logistics companies that are located, or willing to locate within a logistics cluster.

Originality/value- While there is a growing interest in the environmental sustainability as an emerging factor that affects companies, there is a lack of empirical study investigating how being located in such cluster can help companies to reduce the environmental impact.

Keywords: Logistics Clusters, Environmental Impact, Relational View Theory.

INTRODUCTION

The link between logistics clusters (LC) and firm's performance has been recognised as a source of potential competitive advantage and sustainable growth (DeWitt *et al*., 2006; Rivera *et al.,* 2014). According to Sheffi, (2012, p.79) LC can be defined as *"very high concentration of logistics activities relative to the local population or economy"*. LC have received attention due to the substantial benefits they offer; access to infrastructure and physical transportation facilities such as roads, rail, and intermodal terminals, value added services such as research centres and light manufacturing, low cost, and environmentally friendly (Cambra-Fierro and Ruiz-Benitez, 2009).

This research is interested in understanding LC's development and particularly to explore the implications on environmental performance. Logistics activities such as freight transport are considered to be significant and visible contributors to CO_2 emissions (Dekker *et al.,* 2012). However, despite the growing environmental concerns in recent years, the environmental performance and impact are still not yet clearly demonstrated in the development of LC. Drawing on the clusters literature and using the Relational View (RV), a conceptual framework is developed and explored through a total of 5 case studies conducted in two LC. This study also aims to explore the most relevant factors that could lead to environmental actions, and whether or not firms' managers incorporate environmental principles and strategies into their decision-making processes.

The rest of the paper is organised as follows. First, a literature review and conceptual framework along with its propositions are presented in conjunction with an analysis of the main enabling factors which have been identified based on an extensive literature review and on selected theory. Second, the research method used in this study is described followed by the study's findings. Finally, a conclusion is presented at the end of the paper.

LITERATURE REVIEW AND THE CONCEPTUAL FRAMEWORK

In this research RV is used as a suitable lens because of its relevance, and simplicity of application due to its unique enablers that allow firms to achieve mutual benefits that cannot be achieved individually. Within the current research context, LC provides a suitable venue to allow firms to interact with and gain from those benefits, due to the advantage of firms' geographical proximity. In total, four main enabling factors have been identified based on the extensive literature review and on the RV theory.

The first factor is *investing in a collaborative relationship*, which is suggested as an appropriate strategy for companies to implement in order to enhance operational efficiency, reduce cost, and improve environmental impact (Sheffi, 2013). The purpose of considering this factor is to explain why and how companies invest into collaborative relationships in an attempt to reduce environmental impact.

The second factor is *firm's capabilities*. Firms tend to achieve higher capability if they are located in LC due to the high level of competition and productivity (DeWitt *et al*., 2006; Patti, 2006). The purpose of considering this factor is to explore the firm's complementarity skills (e.g. IT skills), resources and capabilities (e.g. use of IT equipment or information sharing), and their effects on environmental performance.
The third factor is *firm's knowledge*, which refers to how companies engage in knowledge sharing, and in particular, knowledge relating to environmental performance. The purpose of considering this factor is to explore how companies share environmental knowledge, and how they share general knowledge and adapted it to an environmental end (Wu and Hassis, 2013).

The fourth factor is *governance mechanisms,* which refers to how firms govern their logistics activities and relationships. The purpose of this factor is to understand how a partner employs effective organisations governance and how governance mechanisms influence the success of a collaborative relationship. The conceptual framework and

propositions are presented in Figure 1. In the following paragraphs, the detailed propositions are presented.
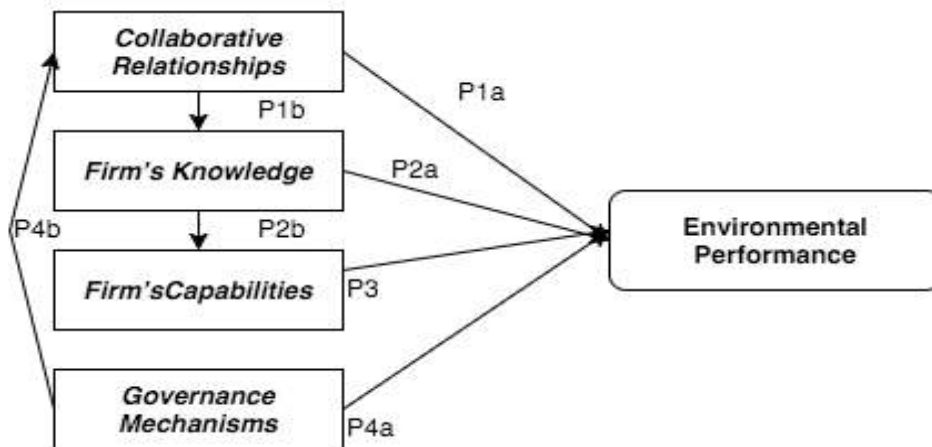
Figure 1: Conceptual Framework

Collaborative Relationships

Developing a relationship with other organisations is believed as a strategy to enhance firm's competitive advantage (Chen *et al*., 2004). From a RV perspective, Dyer and Singh (1998, p. 662) stated that "a supernormal profit jointly generated in an exchange relationship that cannot be generated by either firm in isolation and can only be created through the joint idiosyncratic contributions of the specific alliance partners". Thus, when companies are located in a close geographical proximity with other organisations, there is a possibility for mainly logistics companies to collaborate either with logistics or other organisations located in the cluster (e.g. manufacturing, research institute and suppliers). When it comes to the environmental performance, several researchers agreed that collaborative relationships reduce environmental impact and cost associated with logistics activities as well as improves the operation efficiency (Patti, 2006; Vachon and Klassen, 2008). For instance, studies on collaborative practices discussed the opportunities that LSPs may offer such as enhancement in their operational performance, improve environmental performance by increasing the load factor and minimise the running empty (Stefansson, 2006; Cruijssen *et al*., 2010). This leads to the first proposition: *P1a: Collaborative relationship among firms in LC has an impact on environmental performance.*

The importance of knowledge and learning in logistics and supply chain operations is seen as a source of competitive advantages (Spekman *et al.,* 2002). From a RV perspective, engaging in knowledge sharing and joint learning can improve and overcome collaborative barriers between firms.

Maskell (2001) suggested that once the existence cluster adds values and generates knowledge in addition to other benefits, and once the cluster established, it attracts new firms to join it and expand the knowledge base. In addition to that, knowledge is regarded as a crucial enabler that can have a positive impact on the collaborative practices in LC. From a knowledge perspective, the cluster is not only facilitating the frequency of firm's interactions, but also enhances the knowledge sharing to be more effective. Knowledge sharing between organisations in LC enables them to streamline the flow of information, products and ideas across the firm's boundaries which in turn improves their ability, adaptability and accuracy of the entire supply chain. To successfully achieve the aim of inter-firm knowledge sharing, it is important for all the

involved members to invest in collaborative relationships (Dyer and Singh, 1998). Thus:
P1b: Collaborative relationship among firms in LC has an impact on firm's knowledge.

Firm's Knowledge

The importance of firm's knowledge can result in environmental performance improvements (Wu and Hassis, 2013). This is true if companies effectively develop and share environmental knowledge and particularly knowledge related to the understanding of pollutant emissions along with their consequences. Sustainability, in general, is becoming more dependent on knowledge management execution (Wu and Hassis, 2013). Hence, nowadays there has been recognition that knowledge is regarded as intangible assets that have positive effects on environmental performance (Huang and Shih, 2009). From a LC point of view, geographical proximity helps the firm to better utilise the knowledge from their partner in the cluster due to the knowledge sharing mechanisms (Tallman *et al*., 2004). This leads to: *P2a: The knowledge sharing among firms in LC has an impact on environmental performance.*

It is known that knowledge is considered as one of the main forces behind the success of the cluster development (Porter, 1990). The effect of firm's knowledge in the cluster will generate a cumulative process of knowledge creation among the firms (Ibrahim et al., 2008). The ability of knowledge to flow freely between organisations in the cluster is high and would enhance the cluster to grow which in turn results in improving the firm's capabilities. Consequently, knowledge sharing can have a direct effect on firm's capabilities which encourage firms to invest in knowledge to improve their capabilities (Lin, 2007). According to RV, combining resources such as knowledge and engaging in knowledge sharing would result in better capabilities for collaborative firms. For example, the production networks of GM's and Toyota have shown the effective of how knowledge sharing can generate inter-organisational competitive advantage. Toyota invests in a number of programmes to facilitate the knowledge sharing among the suppliers (Dyer and Singh, 1998). This leads to: *P2b: The knowledge sharing among firms in LC has an impact on company's capabilities.*

Firm's Capabilities

Organisations that have a limited capabilities and resources are likely to attempt a weak response to the environmental requirements (Lee and Klassen, 2008). Thus, the company's ability to identify, develop and introduce new capabilities has been recognised as an essential capability in its own right. Moreover, companies in the cluster are more likely to have the ability to sense, reconfigure their functional competencies and they are able to introduce new configurations which can help firms to improve environmental performance (Helfat et al., 2007). Having the right capabilities can lead to new insights and improved the firm's process and thereby they enhance environmental performance (Paulraj et al., 2008). Firm's capabilities are important in this stance, because firms are likely to have the necessary experience and absorptive capacity to be able to respond to any changes might occur such as new government regulations and legislations or stakeholders pressure to respond to specific issues (Srivastava, 2007). Thus**:** *P3: The firm's capabilities in LC has an impact on the environmental performance.*

Governance Mechanisms

Collaborative firms need to introduce a specific governance mechanism that lies in their interest and in order to protect and support their investment in specific assets. In addition, adopting the right governance mechanism will help collaborative organisations to achieve a win-win situation.

For example, relational governance mechanism can be an effective means by which to respond to environmental performance due to its flexibility-enabling advantages. However, in LC context, it is not clear what sort of a trade-off exist between the types of governance mechanisms. Given the complexity of the logistics operations among supply

chain partners and the rapid changes in the business environment, it is necessary to governance beyond the formal contract and towards closer relational governance (Dyer and Singh, 1998; Poppo and Zenger, 2002). For example, organisations (e.g. logistics companies or research institute) in the cluster can establish a relationship with the manufacturer to involve addressing environmental concerns from early stages in their product development, packaging eco-design or by sharing their knowledge and experience to improve environmental performance. This leads to: *P4a: The governance mechanism among firms in LC has an impact on environmental performance.*

Prior research emphasises the role of governance mechanisms to enhance the organisation performance and it also regarded as a major determinant to effectively manage the relationships among collaborative partners (Benton and Maloni, 2005; Wang and Wei, 2007). According to Zaheer and Venkatraman (1995), the relational governance mechanisms are embodied in the originations relationship structure and process, thus, they are highly influenced by firms relationships performance with other partners across the supply chain. Moreover, the closer relationships establishment among supply chain partners followed with an investing in specialised assets leads to a shift toward essential governance between partners, this also requires them to frequently interact with each other. In LC context, relational governance can be regarded as a means to strength the relationship among collaborative partners (e.g. manufacturing and distributors). From a relationship perspective, relationship governance can be regarded as a strategic element to maintenance and develop a collaborative relationship among different supply chain partners. Thus: *P4b: The governance mechanism among firms in LC has an impact on collaborative relationship performance.*

METHODOLOGY

This paper is based on a case study, which is an appropriate when there is a need to explore a new phenomenon within the real-life practice (Yin, 2003). In order to get in-depth insights into an unexplored phenomenon, it was suggested that a number of four to ten case studies is an ideal number for conducting a qualitative analysis (Eisenhardt, 1989). This research employs a qualitative research design methodology through a means of an exploratory approach in which semi-structured interviews with logistics and operations managers of transportation, warehousing, forwarder companies have been used as main data collection method. The theoretical constructs explored in this study were mainly related to the logistics companies located in the LC. In this research, five case studies were conducted with one interviewee per company and each interview last for approximately 45-60 minutes. The participants included professionals from leading logistics companies that were selected carefully to view their current and future strategies towards reducing the environmental impact. Moreover, the targeted interviewees were chosen on the basis of their availability, experience and depth knowledge related to the logistics operations. The interviews were carried out in two clusters located in Saudi Arabia and all the interviews were conducted through a face-to-face interview and all interviews, expect one were digitally recorded and field notes were also used.

FINDINGS

The findings revealed that there is no clear vision on how such reduction can be achieved. Based on the empirical results, overviews of the formulated propositions are described next to explore whether they are supported or not.

Collaborative Relationship

Results show that collaborative relationships among companies are increasing due to the potential benefits offered by investing in such relationship. "*For us, collaborative relationships have to co-exist with growth in the logistics industry. There is no such thing*

as one company does all or one solution fits all model in logistics and supply chain" says the Operation Manager of a Chemical Warehousing Company D. Moreover, recent research has indicated that not only logistics companies would collaborate but also manufacturing firms would consider the collaborative initiatives in the near future, thus, such LC can be a potential venue for those manufacturing who wanted to invest in a collaborative relationship (Hammant, 2011). However, some companies are not aware of the environmental benefits that could be achieved when collaborating with others in the LC. For instance, the Operation Manager of Warehousing Company D stated that "*It is not consciously done as a pre-requisite, however we look at it more towards an operational efficiency, cost and value addition to the end user*". In this context, companies are willing to collaborate for the purpose of mainly cost reduction and operationally efficiency but environmental aspect seems ignored. For example, Operation Manager of Transportation Company A highlights that "*We joined here to work with others, being here is good to improve our business networks and when it comes to environmental concerns, it depends on the nature of the collaboration. In most cases we collaborate to reduce the cost and improve efficiency of our operation and environmental impact comes last I think*". On the other hand, knowledge concerning the environmental aspect is regarded as an important factor within the co-located companies. For example, the Operation Manager of Warehousing Company B stated that "*We believe being among all the logistics and manufacturing companies will increase our business increase our level of knowledge, increase our awareness of environmental issue and increase our awareness of the safety methods*". Therefore, we can claim that both propositions P1a and P1b are supported.

Firm's Knowledge
Apart from two companies, the rest are considering the importance of knowledge in general and knowledge that related to the environmental impact. In fact, results reveal that firms are willing to share knowledge with others in the cluster to improve their operational performance. According to Operation Manager of a Chemical Warehousing Company D highlights that "*We share our knowledge with the other to drive better utilisation, implementation of standards and overall improvement in productivity*". That means better utilisation will lead to environmental performance improvements and therefore, the environmentally related knowledge is likely to be shared. The Logistics Manager of Company C highlights an interesting example "*We have some ideas and posters in the company along with a 'go green' sign at everywhere which encourage our employees to learn more and share more knowledge that is related to improving the environmental practices*". Moreover, the flow of knowledge and particularly environmentally related knowledge (e.g. clean processing or knowledge related to green packaging) can help companies to improve their existing capabilities and to encompass new green knowledge which in turn will enable to improve the overall environmental performance. Therefore, the results seem to support the proposition P2a and P2b.

Firm's Capabilities
The importance of firm's capabilities depends on the ability to modify the operational capabilities. For example, if the firm is planning to adopt new environmentally friendly process or to change the current strategies, the firm should have appropriate capabilities to be able to respond to such changes.
"*In this market if don't have good capabilities you can survive because the market is evolving and you have to evolve with it*" says Operation Manager of Transportation Company E. Thus, the needs for firm's capabilities are essential to respond to the competitive strategic goal and in ensuring the firms are able and capable of addressing the environmental requirements.
Moreover, the LC allows for a better access for companies wanting to take advantage of being in a close proximity to improve their capabilities, "*Being located in place where many logistics companies around us, gives us the chance to learn to improve our capabilities to be able to compete and to also be more provide more innovative*

solutions" says the Operation Manager of a Chemical Warehousing Company D. Based on the above proposition, we can claim that P3a is valid.

Governance Mechanisms

Companies located within the cluster have better opportunities to collaborate with others such as manufacturer to respond to the environmental and safety issues. According to the Operations Manager of a Chemical Warehousing Company D, "*We have been very lean on the use of any device or design that causes environmental impact and ensure that we work with engineering design firms that take this into consideration*". Moreover, the Operation Manager of a Chemical Warehousing Company B highlights that "*The government inspector visits us yearly and sometimes random visits to make sure we follow the right environmental and safety procedures*". Due to the geographical proximity and trust between companies located in the cluster, they are in most cases adopts the self-enforcing mechanisms. According to Operations Manager of Transportation Company E, he stated that "*Normally we follow self-enforcing mechanism and sometime third party depends on the nature of the relationship*". Thus, the nature of the relationships affects the types of the governance mechanisms company's follow. In fact, supply chain partners who developed a strong relationship tend to establish a governance mechanism that helps firms to reinforce and safeguard the collaborative partnership in addition to the maintaining the resource sharing. Therefore, the proposition P4b is verified; whereas there is not enough evidence to support P4a.

CONCLUSION

Previous studies on LC have focused on the economic and social aspects of sustainability, this research concentrates on the environmental performance and provides a framework which explores the factors that can help companies to reduce the environmental externalities. This exploratory study contributes to the body of knowledge on LC by presenting a comprehensive theoretical basis in understanding the environmental implications of the LC. The findings are in line with the RV theory showing that companies can achieve better operational and environmental performance when working with other partners. From the theoretical perspective, it can be seen that companies can improve the environmental performance when collaborating with others which would result in a sustainable competitive advantage. Therefore, one of the key features of RV is that the individual firm is embedded in a network of relationships and develops collaborative relationships between companies, which provide an opportunity to create value and enable better access to resources and gain benefits that cannot be gained by individuals alone. Our findings also suggest that, the LC would provide examples of operationally viable logistics strategies that reduce the greenhouse gas (GHG) emission primarily the CO_2 by reducing the amount of energy and fuel consumed through the logistics activities. Prior research on LC does not fully recognise and appreciate the importance of sustainability, and environmental performance in particular. Therefore, this exploratory study provides useful insights on the current environmental performance of five companies located in the LC development and highlights the environmental sustainability as an important area for future empirical research.

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Section 7: Knowledge management and E-business in supply chains

ANTECEDENTS TO SUSTAINABLE SUPPLY CHAIN INNOVATION (SSCI)[1]

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Abstract

Purpose of this paper:
Sustainable supply chain innovation (SSCI) has gained increasing attention from both academia and corporation. However, the systematic research focusing on its antecedents is still rare.

Design/methodology/approach:
To investigate the antecedents to sustainable innovation within supply chain context, a conceptual framework is proposed based on literature review and social capital theory. In the framework, all critical antecedents to supply chain innovation capabilities are well-organized within three dimensions of social capital including structural, relational and cognitive capitals. Innovation capability is expected to deliver sustainable performance in supply chain, which is called as sustainable supply chain innovation (SSCI).

Findings:
In this study, a series of propositions are proposed. We argue that three dimensions of social capital in supply chain are all positively related to supply chain innovation capabilities and lead to an increasing and sustainable innovation performance. The relationships are also positively moderated by an advanced information technology application.

Value:
This study provides a complete view of the application of social capital theory onto supply chain innovation and creates a linkage between supply chain innovation and sustainability. A greater understanding on such innovation framework and their impacts enable firms to allocate related resources to establish or strengthen the innovation capabilities, followed by an expected sustainable performance as a result. Hopefully, this study and the proposed framework could be appreciated by practitioners in both academia and corporation for further improvement and research.

INTRODUCTION

Innovation has been considered as a key determinant for organizational competitiveness and success (McAdam and Keogh, 2004). Nowadays, the application of innovation has been also extended from a solo organization to the supply chain which is built on the idea that collaborative work and information transfer up- and downstream of the supply chain improves innovation (Christopher, 1992) The innovation in the supply chain must not only improve economic performance, but also meet environmental and social performance metrics increasingly associated with corporate social responsibility (CSR) (Amaeshi et al., 2008). Sustainable supply chain innovation, as a result, is identified to maximize the supply chain profitability, minimize the environmental impact and maximize the social well-being at the same time (Elkington, 1998, Hassini et al., 2012).

Literatures have identified the innovation abilities of a firm. However, the innovation in the supply chain depends on not only the efforts carried out by a sole firm but also the capabilities of diverse firms in supply chain network (Arlbjorn and Paulraj, 2013). Furthermore, economic performance shouldn't be the only target of innovation; environmental and social goals are also expected to be achieved. Therefore, there is an urgent need to explore the antecedents to innovation that are related to supply chain and its sustainable outcome. As the supply chain innovation is usually conducted by sharing knowledge across organizational boundaries through network ties and collaborative ties among firms, which positively impacts the innovation performance (Wei and Ju, 2010). The social network concept and social capital theory are applied to establish a conceptual framework of key antecedents to supply chain innovation and its sustainable performance.

This conceptual research paper is proceeded by giving a review of the literature on definition of sustainable supply chain innovation and its antecedents, providing an overview of the theoretical foundations and its development, proposing the framework and propositions, and finally discussing the theoretical and managerial implications.

LITERATURE REVIEW

The innovation in supply chain could be a powerful tool to improve the effectiveness of SCM by smoothing interactions of supply chain participants including suppliers, manufacturers, distributors and customers (Lin, 2008). It is based on the concept that collaborative work and information transferring among participants improve the innovation in the supply chain. Arlbjorn and Paulraj (2013) mentioned that the innovation within supply chain network is "an incremental or radical change in process, structure, and/or technology that takes place in the supply chain network so as to create value for all stakeholders". Supply chain enables the innovative channel integration, which was called as "the fifth generation innovation" by Rothwell (1992), delivering the need of great integration in process at both intra and inter-firm level (Liao and Kuo, 2014).

The supply chain innovation (SCI) was aimed to reduce cost, lead time, create new strategies, ensure consistent quality, and form the flexibility to deal with changes from outside or inside of business environment (Lee et al., 2011). But as the increasing cognition to sustainable development, sustainable supply chain innovation appeared, which calls for meeting the needs of the enterprise and its stakeholders, while protecting, sustaining and enhancing the human and natural resources simultaneously. The sustainability in business context was defined as the capability to run business focusing on maintaining the balance of economy, environment and society (Hassini et al., 2012).

SCI that shroud multiple innovative activities occurring in supply chain must be accepted by all parties in supply chain. Thus, the supply chain innovation (SCI) can be defined as the integrated changes in product, process, marketing, technology, resource and/or organization, which are associated with all related parties, covering all related functions in supply chain and creating value for all stakeholders. Sustainable supply chain innovation (SSCI), furthermore, results in a balanced performance of economic, social and environmental dimensions. The antecedents to supply chain innovation in prior researches can be generally separated into motivators and barriers which positively stimulate or negatively hinder innovation occurrence.

In motivators group, integration of supply chain innovative channel generates the formation of supply chain value innovation. The implementation of innovation strategy requires a well-integrated supply chain involving coordinating the material and information obtained from and flows among suppliers, manufacturers and customers (Liao and Kuo, 2014, Narasimhan, 2013). Therefore, activities of gaining the market information and processing information shared by external parties help to remain competitive in uncertain business environments and achieve innovation in the supply chain (Bouncken, 2011). Learning, leveraging and integrating knowledge in the supply network with own knowledge assets increase innovation performance (Berghman et al., 2012). Upstream directives of firm which are pre-sets including guidelines, rules,

principles, instructions, and plans for coordination can formally lay down the concept, design, functionalities, and several duties of suppliers for the innovation (Bouncken, 2011). Collaboration is an inter-organizational relationship type in which the participating parties agree to invest resources, mutually achieve goals, share information, resources, rewards and responsibilities as well as jointly make decisions, solve problems and continuous innovations (Blome et al., 2013). With the increase of customer sophistication, customer requirement has been identified as a key pressure to motivate the innovation. Capturing customer insights increase the extent of interaction, monitoring and measure customer satisfaction and finally increase the performance of supply chain innovation (Gualandris and Kalchschmidt, 2014). In supply chain network, direct and indirect relationships among supply chain partners offers possibility for innovation and achieving a superior innovation performance (Autry and Griffis, 2008). Trust, as an essential element of relational architecture, is a decision to rely on partners with an expectation that they will follow a common agreement and has been proved to be an enabler of collaborative innovation (Fawcett et al., 2012). Moreover, the network structure has a positive impact on the innovation-oriented performance in supply chain, particularly including the location of actor firm, the number of direct ties and the ways it connected or disconnected from other firms (Autry and Griffis, 2008).

In barriers group, the reluctance to innovation is due to the high cost of the investment on innovation along with a long return lead time and a possible failure (Bello et al., 2004). The uncertainties and risk accompanied by innovative activities in supply chain has been classified into technological, commercial, organizational and societal uncertainties (Silvestre, 2014). An high level of supply based complexity could also lead to a difficulty for the acceptance of participants in innovation (Choi and Krause, 2006).

A supply chain is essentially a set of social networks comprised of ties among firms within a particular industry or group. In supply chain innovation, firms share knowledge across organizational boundaries through their network ties among firms, which positively impacts the innovation performance (Wei and Ju, 2010). Thus, it is vital to analyse sustainable supply chain innovation from network perspective. And, the analysis of relational attributes rather than individual characteristics distinguish this research from others. Drawing from the social network concept, firms' social capital can help the exchange of learning information in supply chain, thus enables knowledge creation and innovation (Bourdieu, 1986). Hence, social capital theory is applied to establish a framework to reveal the impact of antecedents to supply chain innovation and its sustainable effects.

RESEARCH FRAMEWORK AND PROPOSITIONS

Social Capital and Supply Chain Social Capital

The concept of capital has been well known as the accumulation and deployment of resources which are expected to gain positive returns (Brewer, 1984). A managerial focus on capital on revenues is advantageous to provide a long-term and farsighted view on the firm's overall competitive advantages (Autry and Griffis, 2008). Nahapiet and Ghoshal (1998) proposed that social capital is composed of three interrelated dimensions: structural, relational and cognitive capitals. Firstly, the structural capital including social interaction could be defined and measured by density, hierarchy and connectivity. The position of an actor's contacts and interactions in a social structure provides certain advantages for the actor. People in the network can use their personal relationship to get works, information, and any specific resources. Secondly, the relational capital refers to assets based on relationships, such as trust and reputation. This dimension concentrates more on the formal infrastructure in a network of relationships such as social norms, obligations and expectation, as well as identity. Finally, the cognitive capital could be defined as resources providing shared basis for interpretations and representations among network participants. As supply chain is essentially connections of firms (actors), social capital theory has a great potential

applicability for supply chain analysis. Considering the social capital, supply chain has inherent "social identity salience". Supply chain social capital could be defined as "a set of social resources embedded in the relationships in a supply chain network, including the relationships per se, the interactions among different actors, and the processes derived from those relationships within a supply chain" (Min et al., 2008).

Supply Chain Innovation Capabilities

Firm innovation capability is a collective of capabilities, which was defined as capabilities of the "learning-to-learn" (Collis, 1994), or as "the potential ability of an organization to position itself in an arena of modernism such as new product development, technology and other advancements that result in competitive advantages over its rivals" (Chandler et al., 1999). According to the capabilities-based view, supply chain innovation could be described as a set of supply chain innovation capabilities and innovation performance. Supply chain innovation capability is a set of potential capabilities of supply chain participants to integrate the resource and knowledge, to stimulate and manage creative ideas, to implement and diffuse the innovation which creates value for stakeholders. It could be measured from three dimensions: the abilities to learn and share knowledge, the abilities to create and realize innovation idea, and the abilities to internal and external diffuse innovation.

The previous knowledge is the cumulative result of the firm's internal- and external-related efforts in the past. Learning and sharing knowledge are the capabilities to process knowledge inter-firm, more specifically, to create, acquire, transfer and integrate knowledge, to fluid communicate, dialog and debate among organizations, and to modify its behaviours to reflect new cognitive situations aiming at improving its performance (Jerez-Gómez et al., 2005). Learning and sharing knowledge have been proved to be positively related to innovation performance (Camisón and Villar-López, 2011).

In a complex and dynamic process of generating new ideas, it is required to determine the direction of supply chain innovation, which leverages supply network resources for innovation (Narasimhan, 2013). Usually the idea creation is less costly compared to the later stage in innovation process, so that firms expect a larger number of ideas or solutions available for exploitation (Flynn et al., 2003). After the innovation ideas are generated, they should be organized and prioritized to be accepted, rejected, modified or combined. While the prioritized idea is selected, a small range will be chosen to implement a pilot run with some resources in a short period of time. The realization is managed by planning, organizing, motivating and controlling resources and time to achieve specific goals (Nicholas and Steyn, 2012).

The last dimension of supply chain innovation capabilities required is the internal and external diffusion of innovation among supply chain participants. Based on innovation diffusion theory, innovation diffusion is the process to communicate through certain channels over time among the participants of a social system (Rogers, 1995). The capabilities of diffusion could be defined as the capability to communicate with participants and balance the benefits and interests of all stakeholders in the supply chain.

Sustainable Supply Chain Innovation Performance

The purpose of supply chain innovation should be achieving a sustainable performance considering not the only economic dimension, but also social and environmental dimensions (Labuschagne et al., 2005). According to Elkington's definition of the triple bottom line, the sustainable supply chain innovation performance could be measured from economic, environmental and social dimensions (Elkington, 1998).

According to social capital theory, the potential antecedents are organized within three dimension of supply chain social capital. Structural capital influences the development of the relational capital and cognitive capital. For instance, the strong and symmetrical ties usually associate with the development of affective relationships, and may impact firms'

motivation to engage in social interaction and exchange knowledge in turn (Krackhardt, 1992). Similarly, stable networks with dense relations and high level of interaction are beneficial to the development of different facets of the cognitive social capital (Boisot, 2013). Figure 1 provides a graphic depiction of research structure and propositions.
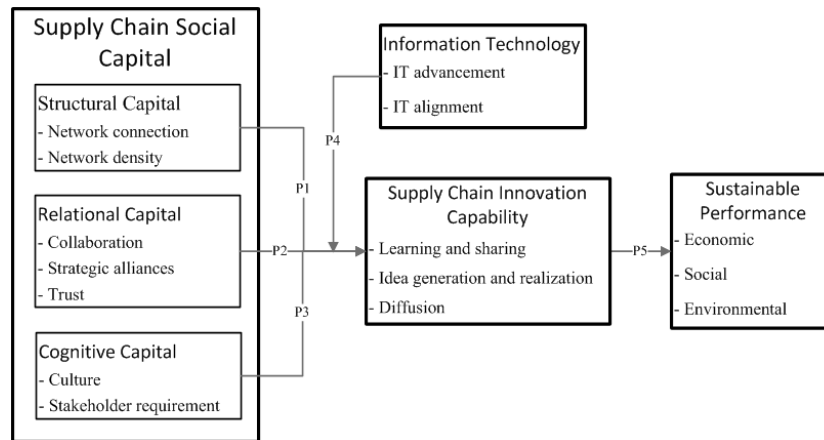
Fig. 1: Framework of Antecedents to Supply Chain Innovation and Performance

Supply Chain Structural Capital and Innovation capability
Supply chain Structural Capital is considered as the location of actor firm within the network and the ways connecting or disconnecting with other firms, rather than focusing on the quality or nature of connections (Autry and Griffis, 2008). Network connection and network density are two dominant structural concepts in structural capitals. Firstly, network connections represent how actor firms in supply chain connect to each other. The connections are regarded as pipelines, or channels through which resources and information flow. As a result, social relations could reduce the amount of time and investment required to access to information. Thus, a proper network connection could improve the supply chain innovation capability. Secondly, network density provides an overall measurement of network connectivity, which is defined as "the extent to which possible connections within a network are activated, and is commonly worked as the ratio of active to potentially active ties" (Wasserman and Faust, 1994). Structural holes are spaces in a network with missing ties or lacking density. A network with rich information is more likely to provide a reliable flow to and from those places, which benefits supply chain innovation. On the other hand, in a network with few information and contacts, the dense network is inefficient and it returns less diverse information for investment (Burt, 1992). Network structures make the valuable resource as channels or conduits for knowledge diffusion and transfer. Thus, we propose P1: Structural capital will be positively related to supply chain innovation capability.

Supply Chain Relational Capital and Innovation capability
Supply Chain Relational Capital refers to "the degree of reciprocity and closeness among supply chain participants" (Rindfleisch and Moorman, 2001). It builds the expectations of trust and exchange of information which stimulate information trading and knowledge flowing (Uzzi, 1997). A frequent contact and relational closeness among supply chain participants enhance the complex information learning and transferring because information exchange require a repeatable process to balance the costs and benefits (Schulz, 2001). Three concepts related to relational capital are considered: collaboration, strategic alliances, and trust among supply chain participants. Collaboration is to collectively achieve a common goal for participants in supply chain. Relational capital involves all joint activities in long period. Ellinger et al. (2000) argued that a higher level of supply chain collaboration results in a greater business-partner independence. Organizations that pursued both internal and external collaborations are beneficial for partners to share information and risks, synchronize business operations, improve customer services, and finally enhance the satisfaction to create an excellent supply

chain. Firms enhance their value creation by embedding achievable resources into objects, changing and integrating the resource and reconfiguring value constellations. In conclusion, supply chain collaboration enriches supply chain innovation capability. To achieve a common goal of supply chain, strategic alliance is the key to supply chain relational capital. Strategies alignment across supply chain participants includes two steps. One is to understand knowledge of requirements clearly and make plans, which requires developing a common strategy. Another is to develop a technology strategy based on appropriate financial and knowledge resources. The strategy alignment and the integration among participants create a better context for innovation efforts (Narasimhan, 2013). Trust refers to the extent to which one may rely on another to look after its business focus, which is the essential of a business relationship. The level of trust determines the extent to which organizations are willing and able to interact with each other (Dodgson, 1993). The competence of trust proves that less frequent and more high-quality and valuable interactions lead to increasing generation of continuous innovations (Nooteboom et al., 1997). With a closer relationship and linking to each other, the participants in supply chain could reinforce their competitive advantage in multiple ways (Uzzi, 1997). Therefore, increasing the capacity to access resources and encouraging to exchange proprietary information, relational capitals not only enhance the acquisition of information, but also improve the utilization of information in innovation (Rindfleisch and Moorman, 2001). Thus, we propose P2: Relational capital will be positively related to supply chain innovation capability.

Supply Chain Cognitive Capital and Innovation Capability

Cognitive capital includes all the resources providing to supply chain participants with shared representations, interpretations and systems of meaning (Nahapiet and Ghoshal, 1998). In supply chain, participants not only need to cognize that innovation usually generates through integrating knowledge and experiences from supply chain, but also need to cognize diversity of opinions, expanding knowledge such as institution, business environment and meaningful communication with all stakeholders. Generally, cognitive capitals include culture and stakeholder requirement. The proper culture or climate in the organization is crucial for innovation. The components underlying this aspect include shared vision, tolerance of ambiguity, creative time, empowered employees and constructive communication (Lawson and Samson, 2001). The valuable, rare and inimitable culture and its extension to supply network are supportive to innovation, which could create a strong competitive advantage (Narasimhan, 2013, Barney, 1991). Stakeholder could be defined as "any group or individual who can affect or is affected by the achievement of an organization's purpose". Stakeholders usually include financial claimants, non-governmental agencies, employees, customers, communities, universities, media, governmental officials, etc. (Stubbs and Cocklin, 2008) and could be classified into primary and secondary stakeholders (Clarkson, 1995). Understanding the requirements of stakeholders and cognizing the collaboration among external stakeholders are as important as the collaboration within the supply chain itself (Silvestre, 2014), which increase the probability of innovation success. Thus, we propose P3: Cognitive capital will be positively related to supply chain innovation capability.

Information Technology and Supply Chain Innovation Capability

Information technology (IT) has been recognized as a "catalyst" of the process which transforms resources related to IT into higher value for a firm, which is expected to create a more sustainable competitive advantage(Wu et al., 2006). The application of IT in supply chain enables a firm to develop, store and accumulate knowledge related to stakeholders and enhance the supply chain capability and performance (Tippins and Sohi, 2003). IT advancement and IT alignment are two dimensions considered for information technology. In supply chain, IT advancement creates customer solutions ahead of competitors (Wu et al., 2006). IT alignment is the extent of firm's IT being compatible with its channel partners, which stands for the level of IT embeddedness across the supply chain. To achieve a higher efficiency, it requires channel partners to coordinate and align business processes with each other (Powell, 1992), so that advancement and

alignment of IT system in supply china can accelerate social capital transforming into stronger supply chain innovation capability. Thus, we propose P4: Advanced information technology application will positively moderate the effect which all three dimensions of social capital have on supply chain innovation capability.

Supply Chain Innovation Capabilities and Sustainable Performance
Supply chain innovations bring economic benefit and create first mover advantage in competition for participants. While supply chain innovation considers the requirements from stakeholders, it is possible to achieve the balance among economic, environmental and social performances, which is called as sustainable performance (Labuschagne et al., 2005). Awareness of synergy between innovation and sustainability could be developed stage by stage, while the innovation and sustainability efforts are started to be integrated, such as sustainable design and product stewardship (Hansen et al., 2009). Hence, the establishment of supply chain innovation capability based on social capitals and advanced information technology application enables sustainable performance. Thus, we propose P5: Supply chain innovation capabilities will be positively related to sustainable performance in supply chain.

IMPLICATIONS FOR RESEARCHERS AND MANAGERS
In the modern business context, innovation associating with supply chain has been recognized as a powerful weapon to create competitive advantage. This study employs social capital theory and establishes a conceptual framework to reveal antecedents to supply chain innovation capabilities and its sustainable performance which is moderated by information technology.

This research extends the argument of Autry and Griffis (2008), who firstly employed social capital theory to discuss firms performance in supply chain. This framework provides a more complete view by proposing all three dimensions of social capital as antecedents to supply chain innovation and its sustainable performance. This research has also proposed and clearly defined some key concepts such as supply chain innovation (SCI), sustainable supply chain innovation (SSCI), and supply chain innovation capabilities. For managers, the conceptual framework and propositions might improve their understanding on sustainable supply chain innovation, and guide them to allocate related resources to establish or supplement the innovation capability to achieve a sustainable performance.

In this study, we argue that supply chain social capital containing structural, relational and cognitive capitals are all positively related to the supply chain innovation capabilities and result in sustainable innovation performance. The relationships are positively moderated by advanced information technology application. Further work could empirical test the proposed framework and demonstrate the positive relationships by survey.

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THE IMPACT OF SUPPLY CHAIN SYSTEM AND LEARNING ON THE SUSTAINABLE PERFORMANCE: EMPIRICAL EVIDENCE FROM CHINA

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Abstract
Purpose of this paper:
The purpose of this paper is to identify and empirically test a framework analyzing the effect of supply chain system, which consists of function, structure, and context, on sustainable performance. The study further explore how could supply chain learning affect sustainable performance directly and play a mediate role between supply chain system and supply chain sustainable performance.

Design/methodology/approach:
The study develops a structural equation model to test the hypotheses. Data were collected based on a survey of 264 firms in eight industries located in China.

Findings:
The study indicates that supply chain system, that is, function, structure, and context could directly and indirectly enhance the three dimensions of the supply chain sustainable performance, in economic, social, and environment perspective. Furthermore, authors also find that supply chain learning as a catalyst for supply chain system could affect the sustainable performance of supply chain positively.

Value:
The study is among the first to view the effect of the function, structure, and context of a supply chain on supply chain sustainable performance with the system theory perspective. In addition, the paper explores the role of supply chain learning as a mediating variable between supply chain system and sustainable performance.

Research limitations/implications:
Firstly, the empirical data did not include the change of a supply chain system and supply chain learning over time. Therefore, future research might aim at a longitudinal study.

Secondly, our results are based on answers of a single respondent of each organization. Future research might want to include multiple respondents per organization with an extension on objective measures instead of perceptual measures. Thirdly, as our samples are limited in Chinese firms, we suggest a future research explore other contexts as a comparison. Finally, future research might divide the participants of supply chain learning into suppliers and customers so as to exploit the impact respectively.

Practical implications:
The proposed model offers managers a path to rethink and redesign their activities to achieve a supply chain sustainability. To meet the worldwide quest for sustainability, organizations should pay more attention to issues relating to supply chain's function, structure, and context. In addition, more attentions should be paid by organizations to their external context situation and supply chain learning.

1. Introduction

In recent years, China has experienced a remarkable economic growth and has ascended to be the second largest economy in the world(Bai et al., 2015). It results in a growing amount of investment in China by multinational companies, however accompanied by unprecedented environmental and social costs(Bai et al., 2015, John Sands et al., 2015).Given the arising attention to the negative outcome of economic growth, which has become a major challenge for China (Zhu et al., 2013), achieving a supply chain (SC) sustainable development is becoming a hot spot and an urgent problem to be solved. Researchers and practitioners are increasingly considering the impacts and implications of SC sustainability in their fields(Taticchi et al., 2013), which can not only meet the requirements of stakeholders that is to increase the economic performance, but improving the ecological efficiency and social responsibility jointly (Tajbakhsh and Hassini, 2015). Accordingly, it is vital to develop an approach to factors that allow organizations to improve SC sustainable performance continuously.

To date, studies have largely focused on drivers that increase the SC sustainable performance (Golicic and Smith, 2013, Wolf, 2014).However, few scholars have considered the drivers in a system perspective. In addition, little is known about the definition and characteristics of SC function, structure, and context. Therefore, in this paper, we aim to complement this gap by conducting a more comprehensive explore on whether the three inherent properties, function, structure, and context, would increase SC sustainable performance when viewing the SC as a system. On the other hand, it is increasingly well-established in the literature that learning could provide a positive support to the organization competence and performance (Spekman et al., 2002, Bessant et al., 2003). Thus, our study will integrate learning factor into the SC system with an expanding understanding of learning in the supply chain perspective.

Consequently, the objective of our paper is to discuss the triggers on supply chain sustainable performance. First, we seek to propose the definition and characteristics of the three dimensions in SC system on the basis of literature review. Second, we hope explore the impact of multiple dimensions of SC on sustainable performance, in terms of economic, social, and environmental performance. Third, we try to test whether SC learning could

affect SC sustainable performance positively. And finally, we expect to test the model by including SC learning as a mediating variable between SC system and sustainable performance.

2. Theoretical background and research hypotheses
2.1 Supply Chain Function

Function means goals and demands that are imposed on a system(Lang et al., 2007b), such as a supply chain. It aims to meet the demands of stakeholders, including economic, social and environmental stakeholders. In our study, we define the supply chain function as a series of activities, such as plan, source, make, deliver and return, which are designed to meet the demands of stakeholders.

Interactions among supply chain members, including joint setting environmental goals, shared environmental planning, and working together to reduce pollution could improve environmental performance(Vachon and Klassen, 2008). Basnet (2013)also suggested that a company's performance would be enhanced by supply chain functions. In the meantime, the performance of companies on the supply chain would facilitate the whole supply chain performance. Hence we hypothesize:

H1a. There's a direct and positive relationship between the management of SC function and SC sustainable performance.

2.2 Supply Chain Structure

Choi et al. (2001)defined supply chain structure as "the patterns of relationships between organizations that belong to supply chain". Another definition of supply chain structure was carried out by Hur (2004) as "the processes that control and co-ordinate the objectives and activities of independent organizational units that comprise the supply chain". For our study, we view supply chain structure as the integration of the supply chain members, including centralization, formalization, and communication.

In line with the definition, the purpose of SC structure is to enable and encourage organizations to be integrated and pursue for their ultimate aims(Baban and Pinar, 2013). Dale (2007)also puts forward that a company is willing to adjust its structure in order to serve their customers in the most efficient way and to maximize its profit. Hence we hypothesize:

H2a. There's a direct and positive relationship between the management of SC structure and SC sustainable performance.

2.3 Supply Chain Context

Context refers to "all environment constraints that are permanently relevant to system or impact factors"(Lang et al., 2007b), which contains both natural and societal context(Lang et al., 2007a).A considerable amount of researches have implied stakeholder theory to analyze the influence that stakeholders have on supply chain system. We conclude that supply chain context refers to natural and societal context, where supply chain external stakeholders including government, NGOs and community locate.

As far as Maria Jesus Saenz et al. (2015) concern, pressure from stakeholders imposed on sustainable supply chain management may bring about sustainability awareness, adoption of sustainability goals, and implementation of sustainability practices. Hence we hypothesize:

H3a. There's a direct and positive relationship between the management of SC context and SC sustainable performance.

2.4 Supply Chain Learning

Daniel J. Flint (2008) points out that SC learning infers that firms as well as suppliers and customers are all actively participating in the learning process of SC management. However, previous studies about learning had only limited concentration in the organization itself. As a result, our research would like to fill in the gap and pay more attention to SC learning.

A company's ability to innovate and learn lies directly to a company's value, proposed by Bhagwat and Sharma (2007), for the reason that innovation and learning could not only bring efficiency to operation, but make it possible to meet the varied requirements of customers through cost reduction and product differentiation. Hence we hypothesize:

H4. There's a direct and positive relationship between SC learning and SC sustainable performance.

In addition, it is of importance to pay attention to the pre-conditions for SC learning. Mentzer et al. (2001)suggest that mutual trust, long term cooperation commitment, and willingness to integrate key business process into the SC are essential for supply chain learning. These were further confirmed by Spekman et al. (2002), who present that the following six factors are vital to supply chain learning: trust, the degree of commitment, the type of relationship, decision-making style, the company's culture, and the degree of a win-win oriented partnership. Hence we hypothesize:

H1b. There's a direct and positive relationship between the management of SC Function and SC Learning.

H2b. There's a direct and positive relationship between the management of SC Structure and SC sustainable performance.

H3b. There's a direct and positive relationship between the management of SC Context and SC sustainable performance.

Brewer and Speh (2000)propose that supply chain firms continually learn and innovate in four ways. Firstly, by redesigning the products and processes to increase value. Secondly, by collaborating with inter-organizations within a supply chain to add value delivered to customers. Thirdly, by improving the management of supply chain information to ensure accurate and timely decisions can be made by SC partners. Finally, by monitoring the external marketplace to ensure that the value can be delivered to customers. As a result, four applications above enable firms to gain a balance between finance and non-finance performance. In accordance, supply chain sustainable performance may be enhanced in the future. Hence we hypothesize:

H1c. The effect of SC Function on SC sustainable performance is mediated by SC learning.

H2c. The effect of SC Structure on SC sustainable performance is mediated by SC learning.

H3c. The effect of SC Context on SC sustainable performance is mediated by SC learning.

Our hypothesized research model is presented in Figure 1. In the following part we develop our research model step-by-step.
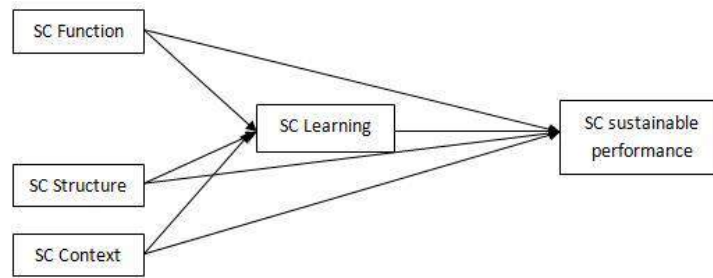
Fig.1. Research model

3. The empirical study

3.1 Sample and Data Collection

For this research, data were collected in China by survey. Our survey was designed to proceed in two stages. In the first step, an extensive literature review on SC function, structure, context, SC learning, and SC sustainable performance were conducted to ensure the content validity of the questionnaire. Following that, a pilot study was conducted with 5 experienced managers reviewing the preliminary questionnaire and checking the appropriateness of each item. Adjustments to the structure and content of the questionnaire were made accordingly.

Data collection was accomplished via a web-based survey system. Overall, we collected 264 firms as our sample.

3.2 Measures

To increase the degree of validity, multiple indicators were used to represent each construct. The theoretical constructs used in this study were developed based on past research. We made use of the five-point Likert scale (1=strongly disagree, 5 =strongly agree) in our survey.

4. Results

After data collection, the data analysis of the study was estimated with SEM using AMOS. While structure equation modelling can examine the mutual relationships simultaneously among a set of posited constructs, which are measured by the observed(Chen and Hung, 2014), Then the data analysis was developed in the two stages: evaluation of the measurement model, and the structure model(Anderson and Gerbing, 1988).

4.1 Reliability and validity

The evaluation of a reflective measurement model should include reliability, convergent validity, and discriminant validity(Hair et al., 2011). The reliability indicates the internal consistency of the indicators measuring a given factor(Chen and Hung, 2014), which can be measured by composite reliability indicator(CR). Except for Community whose CR value is 0.693, the value of all other constructs exceeded 0.7, which satisfied the minimum standard.

Convergent validity exists when all loadings are generally significant above 0.7, and average variance extracted(AVE) value surpasses 0.5, indicating that the items share at least half of their variance with the construct(Hajmohammad and Vachon, 2014). The results show that most constructs in the study have reached a statistically adequate level, while Plan, Formalisation and Communication are closely reaching 0.5.

Discriminant validity was established by comparing AVE and correlation between the constructs(Anderson and Gerbing, 1988) to test whether one construct would overlap the conceptual territory of another construct(Hajmohammad and Vachon, 2014). If the square roots of AVE for a construct is higher than the correlation between two constructs, the evidence of sufficient discriminant validity exists(Fornell and Larcker, 1981). The results show that the performance of all constructs are acceptably in general.

4.2 Structure model

Based on the measurement model, we built a structure model to test our hypotheses given before. In order to evaluate the direct and indirect impact of the SC Function, SC Structure and SC Context on SC sustainable performance, we constructed a separate structure model for each construct(Hsu et al., 2013), as is shown in Table1. All the three models were tested with a result that they had a satisfactory model fit results while all loadings were significant ($p<0.05$). They support H1a, H1b, H2a, H2b, H3a, H3b, and H4. To further analyse SC Learning as a mediation between SC system and SC sustainable performance in the model, we applied Sobel test thereby(Preacher and Hayes, 2004). Our findings on Sobel test results show that H1c, H2c, H3c are confirmed.

Table1 Results of Structure models

Structural equation model	Standardized loading	S.E.	t-value	Hypotheses
Model 1 SC Function				
Function→Performance	0.482*	0.154	3.449	H1a:supported
Function→Learning	0.837*	0.139	7.953	H1b:supported
Learning→Performance	0.324*	0.110	2.465	H4:supported
Sobel Test	Sobel=2.646; P<0.05			H1c:supported
Model fit: χ^2/ df=2.18; CFI=0.958; GFI=0.930; AGFI=0.898; RMR=0.028; RMSEA=0.067				
Model 2 SC Structure				
Structure→Performance	0.497*	0.140	3.150	H2a:supported
Structure→Learning	0.859*	0.086	10.556	H2b:supported
Learning→Performance	0.302*	0.128	1.973	H4:supported
Sobel Test	Sobel=2.296; P<0.05			H2c:supported
Model fit: χ^2/ df=1.82; CFI=0.977; GFI=0.952; AGFI=0.923; RMR=0.025; RMSEA=0.056				
Model 3 SC Context				
Context→Performance	0.411*	0.068	4.899	H3a:supported
Context→Learning	0.552*	0.079	6.636	H3b:supported
Learning→Performance	0.501*	0.068	6.282	H4:supported
Sobel Test	Sobel=5.070; P<0.05			H3c:supported
Model fit: χ^2/ df=2.07; CFI=0.964; GFI=0.944; AGFI=0.910; RMR=0.035; RMSEA=0.064				

In conclusion, the original conceptual model has gained adequate support from the survey data. SC Function, Structure and Context are related to SC sustainable performance both directly and indirectly.

5. Discussion

The arguments made in the paper illuminated how three aspects of SC system, that is, function, structure, and context could directly and indirectly enhance the three dimensions of the SC sustainable performance, i.e., economic performance, social performance, and environment performance.

Theoretically, the study is distinct from previous researches in the field of supply chain and sustainable performance; we view supply chain as a system, which is characterized by three dimensions: function, structure, and context. On the basis of a large amount of literature review, we present our definitions of SC Function, SC Structure, and SC Context. Furthermore, a theoretical contribution of our research is having confirmed the multidimensional nature of supply chain function, structure, and context by carrying out a second-order CFA. Specifically, SC Function consists of five first-order latent variables: Plan, Source, Make, Deliver and Return. SC Structure contains three first-order latent variables: Centralisation, Formalisation, and Communication. And SC Context is comprised of three first-order latent variables: Government, NGOs, and Community. Each latent construct have several corresponding measures.

In addition, our research extends the understanding of learning in SC level compared with previous focus on the organization level. Because, from the perspective of SC system, it is more meaningful to study the whole SC than a single organization in the interdependent society. As a result, based on literature review, we view learning in the context of supply chain. Although the improvement of SC performance through learning have been demonstrated in varied researches, the mediation effect that SC learning makes on SC sustainable performance in the SC system is still limited. Thereby our study has made contribution in testing this relationship.

In the practical level, the proposed model offers managers a path to rethink and redesign their activities to achieve a supply chain sustainability. Based on our findings, a sustainable SC system could promote SC sustainable performance. For instance, to meet the worldwide quest for sustainability, organizations should pay more attention to issues relating to SC function, structure, and context, including but not limited to: cooperating with partners to formulate annual plan, cooperating with partners to forecast products demand, developing an information communication platform, sharing information with partners, etc. Moreover, to advance supply chain learning of organizations continuously, government ought to promulgate relevant environmental laws and regulations, while NGOs and community could urge companies to take environmentally friendly activities. In addition, more attentions should be paid by organizations to their external context situation and supply chain learning, for the reason that a better performance on economic, social and environment could be developed, if organizations are able to develop their learning ability affectively. Overall, in a complex business environment, only if the firms realize the importance of adjusting their supply chain system accordingly and learning from suppliers and customers continuously, could organizations acquire additional opportunities and competitive advantage.

6. Conclusion

A large numbers of literatures exist in discussing drivers that increase SC sustainable performance. Most of the studies were scattered. This research has generated a valuable

insight into viewing supply chain as a system to explore the same issue. The hypothesized relationships were tested by structural equation model to demonstrate that SC Function, Structure, Context and SC learning all positively affect SC sustainable performance. Specifically, SC learning is a catalyst for supply chain sustainable performance in the perspective of supply chain system. The results shed light on the role of supply chain system itself on supply chain sustainable performance.

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EVALUATION OF SECURITY SYSTEMS WITH ELECTRONIC SEALS AND DGPs FOR CONTAINER TRANSSHIPMENT TERMINALS

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ABSTRACT
In order to mitigate the potential negative impacts on port efficiency while complying with the security regulations, terminal operators are attempting to enhance container transshipment by adopting security systems with the tracking and location technologies. However, the evaluation of suitable security systems is challenging due to technical complexities and empirical uncertainties of container transshipment processes. This study aims to overcome the challenges of system evaluation by developing a decision support model with multi-objectives of minimizing implementation costs, and maximizing time savings and security standards. The proposed model is based on the approaches of influence diagram and utility theories. It takes into account the risk attitude of decision maker, decision planning horizon, and uncertain variables affecting the implementation of technology solutions. The decision alternatives of security systems considered in this study include the combinations of electronic seals, RFID vehicle control system, and differential global positioning system. To illustrate the practicability of the proposed evaluation apporach, a simulated case study based on the environment of the Port of Yokohama was investigated. Terminal operators can use the proposed model to facilitate the evaluation process of security systems with a balance among implementation costs, time savings, and security standards.

INTRODUCTION
Since the September 11 terrorist attacks, governments and organizations have launched several initiatives or regulations, such as 24-hour Advance Vessel Manifest Rule, Container Security Initiative, Customs Trade Partnership Against Terrorism (C-TPAT), Smart and Secure Tradelanes (SST), Cargo Handling Cooperative Program, and International Ship and Port Facility Security (ISPS) code, to strengthen security standards and deter terrorist threats (Peterson, 2008). Although these actions aim to improve the security of container transport, they may incur additional workloads and costs for terminal and transport operators (Urciuoli et al., 2010). For instance, the C-TPAT program requires considerable amount of investments on partnership building, security training, security threat planning, and operational costs (Park, 2013). Some study reported that the annual costs and administration works of Swedish ports have increased significantly since the implementation of the ISPS code (Mazeradi and Ekwall, 2009). In order to mitigate the potential negative impacts on port efficiency while complying with the new security regulations, supply chain practitioners are looking for solutions from information and communication technologies (Ngai et al., 2007). Several port development initiatives have attempted to enhance container transshipment by applying security systems with the tracking and location technologies including optical character recognition (OCR), radio frequency identification (RFID), real time location systems, differential global positioning system (DGPS), geographical information systems, and electronic seals (e-seals) (Bollen et al., 2004). The challenges for container terminal operators are to evaluate the most suitable security systems that can yield the maximum productivity, while considering complicating factors such as investment return, risk aversion of ocean stakeholders, standardization, and information sharing and integrity. Because these security solutions generally involves with enormous investments, terminal operations could suffer a competitive disadvantage by investing in wrong solution at the wrong time or by investing too much in the right ones.

To help the terminal operators with a practical and convenient tool for the evaluation of security systems for container transshipment processes, this study aims to develop a

decision support model with multi-objectives of minimizing implementation costs, and maximizing time savings and security standards. The proposed model is based on the approaches of influence diagram and utility theories. It takes into account the risk attitude of decision maker, decision planning horizon, and uncertain variables affecting the implementation of technology solutions. Terminal operators can use this model to evaluate whether to invest on tracking and location technology solutions with a balance among implementation costs, time savings, and security standards. Because the container transshipment processes are highly vulnerable to smuggling, counterfeiting or operational corruption, the associated risks of container transshipment can be alleviated to some degree if suitable security systems with location and tracking technology are implemented. The technology solutions considered in this study include active e-seal system, RFID vehicle control system, and DGPS. The active e-seal is an electronic version of ISO 17712-compliant mechanical seal that locks the container door to provide physical protection against accidental breakage. By transmitting data on the 433 MHz ISM band, e-seals can report their positions and are able to record the time that they were activated, compromised, or removed (McCormack et al., 2008). Meanwhile, the RFID vehicle control system uses the RFID technology to control truck-related workflows in the loading bay areas, parking slots, and yard entrances, where UHF receivers are installed to identify the truck plate number and driver information stored in the RFID tags that are attached to the windshield of truck. In addition, DGPS can be used in container yards for providing real-time tracking or location information of container handling equipment and containers with improved location accuracy than GPS. Although past studies have already discussed the results and benefits brought by the adoption of these location and tracking technology solutions on container operations (Smith et al., 2009), there is lack of research addressing how to select the appropriate solution for the container transshipment terminals, where there are many complex considerations and factors involved. Influence diagram approach adopted is especially suitable for dealing with the decision problem investigated in this study, because it is capable of compact and intuitive representation of complex situations with fast inference mechanisms (Mauá et al., 2012). Hence, the proposed approach can provide terminal operators a systematic decision support tool to evaluate whether to invest the security systems with e-seals, RFID vehicle control, and DGPS on container transshipment operations. In the following sections, the security systems for the container transshipment processes that this study aimed to address is described first. Then the methodology of influence diagram and inference algorithms used in this study is explained in Section 3. To demonstrate how the proposed decision support model works, a simulated case is illustrated in Section 4. Finally, the last section summarizes the conclusion and future research suggestions.

Security Systems for Container Transshipment Processes
Generally speaking, one of the bottlenecks in container transshipment processes is when container truck enters or leaves the yard portals at port terminals. Truck drivers need to stop at the check point of the portal for the sake of submitting the required documents. Bottleneck could also occur when the truck is lead to the container seal and damage check. On the occasion that the inspection did not pass, truck will be asked for a full container inspection. On the other hand, even if the loaded truck has passed seal and damage inspection, terminal operating system will select a few containers randomly for full container inspection. To solve the above bottleneck problems, security solutions with active e-seal solution or RFID vehicle control system may be the answers to these problems. An active e-seal is powered by battery and generally operated at 433 MHz. The parameter standards for air interface communications of active e-seals have been defined by ISO 18185. Because active e-seals can initiate transmissions without the signal from interrogator, their range of communication can reach up to 100 meters with the capability to overcome minor obstructions. Currently, many commercial e-seals in use are active type due to their enhanced transmission capabilities (Kim et al., 2007). One of the SST initiatives has applied active e-seals on containers with the deployment of interrogators at factory, distribution center, port of loading, port of discharge, rail terminal and retail store. Performance results indicate that the e-seal system could

reduce safety stock, pipeline inventory, administrative labor and pilferage (Dresser, 2004). The Port of Busan has also deployed a trial container tracking system to record and communicate active e-seal's data, which includes container's location and security status, changes in light, temperature and humidity inside the container (Collins, 2005). Hence, the inspection time of seal and container damage can be reduced significantly with the assistance of e-seal system. The need of full container inspection can be alleviated because active e-seal can report the location of its locked container and send alerts upon its breach. In addition, RFID technologies can be applied in the areas of access control, container security, identification and localization, activity tracking and regulatory compliance. For example, APM terminal in Long Beach, CA, has tested a hybrid system of RFID, OCR, and GPS. While active RFID tags attached to container handling equipment are used to track the flow of containers, tamper-proof RFID tags affixed to trucks' windshields can identify arriving or departing trucks (Swedberg, 2006). A container terminal in China with 208 hectares and 9 berths has assessed the feasibility of RFID-enabled vehicle tracking system. With the information provided by the tracking system, the control tower can monitor the traffic condition of the terminal and react to incident more quickly (Ting et al., 2012). Hence, with the deployment of RFID vehicle control system, truck does not need to stop at the portal gate because truck plate number and driver information is transmitted automatically to the system.

In addition, bottlenecks could happen when the container transfers from yard to portal during the transshipment process. Conceding that crane operator can't find the requested container in the container transferring process, terminal operating system will assign staff to look for the missing container and the whole procedures will be time-consuming. This bottleneck problem can be answered by the security solution of DGPS technology. Basic DGPS architecture is composed of networked DGPS stations, where all stations are linked to a central control station for data modelling and correction. Other variant architectures such as single reference station, multiple station, virtual reference station network, and virtual reference cell have also been developed to improve the results of positioning accuracy (Retscher, 2002). Typical application for DGPS in a terminal include rubber tired gantries, rail mounted gantries, and yard tractors. By integrating DGPS and automatic equipment identification into container handling equipment, terminal operators can automatically receive container identification and location (Kelley and Van Steenburg, 1996). Southampton Container Terminals Ltd. has equipped all straddle carriers with DGPS receivers to track the movement of containers. With the implementation of DGPS, there is less chance of containers being incorrectly stacked in the target position (Effective Solutions, 2012). The pilot project of the Valencia Port applied DGPS to provide precise location information both for containers as well as for the monitoring of the yard equipment (Tsertou et al., 2015). Because e-seals, RFID vehicle control system, and DGPS could be the technological solutions for the container transshipment processes, they are the decision alternatives of security systems considered in this study.

Evaluation Methodology
The approach of influence diagram was applied to develop a decision support model to select the optimal security system alternative for the transshipment operations at container terminals. An important advantage of influence diagram is its ease of tools to represent uncertainties by random nodes with conditional probability distributions, which can be derived by related data or subjective measurements from decision makers (Detwarasiti and Shachter, 2005). This feature is useful for practical evaluation because the real impacts of security systems on container transshipment processes are usually unclear before the system implementation. An influence diagram is a directed acyclic graph with random (chance) nodes, decision nodes, and value (utility) nodes. Directed arcs between nodes are used to exhibit the conditional relationships between variables. Uncertainties are represented by random nodes V_i and quantified by conditional probability distributions $P(V_i \mid \text{pa}(V_i))$, where $\text{pa}(V_i)$ denotes the parents of node V_i. The decision model of this study has two decision nodes D_1 and D_2, where D_1 represents the decision about whether to invest in tracking system and D_2 represents the decision about

whether to invest in location system. A decision rule for a decision node D_k is a mapping $\delta_k: \Omega_{pa(D_k)} \to \Omega_{D_k}$, where Ω stands for the Cartesian product and pa(D_k) denotes the parents of node D_k. Accordingly, a policy is a list of decision rules $\Delta = \{\delta_1, \delta_2\}$. Meanwhile, value node *v* represents function that maps the permutation of its parents *pa(v)* to exactly one utility value $f_v(pa(v))$. The goal of this decision problem is to find an optimal policy Δ^* that can achieve optimal expected utility value. Thus optimal policy Δ^* can be obtained by

$$\Delta^* = \{\delta_1^*, \delta_2^* | \mathrm{argmax}_{\delta_1, \delta_2} E_{\delta_1, \delta_2}[f_v(pa(v))]\}. \tag{1}$$

In addition to influence diagram modelling, this study also transforms the influence diagram model into a model of Bayesian networks for efficient probabilistic inference. This step is critical for business practice because the computation time of influence diagram reasoning would grow exponentially as the number of random nodes increases. From the perspective of graphical modelling, influence diagram and Bayesian network can be considered as equivalent approach. Bayesian network is a type of influence diagram without decision and value nodes. However, the inference mechanism is more robust from Bayesian networks. Researchers have also developed different efficient algorithms for inference calculation or approximation. Hence, the decision and value nodes of influence diagram should be transformed into random nodes in order to apply the probabilistic inference algorithms of Bayesian networks. Suppose that our influence diagram model M has only one value node v. Cooper's approach (Cooper, 1988) can be applied to transform the value node into a binary random node by

$$P(v = 0|\pi_v) = 1 - \frac{f_v(\pi_v)}{max_{pa(v)} f_v(\pi_v)} \tag{2}$$

Meanwhile, the decision node D_k of influence diagram model M can be transformed into a random node of Bayesian networks by

$$P(D_k = \delta | pa(D_k)) = \frac{1}{|\Omega_{D_k}|} \tag{3}$$

where $\left|\Omega_{D_k}\right|$ is the number of possible values of D_k. Through the transformation of Eq. (2) and (3), the influence diagram model M can be converted into a model of Bayesian networks M'. The conditional probability of D_k should be changed to

$$P_{M'}(D_k|pa(D_k)) = \begin{cases} 1, & \text{if } \delta_k\big(pa(D_k)\big) = D_k \\ 0, & \text{otherwise} \end{cases} \tag{5}$$

when the optimal decision rule for D_k is found. After the above Bayesian networks transformation, this study applies the algorithm of Jensen, Lauritzen, and Olesen (1990) to efficiently compute the probabilistic inference of Bayesian networks. This approximation algorithm can significantly reduce the computation complexity of the influence diagram model.

Case Study
To illustrate the practicability of the proposed evaluation approach, a simulated case study based on the environment of the Port of Yokohama was investigated. The Port of Yokohama consists of three major container piers: Honmoku, Minami Honmoku and Daikoku. Honmoku Pier is the main pier handling more than 60% of the container cargos in the Port of Yokohama. It contains 10 container berths, which include 4 deep berths with depths of 15m or more. Minami Honmoku pier is being constructed to respond to increasing container cargos and larger container vessels. Two deepest container berths in the country with a depth of 16m are operated in Minami Honmoku pier now. Daikoku pier is planned to have different types of berths, including multipurpose berths to handle automobiles. Large-scale modern logistics facilities such as the Yokohama Port Cargo Center are developed in this pier. These three major container terminals have approximately twenty seven quay cranes, fourteen gates and forty two gated lanes. To evaluate the investment of secuirty systems for the transshipment operations at the Port of Yokohama, an influence diagram model was developed first. Suppose that decision makers of the port administration have two decisions to make. Decision D_1 is composed of 4 alternatives: no investment (d_{11}), investment in e-seal system (d_{21}), investment in

RFID vehicle control system (d_{31}), and investment in e-seal system and RFID vehicle control system (d_{41}). Decision D_2 is comprised of 2 alternatives: no investment (d_{12}) and investment in DGPS system (d_{22}). As a result, a total of 8 alternatives are evaluated in the influence diagram model. The proposed influence diagram model is to make an explicit trade-off among the objectives of maximizing security, maximizing time savings, and minimizing investment costs. The uncertain variables regarding security objective include legality improvement (S_1), reduction of the likelihood of tampering and intrusion (S_2), visibility improvement (S_3), and reduction of human error (S_4) (Chan, 2003, Lu and Yang, 2010). Besides, the uncertain variables regarding time-saving consideration include the yearly time savings (hours) for the outbound processes at the transshipment terminal (T_1), inbound processes at the transshipment terminal (T_2), outbound processes at the container storage yard (T_3), and inbound processes at the container storage yard (T_4). For the consideration of investment cost, uncertain variables include implementation cost (C_{IM}), maintenance cost (C_M), interest rate (I), and annual container volume (N). Accordingly, the influence diagram model can be depicted in Figure 1, where oval rectangle nodes represent the calculation variables regarding the multiple objectives of this investment decision problem.
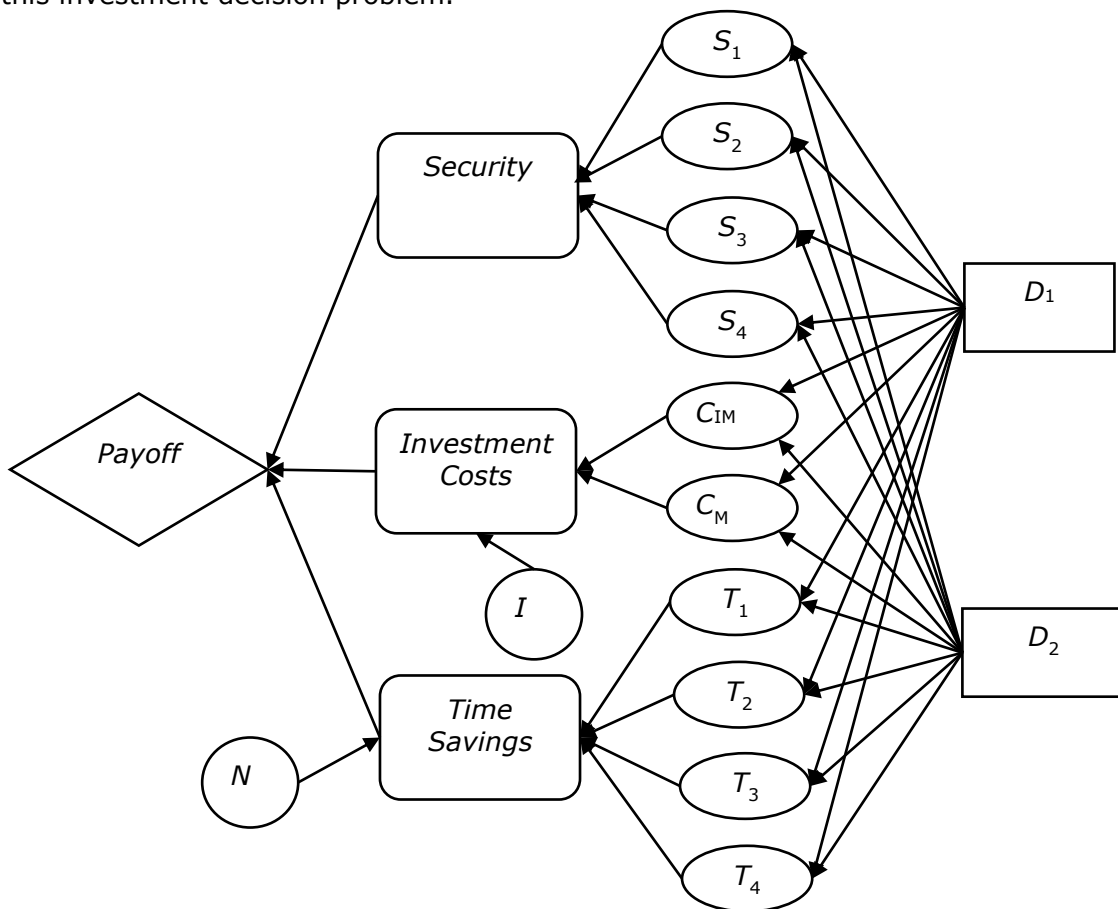
Figure 1: An influence diagram model

In addition to the graphical representation of influence diagram model shown in Figure 1, we also need to assess the discrete probability distributions for all chance nodes and derive the formulas for the calculation nodes of *Security*, *Investment Costs*, and *Time Savings*. Suppose that the decision planning horizon is 5 years. The payoff of decision policy ($D_1 = d_1$, $D_2 = d_2$) can be calculated by

$$\textit{Payoff } (D_1 = d_1, D_2 = d_2) = 0.251 \cdot \text{E}[U(\textit{Security} \mid d_1, d_2)] +$$
$$0.32 \cdot \text{E}[U(\textit{Time Savings} \mid d_1, d_2)] -$$
$$0.429 \cdot \text{E}[U(\textit{Investment Costs} \mid d_1, d_2)], \qquad (6)$$

where the weights of expected utility values were obtained by the approach of analytic hierarchy process. Four experts from the area of harbour management were asked to

perform pairwise comparisons between objectives of *Security*, *Investment Costs*, and *Time Savings* for the container terminals. The findings of utility weights indicate that the objective of Investment Costs is the most important concern of the decision maker. Due to the complexity of the influence diagram model, this study used the methodology described above to transform the influence diagram model shown in Figure 1 into a model of Bayesian networks and then conducted probabilistic inference.

Findings of the expected utility values from the probabilistic approximations are summarized in Table 1. As we can see that the decision policy (d_{41}, d_{22}), which is the investment of all location and tracking technology solutions, has the highest utility values in all objectives, where E[U(*Security* | d_{41}, d_{22})] = 0.8393, E[U(*Time Savings* | d_{41}, d_{22})] = 0.8986, and E[U(*Investment Costs* | d_{41}, d_{22})] = 0.9286. However, its weighted expected utility is ranked 7th among 8 decision alternatives because the weight of *Investment Costs* has negative impacts on the calculation of *Payoff*. On the other hand, the decision policy with the investment of active e-seal system has the highest weighted expected utility, *Payoff* ($D_1 = d_{21}$, $D_2 = d_{12}$) = 0.1115, although its expected utility of *Time Savings* is ranked 6th among all decision alternatives. Based on the assessment of trade-off among the objectives of *Security*, *Time Savings* and *Investment Costs*, the port administration may consider the investment of active e-seal system for the container transshipment processes.

Decision Policy	Expected Utility of *Security*	Expected Utility of *Time Savings*	Expected Utility of *Investment Costs*	Weighted Expected Utility
(d_{11}, d_{12})	0.1102	0.0000	0.0000	0.0277
(d_{21}, d_{12})	0.7865	0.5419	0.6045	0.1115
(d_{31}, d_{12})	0.6646	0.4007	0.4490	0.1024
(d_{41}, d_{12})	0.8137	0.7255	0.7821	0.1009
(d_{11}, d_{22})	0.6938	0.6307	0.6723	0.0875
(d_{21}, d_{22})	0.8315	0.8309	0.8704	0.1012
(d_{31}, d_{22})	0.7539	0.7787	0.8195	0.0868
(d_{41}, d_{22})	0.8393	0.8986	0.9286	0.0999

Table 1: Finding of expected utility values

Among the uncertain variables, number of terminals and annual container volume are the top 2 influential factors on payoff. Hence, one-way sensitivity analysis is illustrated in Table 2 to assess the impacts of terminal number on *Payoff*. When the number of terminals is decreased by 10%, the payoff of the decision policy ($D_1 = d_{21}$, $D_2 = d_{12}$) is reduced to 0.929, which is less than the ones from (d_{21}, d_{22}) and (d_{41}, d_{22}). It implies that the best decision policy could be changed to the investment of e-seal, RFID vehicle control system, and DGPS when the decision environment is based on fewer terminal numbers. On the other hand, the payoff of the decision policy ($D_1 = d_{21}$, $D_2 = d_{12}$) is increased by 17.66% when the number of terminals is increased by 10%. Because the decision policy ($D_1 = d_{21}$, $D_2 = d_{12}$) still has the highest payoff with the increased number of terminals, decision makers can invest the active e-seal system with confidence if they foresee the increasing trend of terminal numbers.

Number of Terminals / Decision Policy	10% decrease		10% increase	
	Payoff	% Change on *Payoff*	*Payoff*	% Change on *Payoff*
(d_{21}, d_{12})	0.0929	-16.62%	0.1311	17.66%
(d_{31}, d_{12})	0.0836	-18.30%	0.1216	18.83%
(d_{41}, d_{12})	0.0840	-16.66%	0.1202	19.19%

(d_{11}, d_{22})	0.0817	-6.58%	0.0935	6.86%
(d_{21}, d_{22})	0.0930	-8.01%	0.1102	9.00%
(d_{31}, d_{22})	0.0777	-10.43%	0.0967	11.40%
(d_{41}, d_{22})	0.0933	-6.55%	0.1077	7.93%

Table 2: One-way sensitivity analysis for the number of terminals

In Table 3, one-way sensitivity analysis is illustrated to assess the impacts of annual container volume on the model's output. When the annual container volume is decreased by 10%, the payoff utility of decision policy ($D_1 = d_{21}$, $D_2 = d_{12}$) is reduced to 0.1011, which is still better than the other decision alternatives. Similarly, when the annual container volume is increased by 10%, the payoff utility of decision policy ($D_1 = d_{21}$, $D_2 = d_{12}$) is increased to 0.1209, which is still higher than the other alternative solutions. It implies that the variability of annual container volume do not change the optimal decsion alternative, which is the investment of active e-seal system.

Annual container volume	10% decrease		10% increase	
Decision Policy	Payoff	% Change on Payoff	Payoff	% Change on Payoff
(d_{21}, d_{12})	0.1011	-9.25%	0.1209	8.46%
(d_{31}, d_{12})	0.0923	-9.84%	0.1119	9.35%
(d_{41}, d_{12})	0.0896	-11.15%	0.1106	9.70%
(d_{11}, d_{22})	0.0751	-14.14%	0.0987	12.80%
(d_{21}, d_{22})	0.0911	-9.89%	0.1094	8.20%
(d_{31}, d_{22})	0.0753	-13.27%	0.0967	11.42%
(d_{41}, d_{22})	0.0918	-8.07%	0.1062	6.36%

Table 3: One-way sensitivity analysis for the annual container volume

CONCLUSION
The technology selection problem of security systems is critical to terminal operators because wrong investment may have negative impacts on operational or financial performance. Especially under the environment full of uncertainties, the return on system investment is difficult to evaluate. To overcome the challenge of choosing the right solution for transshipment operations, the approaches of influence diagram is proposed in this study to facilitate the evaluation processes of security systems with e-seals, RFID vehicle control system, and DGPS. A simulated case study based on the environment of the Port of Yokohama was investigated to demonstrate the practicability of the proposed approach. Findings show that the expected cost of active e-seal system is higher than RFID vehicle control system, while the expected security performance of active e-seal system is better than RFID vehicle system. Among the alternatives of location and tracking technology solutions, the investment of active e-seal system generally proves to be the most suitable choice for the simulated case with the trade-off consideration of time savings, security, and investment costs. E-seal is a type of location and tracking technologies that applies electronic encryption and authentication to protect against container tampering. Many terminals have conducted pilot tests of various e-seal technology to evaluate its applicability on terminal operations. The Port of Kaohsiung has even officially applied the e-seal system for the management of transit containers and proved the investment of e-seal system can improve time efficiency and security of transshipment process (Wang *et al*., 2012). Future studies may include more uncertain variables to fully consider the decision environment of the container transshipment terminals. Other approximation methods can be explored to improve the inference approximation of influence diagram model. Furthermore, terminal administration can

easily modify our proposed approach to develop their evaluation model based on their decision environment and choose the most suitable technology solution for them.

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INTERNATIONALISATION OF LOGISTICS FIRMS THROUGH KNOWLEDGE FLOWS

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Abstract
Purpose of this paper:
The purpose of this paper is to investigate how organisational knowledge flows can support and contribute towards the internationalisation of logistics firms. Global supply chain management entails the internationalisation of logistics companies to establish subsidiaries or international joint ventures in the global markets. The role of knowledge flows facilitates these internationalising logistics firms to be better embedded into a local market across borders. Specifically, this research examines four types of knowledge flows being integrated in the internationalisation process of global logistics firms to achieve internal integration.

Design/methodology/approach:
An exploratory approach employing qualitative multiple case studies are adopted for this research. Seven South Korean logistics firms operating in the UK were identified and studied. The contribution of South Korea and UK to international trade and logistics is similar, but their industry contexts and cultures are quite differed. These seven firms are the entire population of Korean logistics firms which have a subsidiary in the UK. The case firms encompass two liner shipping companies, three international freight forwarding, 3PL companies and two airlines. In total, 17 in-depth semi structured interviews were conducted in each firm with current UK subsidiary managers as well as top and middle managers deployed to the UK subsidiaries and local staff. Within-case and across cases data analysis were carried out and the analysis was facilitated through pattern matching and systematic case comparison.

Findings:
The findings reveal that the existence of diversity and complexity of logistics firms' headquarters and subsidiary relationship within international networks of organisational knowledge flows. Five types of organisational knowledge flows were identified in each

seven logistics firm: knowledge flows from subsidiary to headquarters, knowledge flows from location to subsidiary, knowledge flows from subsidiary to location and knowledge flows from headquarters to subsidiary. In addition, externally sourced knowledge flows were identified to be important in the process of internationalisation.

Value:
Within the logistics domain, this research provides further theoretical insights and a framework into internationalising logistics firms by building on internationalisation process, knowledge management and network disciplines.

Practical implications (if applicable):
This research provides implications for the mangers of both global logistics firms and their subsidiaries. The findings imply that global logistics firms need to have different ways of devising organisational knowledge flows effectively. More holistic perspectives for internationalisation strategy can be developed and the top and middle managers of global logistics firms can obtain useful lessons from this study.

Research limitations/implications (if applicable):
This research suggests key implications for our theoretical understanding of the internationalisation process by integrating the network of knowledge flows and how knowledge flows facilitate operation of logistics firms internationally. However, this research is not without limitations. First, given the findings of this study are based on seven logistics firms, it limits the generalizability of the results toward other industries and countries. Second, emanating from its exploratory qualitative nature, the findings could be tested more systematically through a quantitative approach.

INTRODUCTION
Internationalisation is a complex process which incorporates dynamic changes within an organisation. There can be several reasons for internationalisation: the external market can provide more chance to make profit by exploiting their product or technology; the global economies of scale can achieve a synergy; or the inefficiency from intermediate market operations can be significantly reduced. However, it is a challenging task for firms to be embedded into a local market across borders with diverse cultures and to overcome the dynamic transformations the internationalisation process can pose. The success factor of the internationalisation process is, therefore, how a firm can handle various complexities and achieve competitive advantages. Internationalisation of multinational enterprises (MNEs) has been extensively studied in the international business discipline. The key principle lies on the notion of the firm's inherent 'foreignness' in foreign markets when competing with local firms and it thus discusses the characteristics and processes needed for firms to defeat the disadvantage of this liability of 'foreignness' (Hutzchenreuter, Pedersen and Volberda, 2007). Setbacks in internationalisation are seen to be caused by a lack of knowledge about unknown foreign markets. The required knowledge about markets can only be obtained by actually doing business overseas, as this can provide new entrants with an incremental build-up of information, knowledge and experience accumulation (Johanson and Vahlne, 1977). Thus, the process of internationalisation requires knowledge integration and rigorous learning (Andersen, 1993; Johanson and Vahlne, 2009; Zaheer, 1995) and the role of knowledge integration and learning become critical to success in the process of internationalisation (Autio, Sapienza and Almeida, 2000; Davidson, 1980; Hennart and Park, 1994; Johanson and Vahlne, 1977).
Knowledge is a strategic capability-improving asset or resource when firms incorporate sets of knowledge and skills to innovate new or enhance processes or products and services effectively (Coff, 1997; Nonaka et al., 2000). The knowledge based view of the firm considers a firm as a dynamic knowledge-creating unit and communities (Kogut and Zander, 1993; Nonaka et al., 2000). Knowledge and the ability to continuously generate and exploit such knowledge are the main foundation of a firm's sustainable competitive

advantage (Wilkins, 1989; Teece et al., 1990; Nelson, 1993; Nonaka et al., 2000). Kogut and Zander (1996; 503) consider firms as social communities focusing on 'the speed and efficiency in the creation and transfer of knowledge'. This accentuates the function of knowledge and learning as a key factor (Grant, 2002; Nonaka, 2000; Kogut and Zander, 1993, 1996; Teece et al., 1990). The firm is viewed as a "dynamic body of knowledge in action" (Spender, 1994: 355) which generates an efficient setting for communication and learning within an organisation (Kogut and Zander, 1995).

Knowledge management is a process by which firms create, maintain, share and exploit knowledge to gain advantage from their codified and tacit know-how (Davenport and Prusak, 1998; Huber, 1991; Teece, 2000). This involves not only having access to knowledge, but also having a capability continuously to generate and exploit it through social process of internal transfer (Nelson, 1993; Nonaka et al., 2000; Teece et al., 1990; Wilkins, 1989). This learning capability assists the transformation of knowledge at different organisational levels, so that new knowledge can be created and existing knowledge can be re-combined (Nonaka, 1994). The social process involved means that firms can be regarded as social communities for achieving 'speed and efficiency in the creation and transfer of knowledge' (Kogut and Zander, 1996: 503); a firm that is efficient at internal communication and learning (Kogut and Zander, 1995) is a "dynamic body of knowledge in action" (Spender, 1994: 355). Research has identified the significance of central network points in intra-organisational knowledge transfer (e.g. Tsai, 2001), the importance of knowledge flows within MNEs and the implications for subsidiaries (e.g. Foss and Pedersen, 2002; Monteiro et al., 2008), and the effects of motivation and absorptive capacity on knowledge transfer (e.g. Gupta and Govindarajan, 2000).

Global supply chain management entails the internationalisation of logistics companies to establish branches or joint ventures in the global markets. Despite the prevalent industry culture of internationalisation, there is limited research on the internationalisation process of logistics companies. Particularly, it has not yet been fully explored how the geographically dispersed and culturally separated departments in the logistics companies can be integrated with knowledge integration and organisational learning. According to supply chain integration studies, internal integration is as important as supplier and customer integration because the seamless flows of resources and information across the functional boundaries within an organisation can easily leads to the integration with external firms.

The theoretical foundations for this study come from research that has addressed knowledge integration within firms such as between headquarters and subsidiaries within MNEs. This study will employ these foundations to examine knowledge integration from headquarter and subsidiary manager perspective. This major stream of research has highlighted the strategic importance of knowledge (e.g. Conner and Prahalad, 1996; Davenport, 1998; Kogut and Zander, 1993; Nonaka and Takeuchi, 1995). Grant (1996: 76), for example, describes knowledge as "the most strategically-important resource" for firms. This study aims to investigate the process of knowledge integration and organisational learning in internationalisation of global logistics companies to achieve internal integration. Assuming that internationalisation is a learning process, it suggests a theoretical framework which captures the dynamic interactions between knowledge and information, skills and capabilities as well as learning.

Employing a social capital theory, the aim of this paper is to investigate how social capital dimensions affect the integration of knowledge and learning between headquarters and subsidiary managers of internationalising logistics firms. This research identifies structural, cognitive, and relational dimensions that affect the integration of knowledge between headquarters and subsidiary. The findings indicate that the dimensions of social capital and their interlinkages facilitate headquarters and subsidiary knowledge integration and learning for operating successful internationalisation.

THEORETICAL DEVELOPMENT

The role of knowledge integration and learning in the internationalisation process

In a discussion on knowledge and internationalisation, Knight and Cavusgil (2004: 136) point out that "firms must possess specific knowledge based internal organisation capabilities that support both early internationalisation and subsequent success in foreign markets." The firm's capacity to employ this knowledge and utilise its relationship is a critical factor which offers unique advantages that assist both foreign market entry as and operations within international business (Autio et al., 2000). Increasingly, the significance of learning and knowledge integration in the process of internationalisation is emphasized in an international context (e.g. Eisenhardt and Santos, 2002; Ghoshal and Bartlett, 1988; Gupta and Govindarajan, 2000; Monteiro, Arvidsson and Birkinshaw, 2008; Schulz, 2003; Szulanski, 1996; Zander and Kogut, 1995). The notion of knowledge integration and learning impact on the process of internationalisation can be divided into three levels: the individual level, the organisation and its inter-organisational network level (Casillas, Moreno, Acedo, Gallego and Ramos, 2009).

The integration of knowledge in such diverse settings, such as in networks of headquarters and subsidiary within MNEs is complicated (Schulz, 2003) and the practice of knowledge integration has been identified to be fundamental (Monteiro et al., 2008). There is an agreement in the idea that an MNE is "an international network that creates, accesses, integrates and applies knowledge in multiple locations" (Almeida, Song and Grant, 2002:148). The process of integrating knowledge allows MNEs to obtain the "incremental value of being multinational" (Kogut, 1989: 383). Furthermore, prior experience, both with reference to the amount or intensity and breadth of the knowledge obtained, can play a role as a forecaster of the firm's international activities (Johanson and Vahlne, 1990; Luo and Peng, 1999). Also, the dimension of knowledge integration relates with existing degrees of communication and reciprocity (Monteiro et al., 2008). The knowledge integration usually take place between "highly capable members of an in-crowd", whereas the isolated minority infrequently engages in such knowledge sharing activities (Monteiro et al., 2008).

Johanson and Vahlne's (2006: 175) demonstrate how "learning and commitment building is more about discovering and constructing opportunities… involving other firms in the network" than regarding ambiguity lessening performed by the one firm. In this view, such opportunities that are recognized by a specific firm at a specific point in time principally rely on the accumulation of knowledge and commitment. Thus, the accumulation of knowledge and commitment influences how a firm constructs opportunities; its learning and the interplay between knowledge integration and the degree of foreign commitment is considered as a key factor in the internationalisation process (Johanson and Vahlne, 2006). Firms can obtain experiential, tacit knowledge or managerial resources by interacting with local and international networks that enhance the knowledge integration process (Freeman and Cavusgil, 2007; Laanti, Gabrielsson and Gabrielsson, 2007). The amount or intensity of knowledge that is operationalized generally increases with the number of years that the firm has been expanding aboard (Luo and Peng, 1999). Knowledge acquisition and integration can be also seen as a direct outcome of social capital (Nahapiet and Ghoshal, 1998) which we turn to next.

Dimensions of social capital

The concept of social capital reflects as Nahapiet and Ghoshal's (1998) suggests, "the sum of the actual and potential resources embedded within available through and derived from the network of relationships possessed by individual or social units" (1998, p 243). The relationships that encompass the social capital of MNEs have been noted to be a significant element that impacts the internationalisation process (Agnal, Chetty and Wilson, 2008; Coviello and McAuley, 1999; Ellis, 2011; Kontinen and Ojala, 2011, Yli Renko, Autio and Tontti, 2002). In this research, we employ Nhapiet and Ghoshal's (1998) three dimensions of social capital: structural, cognitive and relational.

Structural social capital: organisational/ network ties

Research on MNEs has conceptualised this type of firm as a network (Ghoshal and Bartlett, 1990; Rugman and Verbeke, 2001) and the structural dimension of social capital is based on business, organisational or network ties involving the pattern of relationships between actors. The relationship and nature of ties within MNEs will impact the social ties between headquarters and subsidiary managers. Integrating information and knowledge is enabled in the location of such relationship in a particular social structure.

Cognitive social capital: shared cognitive goals, culture or ground
The cognitive dimension of social capital is based on shared understanding, goals or ground between network members (Nhapiet and Ghoshal, 1998). Shared culture also represents the degree to which norms of behaviour govern relationship among network members. Shared understanding or goals require having a common understanding and approach to the achievement of network tasks to some extent. Cognitive social capital can be supportive for providing internationalising firms how to knowledge and advice (Gundlach, Achrol, & Mentzer, 1995; Geyskens, Steenkamp, Scheer, & Kumar, 1996). The interactive development of sharing goals or culture can support cognitive social capital and it can further enable the social capital to become relational over time (Lewicki and Bunker, 1988).

Relational social capital: trust and commencement
The relational dimension of social capital is based on emotional closeness and affective commitment illustrating high levels and intensity of social or personal interaction. Here, trust as one of the facets of relational dimension, represents a significant role in the willingness of network members to share knowledge. Network members invest commitment in order to improve trust and reduce uncertainty (Wuyts & Geyskens, 2005). The structural, cognitive and relational dimensions of social capital are likely to be interrelated in complex ways and these can facilitate the development of knowledge integration and learning (Nhapiet and Ghoshal, 1998). To sum up, the role of knowledge integration and learning for internationalisation is significant and the concept of social capital facilitates our understanding of the process of knowledge integration and learning. We suggest that social capital dimensions affect the integration of knowledge and learning between headquarters and subsidiary managers.

METHODOLOGY
Seven South Korean logistics firms operating in the UK were identified and studied. The contribution of South Korea and UK to international trade and logistics is similar, but their industry contexts and cultures are quite differed. These seven firms are the entire population of Korean logistics firms operating in the UK. The case firms encompass two liner shipping companies, three international freight forwarding, 3PL companies and two airlines. The brief profiles of seven cases are illustrated in Table 1. These seven firms offered broad and research access with a richness of data with specific individuals that could demonstrate and explain managerial factors that caused the IJVs' success.

Interviews
The main source of cases data was twenty in-depth semi-structured interviews, lasting from 50 minutes to 180 minutes in the UK and some of these interviews were repeated for further examination and clarification when necessary. Interview data was digitally recorded and transcribed. Interviews are particularly useful tools for collecting intense data when the phenomenon of focus is 'episodic and infrequent' (Eisenhardt and Graebner, 2007, p. 28). To achieve the validity of data collection and analysis process, four different interview protocols were prepared for interviews in order to fit the different groups of interviewees. The structure and contents were mainly identical, but some of questions were omitted to suit relevantly particular groups of interviewees. The protocols were written in English and then translated into Korean. These protocols were reviewed and double checked by two professional Korean linguists for precision and validity to ensure translation equivalence (Sinkovics et al., 2005).

An assurance of confidentiality was given to all interviewees and they were assigned numbers to replace their names to ensure anonymity. Interviews were conducted with current managing directors and senior managers deployed to the UK subsidiaries as local managers in each UK subsidiary as key informants. This may represent the issue of upper-echelon bias with data (Hambrick and Mason, 1984; Pudelko and Harzing, 2007). However, this method is commonly employed in research such as these. Interview data was also triangulated with data supplied by industry experts such as in Korea Trade-Investment Promotion Agency (KOTRA) in the UK and secondary sources.

Table 1. Overview of seven case firms interviewed

Case firm	Sector	Year of establishment in the UK	Overview of firm
Firm 1	Shipping	1980	A global shipping company which focuses on containerised transport. It mainly deals with sea transport, but offers multimodal transport combining the inland services from UK-based inland hauliers.
Firm 2	Shipping	1983	A global shipping company which focuses on containerised transport. It mainly deals with sea transport, but offers multimodal transport combining the inland services from UK-based inland hauliers. It also has a sister company which deals with 3PL services based in the UK.
Firm 3	Airliner	1974	A global airliner which covers more than 100 destinations around the world. It is the world's top company in terms of the volume of international cargo freight.
Firm 4	Airliner	1999	Korea's second largest airliner which covers more than 50 destinations around the world.
Firm 5	3PL	2004	A global 3PL company which operate its subsidiaries all over the world. It has a warehouse and a large organisation in the UK.
Firm 6	3PL	2013	A sister company of LG Electronics established for the domestic logistics. Now it expanded its business scope to the domestic logistics within other countries.
Firm 7	3PL	2007	A courier company which also cover freight logistics and household goods transport around the world.

Qualitative data analysis

Within-case and across cases data analysis were carried out and the analysis was facilitated through pattern matching and systematic case comparison (Yin, 2009). Data collection and data analysis was intertwined in order to avoid data over saturation to filter unrelated data from data collection and inductively formulate or reformulate questions to improve the data collected (Ghauri, 2004; Ghauri and Grønhaug, 2010; Miles and Huberman, 1994). Data coding involved conceptualizing, reducing, elaborating and relating of data. To triangulate data with theory, inductive data codes from detailed content analysis of transcripts were collected into initial categories from pre-existing knowledge management and social capital research, and associations between their categories were noted (Yin, 1993). Following Strauss and Corbin (1998: 11), microanalysis approach of line-by-line data analysis was used to develop an organized and interpreted 'theoretical explanatory scheme'. Interview data was then verified using multiple sources of evidence, in order to enhance validity and credibility (Guion, 2002; Remenyi et al., 1998; Sinkovics et al., 2008). Corroboration was sought from archival data such as corporate internal materials, interim reports, project manuals, business publications, government industry data, and media data sources.

FINDINGS AND DISCUSSION

In the following sections the findings of the multiple cases are reported with three dimensions of social capital respect to the process of knowledge integration and learning of headquarters and subsidiary managers within internationalising logistics MNEs within themes that emerged from the inductive case analysis.

Structural social capital: organisational/ network ties
The hierarchical relationship between headquarters and subsidiaries can pose complexity. The hierarchical nature of ties between headquarters and subsidiaries impacted the social ties between these managers.

Cognitive social capital: shared cognitive goals and culture
The characteristics of the organizational cultures were highly influential in the knowledge integration and learning processes for both headquarters and subsidiary managers as we would expect from the previous research. The shared social and cultures of the headquarters and subsidiary managers significantly differ. Expatriates and international assignees from headquarters all expressed difficulties when working in the UK: it being a culture that is significantly different from their own. The expatriates from Korea felt great challenges in adjusting to subsidiaries' organizational routines. This inhibited the transfer, coordination and employment of their tacit or routine-based knowledge. Institutional factors also influenced organizational and individual behaviours (Scott, 2001, 2002) and the decision-making process and activities (Hitt et al., 2004; Lau et al., 2002) generated managerial systems and approaches that were unfamiliar to the headquarters managers. These differences hindered communication and coordination. The headquarters and subsidiary managers of the project had a shared understanding, as to what knowledge would be the most useful for their firms.

Relational social capital: trust and commencement
The pro activeness of the headquarters managers was not limited within the subsidiaries. Temporary teams or major projects with members from different subsidiaries seemed to have positively influence knowledge inflow and outflow among. Moreover, the headquarters managers openly shared case studies and reports with other international operations themselves. The knowledge integration process generated synergies in directly transferring know-how and best practices and it was supported with sending out key experts if required for implementation. Knowledge integration in this way was active in facilitating and building trust between the headquarters and subsidiary. The findings show that the headquarters managers' social interaction was more prevalent with the parent's other international subsidiaries than with its headquarters, and these relationships positively influenced knowledge integration as a whole. The findings reveal that the existence of a diversity and complexity of logistics MNEs headquarters and subsidiary relationship within international networks of knowledge integration and learning. The structural, cognitive and relational dimensions of social capital are shown to be closely interrelated in complex ways and these can facilitate the development of knowledge integration and learning (Nhapiet and Ghoshal, 1998).

RESEARCH IMPLICATIONS AND LIMITATIONS
This research suggests key implications for our theoretical understanding of the internationalisation process by integrating the network of knowledge and learning and how knowledge integration facilitates operation of logistics firms internationally. Employing a social capital perspective, this research provides implications for the mangers of both global logistics firms and their subsidiaries. Moreover within the logistics domain, this research provides further insights into internationalising logistics firms by combining internationalisation process, knowledge management and network theories. However, this research is not without limitations. Mainly, there are three limitations to this study. First, given the findings of this study are based on seven logistics firms, it limits the degree of generalizability of the results toward other industries and countries. Thus, future research could extend the current setting to other industry contexts or other countries to achieve further theoretical development of internationalisation process. Second, emanating from its exploratory qualitative nature, the findings could be tested more systematically through a quantitative approach. Third, the main source of our data is collected from key informant interviews which could limit our understanding of the multiple cases.

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THE VALUE OF 'SAME DAY' LOGISTICS IN E-TAILING: A REVIEW OF CONSUMER PREFERENCES

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Abstract
Purpose of this paper:
UK e-tailers have been accelerating their delivery speeds, to the extent that 'same day' order fulfilment is becoming available as a standard, rather than bespoke, service to customers (see for example Telegraph online, 2016). Qualitative research conducted with e-tailers, LSPs and a technology service provider, has revealed that 'same day' represents a considerable challenge to the industry (Lasisi et al., 2015). The purpose of the research is to discover to what extent 'same day' is required by customers, and how much they would be prepared to pay for this service?

Design/methodology/approach:
A survey has been designed and piloted, using probability sampling (Bryman and Bell, 2003) and a sample size of n=1194, to discover consumer attitudes to 'same day' delivery. Sample demographics are evaluated by means of descriptive statistics. Survey data is analysed in relation to two hypotheses:

H1. Delivery speed has become a major factor for customers repeated patronage/ loyalty in recent times.
H2. Customers will pay a premium for speedy delivery of parcels with attached importance.

In addition, statistical analysis is employed to explore relationships between demographic variables, preferences and pricing of 'same day' services.

Findings:
Extensive statistical analysis reveals 10 key findings. Some highlights are that whilst H1 is confirmed, customers are generally unwilling to pay a premium for 'same day'. H2 is confirmed, but with a 'low ceiling' for the premium. The research reveals early evening as the favoured delivery time, and some interesting differences in preferences between sub-groups.

Value:
The research will help UK e-tailers and LSPs to design their service offering, and competitive strategies.

Research limitations/implications (if applicable):
The findings concerning consumer preferences do not explain the acceleration in same day services being offered by UK e-tailers. It seems that this development is being driven by retail competition rather than by consumer preferences. However, the service can only be cost effectively offered by very large retailers with distributed inventory, working in partnership with large and vertically integrated LSPs.

Practical implications (if applicable):
The move towards 'same day' poses a considerable threat to smaller retailers and LSPs. A number of competitive strategies could be adopted to counter this threat, and these include: collaborative partnerships between e-tailers and LSPs, and LSPs and LSPs, and mediation by an Electronic Logistics Marketplace.

INTRODUCTION

Research presented in this paper is part of a broader investigation into same-day logistics, examining the issues from customer, retailer and carrier perspectives. Employing a mixed methods approach, the initial qualitative research carried out in 2015, involved expert interviews with 4 carriers, 4 shippers and a technology service provider (TSP). The research revealed that 'same day' B2C represents a considerable challenge to the industry (Lasisi et al., 2015). Historically, '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 these predominantly B2B transactions, it is not the cost of freight that is expensive to the customer, but the cost of not having the parcel. The interviewees noted that market is changing, and that 'same day' has become an evolving B2C business competitive strategy amongst large e-tailers. More recent press reports bear this out, suggesting that that 'same day' order fulfilment is becoming available as a standard, rather than bespoke, service to customers (see for example Telegraph online, 2016). Surprisingly, the interviewees also reported, back in 2015, that they were unaware of any pressure from customers for a 'same day' delivery service, although they did believe that there would be high patronage if 'same day' parcel delivery became affordably available to customers. Carriers were concerned that they did not possess such logistics capability. The Shippers interviewed also believed that there would be no desperate need for 'same day' delivery until it becomes commonplace, and, moreover that most of their carriers render effective 'next day' delivery services.

In this paper we report on quantitative research that aims to discover, to what extent 'same day' is required by customers, and how much they would be prepared to pay for the service?

SELECTED LITERATURE REVIEW

At the beginning of the research project, in 2014, very little academic literature addressed the development of 'same day' logistics. The researcher instead relied on publications addressing issues in parcel services, express logistics, e-tailing, collaboration and innovation, and it was this literature that has helped to develop the research questions that have informed the broader research project. More recently, there has been a flurry of articles which explicitly address the role of logistics in e-tailing, the development of 'same day' logistics, and customer perspectives on modes of delivery.

The role of logistics in e-tailing

According to Sandberg (2013), retail businesses have recently started to see logistics as a primary source of 'sustainable competitive advantage'. He argues that retail businesses, like manufacturers, have become flow oriented to the extent that "superiority in logistics is decisive for the outperformance of competitors and contributes to overall company profitability and growth." In similar vein, Fernie and Sparks (2014) have explained that retail logistics has transformed with time, and that retailers have become the 'captain' that

pilots the entire business flow, focusing on efficiency and effectiveness, through the adoption of quick response and by reducing inventory levels. Commenting specifically on competitive forces in e-tailing, Lin and Lee (2009) argue that success in e-tailing now relies on logistics, i.e. delivery information, delivery speed, cost and reliability.

The development of 'same day' logistics

According to Taniguchi and Thompson (2014), E-commerce has transformed retail logistics to the extent that customers now want parcels delivered at the earliest possible time, to their desired location and at the lowest possible price. They argue that same day delivery is taking over the market, most especially in America, Europe, and Asia where .dot net stores are offering free delivery whilst also investing in 'same day' delivery services. They add that Amazon is setting the pace in the 'same day' delivery market, and that other major retailers have started responding. Examples include eBay Now, Walmart, Nordstrom and Sears' 'same day' delivery services in the US. In Japan, where customers are accustomed to parcel delivery time criticality as a result of assured next day delivery by the major parcel delivery companies like Yamato and Sagawa, this has resulted in customers making speed delivery one of their key loyalty factors. In reaction to this, Japanese e-retailers have included 'same day' delivery in their competitive strategies.

Customer perspectives on modes of delivery

Writing on urban logistics, Savelsbergh and Woensel (2016) argue that the e-retail market has made the desire for speed one of their major competitive strategies, the result of which has been to make 'same day' parcel delivery a growing competitive strategy that has gone beyond just 'same day' to even hourly delivery (the 1 to 2 hour option). Although they add that even though e-tailers are investing in the same day delivery strategies, end consumers are not willing to pay an extra premium, as many of them do not necessarily require such delivery speed.

Miyatake et al. (2016) have focused on how technology has influenced Japanese consumers' attitudes to shopping. Since consumers are unable to use items purchased online immediately, their study considered travel and delivery time as consumers' costs. They explain that in order to motivate and drive customer loyalty, e-retailers have demanded speed delivery from carriers. A survey was conducted to show reasons why consumers choose online shopping, the findings of which are summarised in Table 1. Miyatake et al. (2015) report that most delivery costs from large online retailers are already included in the product cost, and appears to consumers as free delivery and, as a result, online consumers in Japan get most of their parcels delivered without additional cost, and yet comparable to the brick and mortar price. They carried out price comparisons of online shopping versus traditional shopping, and also compared the costs carried by e-retailers compared to bricks-and-mortar retailers. The comparisons reveal that consumers end up spending less, while e-retailers also achieve lower overall costs.

Reason for shopping via the internet	Percentage response
It allows me to buy things regardless of stores' business hours	58%
I don't want to spend the time and money it takes to go to the store	47%
It allows me to easily compare various goods	45%
It allows me to compare prices	42%
It allows me to buy things that only a few stores carry	38%
It allows me to read reviews written by other purchasers	15%
A variety of payment methods are available	13%
I don't have to listen to the sales clerks' sales pitches	11%
Other	7%

Table 1: Customer online shopping reasons. Source: Miyatake et al. (2015)

They therefore concluded that the favourable outcome of the comparison for e-retailers could help to explain the increase in the online retail.

RESEARCH QUESTION AND INITIAL HYPOTHESES

The main purpose of the research was to discover: to what extent 'same day' is required by customers, and how much they would be prepared to pay for the service?

These questions are explored statistically by means of the following hypotheses:

H1. Delivery speed has become a major factor for customers' repeated patronage/ loyalty in recent times.

H2. Online customers will only pay a premium for 'same day' delivery of parcels where significant importance is attached, e.g. for a time critical gift like a birthday present.

The first hypothesis was developed from the literature review, whereas the second was based on the findings of earlier qualitative research involving 13 industry experts (Lasisi et al, 2015).

METHODOLOGY

The research focuses on the delivery preferences of UK online shoppers. There are 39.3 million adults in the UK (Office for National Statistics, 2015), 78% have access to the internet, and 76% of whom shop online, giving a population of 22.7m. In order to achieve a confidence interval of 95% with a 3% margin of error, the target sample size was set at 1068. An online questionnaire was designed, piloted and refined. A convenience approach to sampling was employed, with the survey administered via social media using snowballing (Byman and Bell, 2003), and via email groups, leading to an eventual sample size of 1194.

Descriptive statistics have been employed to evaluate the sample composition. The initial hypotheses H1 and H2 were further clarified through the development of 'null' and 'alternative' hypotheses. As the survey data was ordinal and non-parametric, hypothesis testing was conducted using Kruskal Wallis in SPSS, with the Mann Whitney U test employed to determine points of significance in simple comparisons.

In the process of analysing the data, 7 further hypotheses (H3-H9) emerged (also clarified as 'null' and 'alternate'), with the Games-Howell test employed to determine points of significance for those tests involving multiple comparisons.

FINDINGS

Sample composition

Tables 2, 3 and 4 indicate the gender, age and employment status of the sample. Compared to the general UK population, women are slightly over represented, as are people in the lower age ranges, and people in employment. However, the research is focused on online shoppers, rather than the population as a whole, and the composition of the online shopping population is unknown. Further analyses will be undertaken to account for any bias due to sample composition.

	Frequency	Percentage
Male	570	47.7
Female	624	52.3
Total	1194	100.0

Table 2. Gender distribution of sample

Age range	Frequency	Percentage	Valid percentage	Cumulative percentage
18-24	127	10.6	10.8	10.8
25-34	409	34.3	34.6	45.4
35-44	261	21.9	22.1	67.5
45-54	242	20.3	20.5	88.0
55 and over	104	8.7	8.8	96.8
'I prefer not to say'	38	3.2	3.2	100
Total responses	1181	98.9	100	
No response	13	1.1		
Total	1194	100		

Table 3. Age distribution of sample

Employment status	Frequency	Percentage	Valid percentage	Cumulative percentage
Employed	622	52.1	52.5	52.5
Self-employed	212	17.8	17.9	70.4
Seeking employment	46	3.9	3.9	74.3
Home maker	79	6.6	6.7	81.0
Out of work and not seeking employment	57	4.8	4.8	85.8
Student	85	7.1	7.2	93.0
Retired	49	4.1	4.1	97.1
Unable to work	34	2.8	2.9	100.0
Total responses	1184	99.2	100	
No response	10	0.8		
Total	1194	100.0		

Table 4. Employment status

Respondents were also asked whether they shopped online, and 9 answered 'no'. In view of the research focus, the researcher decided to exclude these questionnaires from the sample, bringing the sample size down to 1185.

Testing the initial hypotheses

Survey findings related to Hypothesis 1 are included in Table 5.

How important would you rate	How often do you shop online?					Mean
	Once a month or less	2-5 times a month	More Often	Total/ Perc		
Unimportant	57	9	4	70	(6.0)	1.24
Neither Important nor Unimportant	41	34	12	87	(7.4)	1.67
Important	194	346	476	1016	(86.6)	2.28
Total	292	389	492	1173	(100)	2.17

Table 5. Online shopping frequency and delivery speed importance

H1 was tested at a significance of 0.05 via null and alternative hypotheses. The alternative hypothesis that "frequent online shopping increases the desire for delivery speed" was accepted.

Some of the survey findings related to Hypothesis 2 are included in Table 6. The question is inviting respondents to consider how much they would be prepared to pay for 'same day' delivery once the service has become common practice.

How much would you be prepared to pay for same day delivery in the following scenarios?-A regular parcel, assuming same day commonplace	How often do you choose express (next day) delivery?					Mean
	Once a month or less	2-5 times a month 5	More Often	Total	%	
<£5	642 (64.7%)	220 (22.2)	60 (6.0%)	992	(87.2)	2.17
£5	105	48	18	171	(15.0)	2.36
£10	24	8	6	38	(3.3)	2.50
£20 or more	3	3	1	7	(0.6)	2.71
Total	774	279	85	1138	(100)	2.22

Table 6. Price sensitivity towards 'same day' services for a regular parcel

Null and alternative hypotheses were tested as before, and the null hypothesis: "Irrespective of customers' desire for express delivery, they won't pay a high premium for the 'same day' delivery of a regular parcel once 'same day' is commonplace", was accepted.
Table 6 reveals that of each frequency category, <£5 has higher preference over other price options, i.e. 87.2% of customers, irrespective of their desire for express delivery, will pay <£5 for the same day delivery of a regular parcel. This therefore implies a low preference for 'same day' courier services, and unwillingness to pay a high premium, regardless of the delivery speed.

The parcels of 'significant importance' aspect of Hypothesis 2 was further explored through another question, as shown in Table 7.

| How much would you be prepared to pay | How often do you choose express (next day) delivery? | | | | | |
	Once a month or less	2-5 times a month	More Often	Total	%	Mean
<£5	83	12	9	104	(9.2)	1.98
£5	301	60	12	373	(32.9)	2.01
£10	298	177	49	524	(46.2)	2.38
£20 or more	93	28	12	133	(11.7)	2.28
Total	775	277	82	1134	(100)	2.21

Table 7. Price sensitivity towards 'same day' services for a parcel with significant importance attached

Null and alternative hypotheses were tested as before, and the null hypothesis: "With attached importance, customers who give preference to express delivery will pay a relatively high premium for 'same day' courier services," was accepted. The results in Table 7 indicate that, with attached importance to a parcel, a sizable proportion of customers will pay £5 and £10 for 'same day' delivery.

Testing the emerging hypotheses

The survey also explored questions relating to the influence of geography, gender, propensity to travel for parcel pick-up, and preferences for home delivery over alternatives. A number of comparison tests were conducted employing null and alternative hypotheses. The findings are shown in Table 8.

No.	Null hypothesis	Outcome of test	Alternative hypothesis	Outcome of test
4	Geographical location will influence customers' courier price decision.	Rejected	Geographical location will not influence customers' courier price decision.	Accepted
5	Gender difference does not influence online shopping attitude.	Accepted	Gender difference influences online shopping attitude	Rejected
6	Gender distribution plays equal role on online shopping frequency.	Accepted	Gender distribution does not play equal role on online shopping frequency.	Rejected
7	Residential address location will influence travel distance to pick up parcel.	Rejected	Residential address location will not influence travel distance to pick up parcel	Accepted
8	Customers will give preference to alternative delivery type over home delivery.	Rejected	Customers won't give preference to alternative delivery type over home delivery	Accepted

Table 8. Exploration of emerging hypotheses

Hypothesis 4 explored geographical differences in terms of: city centre, city suburbs, town and countryside, and it was perhaps surprising that the type of location had no bearing on customer preferences for delivery speed. Testing of Hypotheses 5 and 6 reveal that gender exerts no influence on either delivery speed preference or online shopping frequency. These findings also helps to dispel concerns about gender bias in the sample. Testing of Hypothesis 7 reveals that the distance shoppers are prepared to travel for pick-up is unaffected by their type of location (city centre, suburbs, town or countryside). Testing of Hypothesis 8 indicates a preference for home delivery over alternatives, e.g. click and collect arrangements.

Survey findings concerning delivery mode
Customers will give preference to shippers whose carriers are able to give reliable update as regards parcel delivery time (tracking information).

Early evening is revealed as the favoured delivery time, even with variation in employment status.

The ability to reschedule parcel delivery time and place will influence customers' patronage level.

DISCUSSION
The survey indicates that the desire for speedy delivery increases with on-line shopping frequency. This is unsurprising, as frequent online shopping is inevitably a substitute for visits to the store, where product availability is generally immediate. This finding may be good news for Logistics Service Providers, since it implies more business. However, the second major finding is that although customers have a strong desire for speedy delivery, they are not willing to pay a significant premium for the service. This finding is in line with the 2015 Ofcom report, which revealed that 56% of respondents consider free delivery to be important when choosing a retailer. Taken together, increasing on-line shopping volumes coupled with a customer preference for free/inexpensive delivery implies increasing demand for low cost express parcel services, but does not explain the reported growth in low cost 'same day' services (Telegraph online, 2016). To understand this development, it is necessary to refer back to the logistics triad. As demand for 'same day' cannot be attributed to either carriers or customers for regular purchases, it may be concluded that it is the shippers (online retailers) that are driving this development. This could be seen simply as a new competitive dynamic amongst retailers. Retailers have always competed on product availability (amongst other dimensions of customer service), but within the landscape of multi-channel and omni-channel retailing (Verhoff et al., 2015), product availability is facilitated as much by logistics services as it is by inventory management and store location. For online retail 'pure players', the customers' propensity to substitute online for in-store purchases is significantly affected by the availability of speedy and low cost home delivery service.

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Section 8: Value creation and customer service

THE IMPACT OF CUSTOMER VALUE TOWARDS CUSTOMER LOYALTY OF READY TO DRINK TEA BOTTLED

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ABSTRACT

Purpose of this paper: Business development challenges is about how to encounters competitiveness through value creation concept. This research objective are to provide value proposition and development model of the influence factors for customer loyalty of instant tea drink product based on consumer value through customer satisfaction.

Design/methodology/approach: The study was conducted among young adult customers who lived in Jatinangor District as one of higher education centre area in Bandung City as potential buyer for three kind of ready-to-drink tea bottled brand in Indonesia; with descriptive and explanatory survey data of 90 respondents. Afterwards, the hypotheses were tested by elaborating value on customer proposition and developing conceptual statistical model utilizing path analysis technique to address customer value and satisfaction impact on customer loyalty.

Findings: Tested on validity and reliability showed satisfactory result. Research conclusions showed value proposition of ready-to-drink tea bottled that produce by local company has a higher competitiveness compare to its competitors. Maintaining customer value can improve customer loyalty, whilst require customer satisfaction as one of supply chain performance indicator. Other marketing program and attributes need to integrate in order to gain customer loyalty and be more competitive in the marketplace.

Value: This paper represents a few studies on customer value that conducted especially on beverages product, and show the challenges in buyer behavior of convenience products in a competitive market based on descriptive findings and empirical study.

Research limitations/Implications: Although an extensive literature review was made, this paper is based only on one single case study on one particular area.

Practical Implications: By applying customer value mapping, manager could present their product company position in the marketplace, and create customer loyalty program as part of customer relationship improvement to give more attention to fulfill customer unique needs. It would also give broader information of how extensive the company value creation to encounter market competition.

Keywords: *value creation, customer service, relationship marketing, consumer behavior*

INTRODUCTION

The terminology of value concept and customer service quality including customer satisfaction and customer loyalty has raised many research and shift the point of view both academic study and business practice of marketing, supply chain, and logistics. As logistics become one of business function to deliver quality with capacity for differentiation, then it could enhance a higher customer satisfaction and loyalty (Mentzer et al., 2004: Richey et al., 2007; Saura et al., 2008). Thus understanding market needs and wants as part of customer service to enhance benefit for company, shareholders', and market value by understanding customer loyalty is urgently needed in this tight business competition (Collins et al., 2001; Wiles et al., 2007). This is due to the importance of achieving sustainable competitive advantage in order to increase satisfaction for both company's performance and customer's (Collins et al., 2001; Cheung et al., 2003). Logistic activity directly influences customer service performance in many non expectable ways (Tilokavichai, et al., 2012).

Today business development basic mission is not only based on profitability, but then based on the capability of value creation (Zeithaml & Bitner, 2000). Value is now facing challenges and becoming robust topics for instance satisfaction as strategic focus in marketing and as the central of consumer decision making (Day, 2002) and it is important for producers to understand customer value in distinctive contexts and what appropriate marketing strategies and create the most suitable customer value creation strategies, due to its vocal point in marketing thought and marketing strategy (Smith & Colgate, 2007). Value creation concept also an effort that will impact on wealth creation for its shareholders so then will creating value for both customer and company (Bititci, 2004). That is why many researches are still interesting in the understanding of customer satisfaction and customer loyalty (Musa et al., 2005). It is valuable information of how they try to keep consumer being loyal to the company.

This study was applied in this following model (Fig.1). The investigation of the affected factor of customer satisfaction that come from customer value and followed by its impact on customer loyalty, both from customer value and/or from customer satisfaction. Some literature coincides that customer satisfaction could be the basis for improving relationship (Rauyruen & Miller, 2007), not only for end customer but also for the rest of supply chain actor that connected each other with marketing relationship in the network. It was assumed that customer value affected customer satisfaction, and it will affected customer purchase repetition that reflected by customer loyalty.

Figure 1. The Conceptual Framework

Company ability that support on the successful one suggested by delivering superior customer value (Kang et al, 2007). Value creation concept could give valuable feedback of how the company performs in the industry. The competition of food and beverage products in developing countries such as Indonesia is very fluctuating. Consumer buyer

behavior sometimes is difficult to predict as low risk of barrier to entry. However, there are huge market opportunities for existing product and new product to offer their new innovation and product development in order to fulfill customer needs on something new. Meanwhile, understanding value creation and seeing its benefit are often difficult in developing countries that consist of many small medium enterprises.

Teh Botol brand is one of eminent ready-to-drink (RTD) tea bottled and local pioneer company for tea drink packaged in Indonesia. The development of tea drinks business in Indonesia attracts some foreign company in the marketplace. The launching of Frestea from Cocacola Company and Tekita from Pepsi-Cola Company is a competitor for local company. Consumer demand attracts new competitors to get into the business. Meanwhile, Jatinangor district is one of higher education area centre in metropolitan Bandung City in Indonesia. Student life mostly willing to complete their needs with instant product, due to the limited time and place they have. Product benefit perceived by customer rather from it practicality to consume and it taste based on consumer experience of drinking tea drink in Indonesia that impact on customer loyalty. The effort to be competitive is to offer higher product value with many benefit and lower cost for the customer that expected to achieve customer satisfaction and create customer loyalty.

However, there was still limited study that tried to investigate the antecedent of customer satisfaction that come from customer value and followed by its impact on customer loyalty. There is less concern research in developing country focusing on customer loyalty which is affected by customer value, especially in particular subject such as tea based beverage product with low switching cost. The studies on the important of value creation based on customer are sometimes neglected which theoretically influence consumer buyer behavior by means on customer satisfaction and customer loyalty, although it is not the only factor that impact on the success of a product in the market. This research objective is to demonstrate customer assessment on customer value of top three different kinds of RTD tea drink in bottled brands, and to investigate the impact of customer value with a particular emphasis on defining factors towards customer satisfaction and continued its impact towards customer loyalty.

LITERATURE REVIEW

Customer Value

Customer delivered value is difference between total customer benefit and total customer cost (Kotler, 2000). Other importance of value is innovation of proactive company that will give opportunity to get superior customer value, while other with reactive innovation will just serve customer with fair value compare to its competitors (Ingenbleek et al., 2001). There are four aspect of value dimension based on Sweeney & Soutar (2001), emotional value; social value; quality performance value; and price/value of the money. However, it is a very subjective matter only a few of customers who have expertise in valuating and assess the quality and their perceive value, that is why it is necessary for marketer to be able to communicate powerfully the customer value to achieve superior customer value (Lovelock and Wirtz, 2004).

Customer Satisfaction

Customer satisfaction according to ISO 9000 is user opinion about the degree that meets its requirements (Maric & Arsovski, 2010), and as customer evaluation based on their experience and reaction to a certain product transaction event (Jiang & Rosenbloom, 2004). Some research have found that customer satisfaction is not the only factor regarded as valuable outcome to be consider as good marketing management (Malthouse et al. 2004). In fact customer satisfaction is an introduction to meet and maintain further customer loyalty in the future (Gilaninia, et, al., 2013). Other research findings also

discovered that customer satisfaction is an essential desired outcomes for customer loyalty, customer retention, and moreover company profitability (e.g. Burnham 2003; Kassim 2001).

Customer Loyalty

Loyalty is a concept where to apply in condition that customer will continue to join within the relationship although they might have some particular reason to walk off (Debonis, et al., 2002). Customer loyalty is a sensible decision of preference for customer value engagement and promises. A high degree of satisfaction will deliver to a high degree of customer loyalty (Jones & Sasser, 1995), and company that could supply a high quality product and service to the customer will continually create competitiveness and moreover will increase customer loyalty (Gilaninia, et, al., 2013). One concept stated by Richards and Jaones (2008), the importance of value as one of three factors that could drive company development and give full support as customer equity measurement. Product value will proposed to enhance customer satisfaction that will affect loyalty of customer.

RESEARCH WORK

The research conducted survey descriptive research design in order to gain insight of value proposition and the impact of customer value towards customer loyalty through customer satisfaction. It was done in Jatinangor District in Bandung City as higher education centre area. The survey was facilitated with three part questioners (customer value, customer satisfaction, and customer loyalty) and utilized as survey instrument.

Survey through questionnaire with face-to-face interview was applied with 90 young adult customers who had the experience in consuming these three kinds of observed ready-to-drink tea bottled brands, there were Teh Botol, Frestea, and Tekita. Number of sample was obtained using iterative sample technique (Riduwan and Achmad, 2008) with repeatedly counting formula. In addition, the acceptable level to decide sample size for multiple regression analysis is 15 to 20 observations for every independent variable (Hair et al, 2006). This study had two independent variables; customer value as the independent variable for customer satisfaction and then continued by customer satisfaction as the independent variable for customer loyalty. Thus 90 respondents was met the desirable sample size.

Respondents was answered 20 questions and divided in several sections, there are demographic section with fill-in-blank form, while the rest part of the questionnaires appointed for customer value, customer satisfaction, and customer loyalty were designed with multiple response options. First, pilot test was applied and it showed that all questionnaire items are acceptable in validity and reliability (Cronbach's alpha = 0.845 (customer value); 0.913 (customer satisfaction); and 0.897 (customer loyalty)). The final form of the questionnaire consist thirteen indicators items of customer value that computed by factor scores from product value as the ratio of product benefit from product attributes benefit, price benefit, distribution benefit, promotion benefit; and product cost from monetary cost and non-monetary cost (time cost and energy cost). The customer satisfaction was represented by three indicator items and measured using factor scores from repeat buying intention, post purchase satisfaction, and post purchase pleasure. Afterwards, customer loyalty was utilized four indicators and counted using factor scores from customer retention, customer likelihood to buy same product, customer purchasing loyalty, and customer likelihood to recommend.

Data analysis design was conducted in three stages. The first stage was initiation stage to gather and examined the filled questionnaires. The second stage was processing the data with tabulation in order to present value proposition based on customer value

mapping. The last stage was data verification using path analysis to test a comprehensive correlation among every observed variable.

Mapping on value of customer was applied to elaborate the position of three brands RTD tea bottled that being observed. Before building customer value mapping in four-spaces, customer value analysis was firstly applied. The mapping showed in two dimensions graphic, where vertical axis described relative benefit and horizontal axis described cost relative. The analysis was examined by counting the ratio between product benefit and product cost, and calculating overall value from every score of overall product benefit – and overall product cost. The discovered score will identify the position of each ready-to-drink tea bottled on the map.

Afterwards, verification testing on the impact of customer value towards customer loyalty through customer satisfaction was done using path analysis. The Impact analysis of each variable on model construct was tested using path analysis method, assisted by SPSS 20.0, with path diagram model (fig 2). This is a causality analysis to examine the pattern effect of customer value towards customer loyalty through customer satisfaction. The analysis was to clarify the different attribute among marginal coefficient and to give in-depth information when casual by causal explanation are no longer suitable in the circumstances (Bratholomew et al, 2008).

Structured equation for path diagram:
$$Y = \rho_{yx}X + \varepsilon_1$$
$$Z = \rho_{zy}Y + \varepsilon_2$$
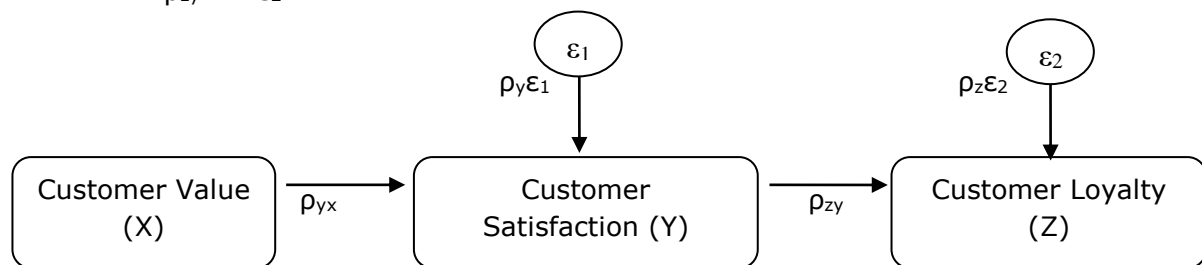
Figure 2. Path Diagram Model

Hypothesis on this research is an influence of customer value of Teh Botol Brand towards customer satisfaction, and also an influence of customer satisfaction of Teh Botol Brand towards customer loyalty. In order to define the influence of customer value towards customer satisfaction and the influence of customer satisfaction towards customer loyalty, the following are the hypothesis.

a. H1 = there is a significant influence of customer value towards customer satisfaction
b. H2 = there is a significant influence of customer satisfaction towards customer loyalty
c. H3 = there is significant influence of customer value towards customer loyalty through customer satisfaction

RESULTS AND ANALYSIS

Customer Value Analysis

This mapping analysis was to describe the position of three brand of RTD tea bottled including their competitiveness based on product value which compares overall benefit and overall cost spent by customer to buy the product. Product benefit were obtain through marketing mix of the product design and packaging, quality, brand, customer taste, and product size, price fairness, distribution, and promotion; meanwhile cost were obtain through material cost and non-material cost. Customer value mapping of three different brand of RTD tea bottled showed Teh Botol give the highest value for the

customer and achieved superior value for its product (fig.3). Based on Martinez and Bititci (2001), the importance of mapping this value proposition have function to assess company competencies and capabilities which have done and develop in order to deliver value proposition to their customer as much as efficient and effective to bring satisfaction for both firm and customer.

Customer value for every customer is unique and dynamic within individual customer over time and also it is relative to each customer whether based on comparison of discovered or imagined alternatives (Ulaga, 2003). This means that customer value could change within time and business environment changes. Teh Botol brand were popular because they have been 46 years in the business. Their experience dealing with customer leads them to have a broader insight of how attract customer and serve them with higher benefit then other competitors. However, the existence of new entrance to the market such as Frestea should not be ignored. Although they are new in this product, but as shown in the mapping they have been attract consumer awareness and gain superior value and stand on competitive advantage area.
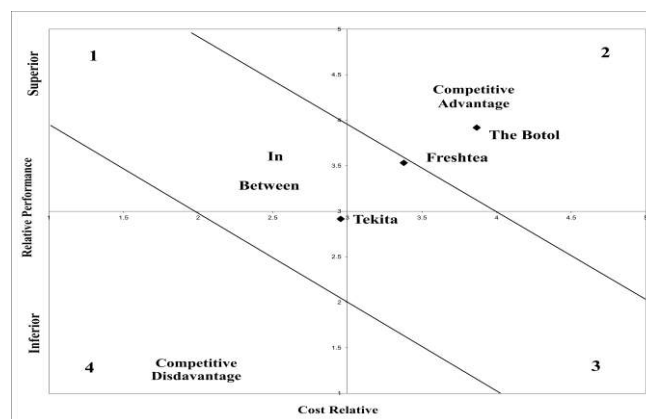
Figure 3. Customer Value Mapping

Correlation among Variables

Data analysis through path analysis which first transformed the data value from likert scale with its ordinal data value to interval measurement scale using method of successive interval; then correlation between variables for customer value (X), customer satisfaction (Y), and customer loyalty (Z) were counted using product moment formulation. Result showed on table 1, correlation between customer value and customer satisfaction is quite strong with linear correlation; meanwhile customer satisfaction and customer loyalty have a very strong relationship with also linear correlation. Creating customer value is one of organization purpose and predecessor of key success to customer satisfaction and customer loyalty (Woodall, 2003). This is relevant to this research finding for the linear correlation between customer value, satisfaction, and loyalty.

Table 1. Correlation Matrix Among Variables

	X (value)	Y (satisfaction)	Z (loyalty)
X (value)	1.000	0.423*	0.360*
Y (satisfaction)	0.423*	1.000	0.675*
Z (loyalty)	0.360*	0.675*	1.000

Note: * Correlation is significant at the 0.05 level (2-tailed)

Path Coefficient

This study applied a structured model consisted of one independent variable, one mediating variable, and one dependent variable. Path coefficient was explained as Beta coefficient (table 2).

Table 2. Path Coefficient

Model	Un-standardized Coefficients		Standardized Coefficients	t	Sig
	B	Std. error	Beta		
1 (constant)	1.294	0.558		2.320	0.023
a. Customer value	0.625	0.143	0.423	4.377	0.000
1 (constant)	0.432	0.340		1.270	0.207
b. Customer satisfaction	0.769	0.090	0.675	8.579	0.000

a. Dependent Variable: Customer satisfaction
b. Dependent Variable: Customer Loyalty

Coefficient Determination

Path coefficient (ρ_{yx}) and (ρ_{zy}) for other variables which were not included in this study (table 3) were examined by evaluating the coefficient utilizing the formula below:

(I) $\quad P_{Y\varepsilon} = \sqrt{1 - R_{yx}^2}$; $\quad P_{Y\varepsilon} = \sqrt{1 - 0,179}$ = 0,906.

(II) $\quad P_{Z\varepsilon} = \sqrt{1 - R_{ZY}^2}$ = $\sqrt{1 - 0,455}$ = 0,738

Table 3. Path Coefficient for other variables

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
I	0.423[a1]	0.179	0.169	0.72463
II	0.675[a2]	0.455	0.449	0.67244

a1. Predictors: (Constant), Customer value
a2. Predictors: (constant), customer value

Each model tested in this study showed distinct effect proportion as described as follow:

1. The result of t-test showed significant result of customer value (t-test = 4.277 with t-table = 1,987). Structural model of customer value influence on customer satisfaction of Teh Botol RTD tea bottled showed as follow.

Y = 0,423 X+0,906

Research showed that customer value gave 17.9% contribution on customer satisfaction. This give information that a higher perceived customer value will increase customer satisfaction. However, there was 82.1% from other variables that influence customer satisfaction. This emphasis that customer consider many factors in order to fulfill their satisfaction. Many offered product of RTD tea bottled will possibly make customer have many choices and experience to consume of instant tea drink in a different way that historically usually produce home made with its traditional taste.

2. T-test result showed significant impact of customer satisfaction towards customer loyalty (t-test = 8.570 and t-table = 1.987). Structural model of customer satisfaction on customer loyalty of Teh Botol RTD tea bottled showed as follow.

Z = 0,675 Y+0,738

This research explained that customer satisfaction has 45.5% impact on customer loyalty. Customer satisfaction will prevent customer thought to choose other RTD tea bottled. A satisfied customer would evoke to customer loyalty in consumption

experience (Ma & Ding, 2010). Meanwhile, there is still other 54.5% which not being observed in this research that could improve customer loyalty of instant drink.

3. Verification result showed significant impact of customer value towards customer loyalty through customer satisfaction (t-test = 2,7308 and t-table = 1.987). The result showed path coefficient value of customer value towards customer loyalty through customer satisfaction of Teh Botol RTD tea bottled is 28.55% of contribution. This is other indicator that marketing value creation through product value will increase customer loyalty although it should be first make customer to be satisfied with the product. A higher perceived customer value will increase customer satisfaction and further after a higher customer satisfaction will then increase customer loyalty. In order to build customer loyalty and trust then company should know well their customers, which mean company should be able to fulfill customer needs and desires better than other competitors (Maric & Arsovski, 2010), and superior customer value of a products delivered to customers will leads to customer loyalty (Ma & Ding, 2010)

DISCUSSION AND CONCLUSION

Value mapping analysis describe different competitive advantage position of these three different RTD tea bottled brand, and Teh Botol brand stood in competitive advantage area and gain superior value. With explicit focus on customer loyalty, customer value only impacts a much less quarter portion on customer loyalty. It is expected for product to create and develop customer satisfaction to escalate customer loyalty. Limited study investigating customer value of agriculture industrial beverage product and how should this product sustain in the market to acquire loyalty from the customer, due to the rapid competition of instant tea drink in Indonesia. The acknowledgment of today's customer multi-channel customer experience may consider marketer along the supply chain to attract their targeted customer with customer loyalty program.

Furthermore, it is possible for further study and verify the driver components for each factor especially that enhance customer satisfaction and customer loyalty in third party logistics relationship. It is also necessary to give more practical marketing insight of managerial guidance in preserve competitiveness for RTD tea bottled business. Other important study is on customer value perception changes that have particular contribution towards value co-creation concept and its dynamics nature.

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DESIGNING A FRAMEWORK AND RESEARCH MODEL FOR THE LOGISTICS SERVICE PROVIDERS INNOVATION AND ADOPTION

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Abstract

This research work is aimed to examine the technological and non-technological innovation adoption mechanism of Logistics Service Providers (LSPs) in the United Arab Emirates (UAE) as the UAE is considered to be one of the fastest emerging markets in the world. By investigating the critical drivers that stimulates LSPs for innovation, growth and sustainability, the research develops various theoretical hypotheses and design a framework that could be used practitioners in the innovation adoption landscape. The proposed methodology follows with the various hypotheses setting, questionnaire design, focus interview, surveying and testing the variables. The research develops an initial framework as well as measures of various factors that drive for technological innovation and adoption in the UAE perspective. The survey results have indicated mixed outcome stating that the lead logistics service providers (15% respondents) have latest technological adoption however majority of them (47% respondents) are still in their nascent stage of technological adoption because of the associated challenges. The research findings can thus be used to promote innovation in the logistics industry by raising the potential to strengthen the competitive advantage of regional logistics industries and also to strengthen the positioning of Dubai as the logistics hub in the Middle East region.

Paper Type: Research paper

Keywords: *Logistics Service Providers Innovation, Innovation adoption; the United Arab Emirates*

Introduction
Innovation mechanism is a complex process that contains many uncertain business scenarios. Furthermore, when compared to innovations in the manufacturing sector, innovations in the service sector, and particularly in the logistics industry, innovations are less formally organized, less technological, and more incremental in nature (Lin (2006). Some of them tend to be continuous, consisting of numerous small incremental changes which are not considered as innovation individually but become a significant collectively. All these characteristics indicates that studying innovation in the logistics service sector is more challenging as there are fewer precedents to be followed for the forthcoming years. Moreover, innovations in the supply chain are more complicated to study as they often cross firm boundaries though partner relationships and are not easy to identify the path and follow-up.

LITERATURE REVIEW
Innovation in logistics Services
Innovation in logistics services has been defined as "any logistics related service from the basic to the complex that is seen as new and helpful to a particular focal audience. The audience could be internal where innovations improve operational efficiency or external where innovations better serve customers" Flint et al. (2005: 114). According to Lin (2006), logistics innovation can be grouped into two types; Type-1 innovation: technical/technological (stages include data acquisition, information management,

warehousing and transportation) and Type-2 Innovation: administrative and non-technological (activities include; changes in structures, business processes, customer and supplier relationships management and knowledge management issues). Therefore any little improvement in the way of delivering the product, packaging, labeling, warehousing activity, customer service and cost control mechanism etc, provided by the LSPs is considered as the innovation in logistics than the existing way of doing things in logistics industry.

Logistics Sector in the UAE

Geographically, the United Arab Emirates (UAE) is located in the land borders with Oman and Saudi Arabia, it is on the southeastern shores of the Arabian Gulf and western shores of the Gulf of Oman, and it is on the southeast of the Arabian Peninsula. The UAE is one of the six countries that form the Gulf Cooperation Council (GCC) in the Middle East. The UAE is a federation formed by seven different emirates namely: Abu Dhabi, Dubai, Sharjah, Ajman, Umm Al Quwain, Ras Al Khaimah and Fujairah. The UAE has a federal structure composed. The UAE has exploited its potential as a world class logistics hub, with heavy investments in the development of warehousing facilities and transportation infrastructure. A study conducted by Frost and Sullivan (2011) revealed that revenues in the logistics market in 2011 was USD 7.03 billion and is projected to reach USD 9.40 billion in 2014 (Figure 1).
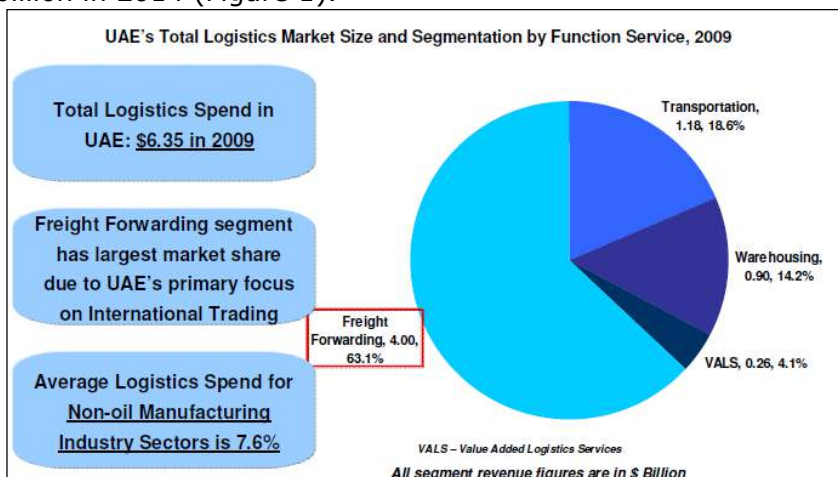
Figure 1. UAE's logistics market; Source: Frost and Sullivan (2011)

The UAE has an advantage over its neighboring countries, as it is a strategic location in terms of a mid-way between the east and the west. Research by Frost & Sullivan shows that a major portion of the logistics revenue i.e. 63.1% has been gained by the freight forwarding segment (an integral part of the 3PL industry) followed by transportation segment with 18.6%. Major portion of the revenue comes from various sectors such as oil and gas, engineering and FMCG industries. This is attributable to international trade activity and large volume of imports from high growth economies such as India and China to name a few. As the UAE manufacturing industries are focused into trade and logistics, the need for freight forwarders and shipping in the logistics sector is high. Through its strategic location, UAE has established itself as a transcontinental center for imports, exports and cross trade.

Need for research

Though there are many prospects for LSPs, the challenges such as labor availability, unskilled workers, heterogeneous in operations and local regulations are yet to be overcome (Transport Intelligence, 2014). Trade corridors can only function if the logistics sector is efficiently regulated. Other challenges faced by LSP's in GCC region could include harmonization of trucking standards, financial incentives for fleet upgrades, sectoral liberalization programs, improving border clearance processes and upgrading border facilities (World Bank, 2015).

Furthermore the literature is limited in dealing with the understanding the LSPs mechanism across borders and its performance in Middle East countries (3PL Study 2012, World Bank, 2010). Major study conducted by Arvis (2010) measured the logistics performance index for selected 150 countries across the world. The Study shows the results of some of the neighborhood countries of UAE and their performance rankings. Singapore is rated as the best country in their study for all indicators in which UAE has been placed in top 20 quartile with the Logistic Performance Index (LPI) score of 3.73 against best score of 4.19 (Singapore). The most interesting thing is that all these GCC countries are ranked within the top 50 out of 150 countries. It also further stimulates us to investigate in depth study of LSP's performance indicators among the companies operating, their innovation and degree of adoption of these process, product and service innovation to their offering in the Middle East region.

Therefore how LSPs are strategically prepared to meet the challenges and innovative enough so as to tab the growing demand of this region in order to provide a sustainable services is really unanswered. This research is an attempt to bridge the gap to examine the current innovation mechanism and its dynamics. An in-depth study of innovation in the logistics service sector therefore requires great effort to follow firms not only in the sector but also their partners. Researchers also may encounter difficulty in finding a sufficient numbers of firms and their partners to participate into the study.

In addition, LSPs innovation relates to multiple stakeholders in the supply chain and their interactions are influenced by various factors. It requires researchers to study the innovation process from multiple angles with various theories in the field of social science, business, and industrial engineering. It needs a strong research support with good understanding of these theories, as well as strong integration ability. The in-depth case study, detailed survey data analysis, and model development and simulation all require a considerable amount of field work in the GCC region.

Research challenge
The study is challenging because the innovation mechanism is complex and complicated with a number of uncertainties. Furthermore, compared to innovations in the manufacturing sector, innovations in the service sector, and particularly in the logistics industry, are less formally organized, less technological, and more incremental in nature. Some of them tend to be continuous, consisting of numerous small incremental changes which are not considered as innovative individually but become significant collectively. All these characteristics make studying innovation in the logistics service sector are more challenging as there are fewer precedents to follow. Moreover, innovations in the supply chain are more difficult to study as they often cross firm boundaries though partner relationships and are not easy to identify and follow-up the path. An in-depth study of innovation in the logistics service sector therefore requires great effort to follow firms not only in the sector but also their partners. Researchers also may encounter difficulty in finding a sufficient numbers of firms and their partners to participate into the study.

THE RESEARCH FRAMEWORK
As a result of globalization, relationship among partners in the logistics and supply chain sector is very complex. Hence, firms needs to collaborate in order to improve the efficiency and responsiveness of their supply chain to allow them to gain competitive advantage over other competing supply chains. A firm can compete by efficiency, differentiation, responsiveness, or a combination of the three by its supply chain (Chopra and Meindl, 2012). For external factors, Fine (2008) studied the impact of industrial environment such as clock speed, institutional pressure, governmental policy, and macroeconomic growth. Literature has shown that the first mover advantage does not exist in some industries such as the disk drive industry (Hamel and Prahalad, 1996). In such an industry, one may explore what are the suitable innovation strategies a firm should take and how to link them with other business strategies. From an infrastructure perspective, Prahalad and Krishnan (2002) highlighted potential impediments from a

sophisticated Information Technology (IT) system to firm innovation, thus questioning the relationship between IT and innovation in the domain of supply chain management. On innovation and firm performance, Hamel and Prahalad (1996) highlighted that the importance of creating a new economy using industry collaboration to gain maximum benefits from innovation. These existing perspectives enable us to assess what are the best commercialization strategies in the service industry in GCC region and how they impact the industry infrastructural issues.

Innovation is becoming a key factor for LSPs to survive and also to thrive in the intense competition. Innovation provides competitive advantage to LSPs (Daugherty et al 1998; Mentzer et al. 2001). Innovation in sustainable logistics becomes another milestone in logistics industry for the end to end service. Innovation in LSPs is a messy process. Franklin (2008) said that "Innovation is often customer driven among LSPs, generalizing it to other customer needs requires lots of reengineering; applying 'Democratized Innovation Model' to LSPs requires modifying the 'end user as innovator' concept". Capitalizing innovation through reactive and channeling approach requires a toolkit based channeling model developing such in-house system made LSPs innovation into a new service called "Lead Logistics Services (LLS)" which can be leveraged to a wide range of customers (Mena et al. 2007). It necessitates for the need of strategic decision making tool to address the emerging constraints because these constraints often act as a driver for new models in innovation. On the other hand, managing this requires an integrated, more flexible, agile framework to meet the organizational clock speed (Flint et al. 2008). In the proposed project, the research develops an integrated approach consisting of traditional and modern (democratized innovator) innovative strategy in the LSPs landscape as a conceptual framework depicted in Figure 2.

On innovation and firm performance, Christensen et al. (2004) highlighted the importance of matching new product commercialization with the industry condition for maximum benefits from innovation. Grawe (2009) carried out a literature review on logistics innovation and drawn a conceptual framework for LSPs. However the study does not address the socio-economic dimension and its impact. The framework can be extended to fit into the regional context of the logistics service industry and also to find suitable exploitation strategies to diffuse some promising innovations via roadmaps and scenario analyses. The core of the framework (adapted from TLIAP, 2015) is the internal innovation process that takes place within one or sometimes even several companies. Actual innovation is produced only upon the completion of the last stage of this process. An invention first needs to be created, followed by its actual implementation and often adoption.
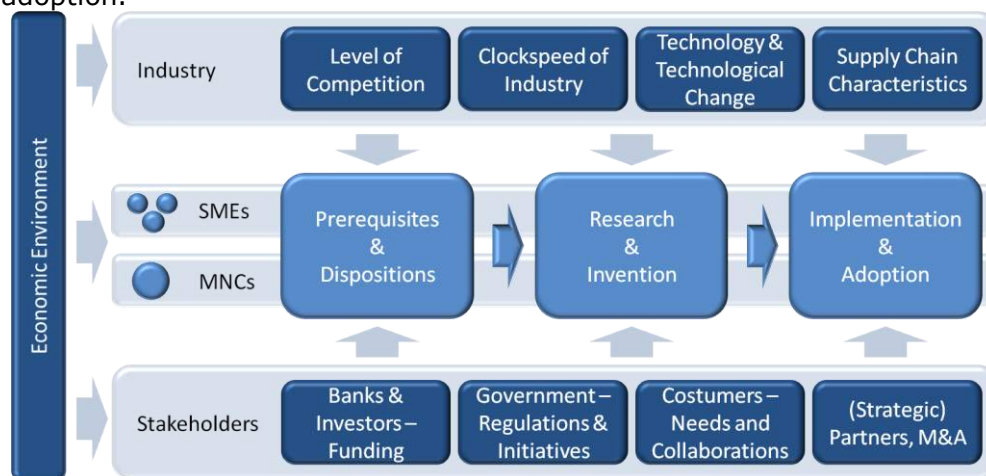
Figure 2: A conceptual framework of the innovation process and the influencing factors in logistics services, Source: The Logistics Institute Asia Pacific (2015)

The development of an innovation is a sequential process that involves three steps: from setting the ground ('Prerequisites & Dispositions') to creating ideas and inventions ('Research & Inventions') to the implementation ('Implementation & Adoption').

Characteristics of this process vary heavily depending on the size of companies and are therefore mirrored by the distinction between small-to-medium enterprises (SMEs) and multinational corporations (MNCs), as well as by the possible interactions between different logistics service providers.

All steps of this process are influenced by external factors that come from the LSPs and specific stakeholders and each of these factors can influence the innovation process at each of its three stages in very different ways. This process is similar to how the clock-speed of a certain industry sets the pace for its growth, maturity and decline in product life cycle. Investors play a crucial role in providing a suitable environment that fosters the innovation process at all the three stages. Furthermore, the current global financial crisis prevents investors and banks from facilitating this process, governmental initiatives may also choose to participate in providing knowledge or funding of different stages of the innovation process.

The Research Question

From the literature review across the various issues driving the innovation mechanism of LSPs, the following research question is generated;

"How innovative are the logistics service providers during the era of global financial crisis in order to provide a sustainable logistics services?"

This research question will lead to influencing theories in the area of logistics innovation and its dynamics under the challenging assumptions drawn in the earlier section of the literature.

The Research Objective

The proposed research question can be addressed by the following objectives:

- Extending the literature review in order to develop an initial framework, as well as measures of various factors that drive for product, process and service level innovation
- Design hypotheses to those identified internal and external drivers of innovation model
- Conducting multiple case studies on the innovation mechanism of a few careful selected LSPs asking "How" and "Why" questions pertaining to innovation
- Performing a questionnaire based survey to gain a broad understanding of innovation mechanisms in the LSP's in order to validate our frameworks

THE RESEARCH METHODOLOGY

The proposed methodology follows five streams namely; hypotheses setting, questionnaire design, focus interview, surveying and testing the variables. The methodology is a mixed/hybrid approach combining the qualitative research (inductive type comprising of hypothesis setting, questionnaire design & focus interview) and quantitative research. The research develops an initial framework as well as measures of various factors that drive for technological innovation and adoption in the UAE perspective.

The hypothesis setting

The research extends the framework highlighted in the earlier section based on variables identified from literature review to derive the hypotheses and to understand the LSPs innovation and its adoption in the region (see Figure 2). Degree of the hypothesis setting and measurement details are based on the conceptual framework. Based on the model displayed in figure 2, this research proposes the below 9 hypotheses.

Hypothesis 1: Technological changes drive positively the LSPs internal innovation

Hypothesis 2: Organisational collaboration and competition drive positively the LSPs internal innovation

Hypothesis 3: Innovation in business process and service drive positively the LSPs internal innovation

Hypothesis 4: Government regulation drives positive external pressure to the LSPs innovation

Hypothesis 5: Investment climate drives positive external pressure to the LSPs innovation

Hypothesis 6: Customer expectation drives positive external pressure to the LSPs innovation

Hypothesis 7: Firms internal pressures is positively associated with LSPs innovation angle

Hypothesis 8: Firms external pressures is positively associated with LSPs innovation mechanism

Hypothesis 9a: The age is positively associated with the LSPs innovation adoption

Hypothesis 9b: The firm size is positively associated positively associated with the LSPs innovation adoption

Hypothesis 9c: The firm type is positively associated positively associated with the LSPs innovation adoption
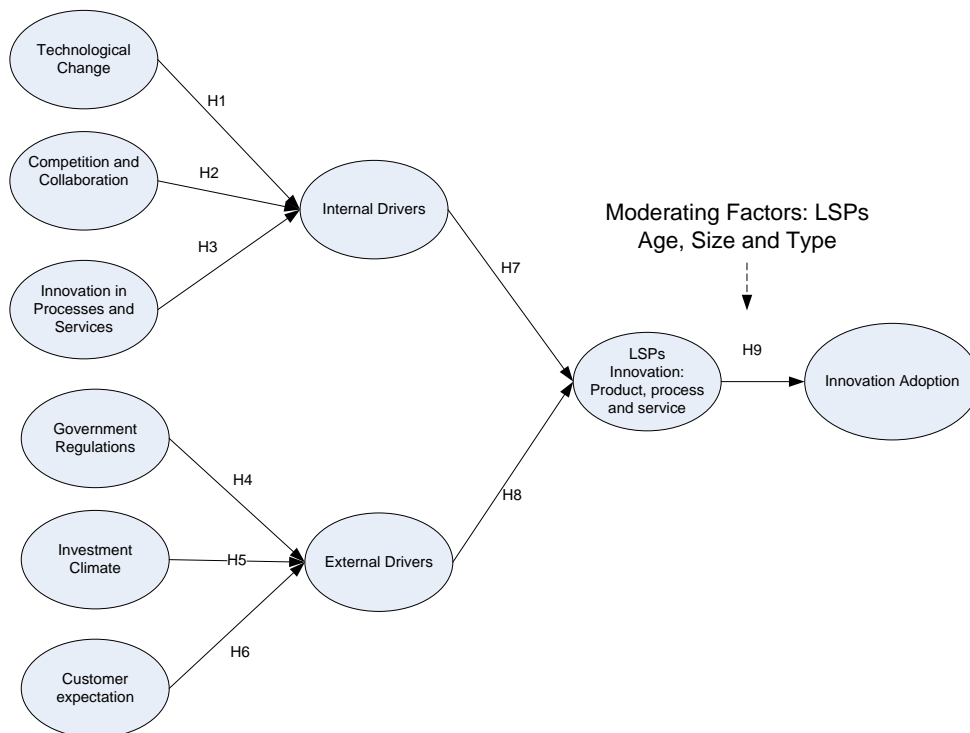
Figure 2. Illustration of the proposed research model with Hypotheses (H1-H9)

Questionnaire design

The Questionnaire survey consists of four main sections: organizational information, company strategies and directions, process improvements and the adoption of emerging technology in the future. Understanding the organizational information enables us to understand the company profile, of their supplier and customer, and distribution of employees with the support of logistics and information technology. Similarly, knowing the company strategies and directions will help to understand their company priorities in pursuit of supply chain management and also to identify whether these priorities are in line with best practices in the world.

Focus Interview

The focus interview provides exceptionally valuable opportunities to gather further pertinent information and perspectives from a wide range of professionals who have knowledge about the LSPs sector and these special topics. The research is aimed to meet five selective industries from each emirate within the UAE to observe its trends and innovation characteristics, which are used for model validation and triangulation.

Surveying

An online survey is hosted through survey monkey and email invitations ailed to 300 (sample size) companies from logistics industries, oil & gas, electronics, telecommunications, food and beverages, chemical, port, customs and other logistics related organizations. The respondents are requested to respond using a five-point Likert scale for most of the questions. The model are tested against the obtained measurement data to determine how well the model fits the data. The results are then triangulated against measured data and real-time scenarios. Techniques like questionnaire design, surveying and spss analysis have been used in different context in different sophisticated application successfully. However combination of these five streams in the context of Innovation dynamics in LSPs context is not yet attempted by any researchers. Moreover, investigating the innovation mechanism of LSPs in this part of world is very new effort and has a great potential for theory building.

An in-depth understanding of regional logistics innovation mechanism would help to identify the most inductive environment for supply chain innovation in the logistics industry, as well as helps to determine the most promising drivers in current logistics services. The research findings can thus be used to promote innovation in the logistics industry by raising the potential to strengthen the competitive advantage of regional logistics industries and also to strengthen the positioning of Dubai as the logistics hub of the GCC region as well as the surrounded logistics hubs such as Bahrain, Kuwait, Muscat and Riyadh.

Major Findings
The survey results have indicated mixed outcome stating that the lead logistics service providers (15% respondents) have latest technological adoption however majority of them (47% respondents) are still in their nascent stage of technological adoption because of the associated challenges. The research findings can thus be used to promote innovation in the logistics industry by raising the potential to strengthen the competitive advantage of regional logistics industries and also to strengthen the positioning of Dubai as the logistics hub in the Middle East region.

Research limitations/implications
The research is therefore limited to the UAE region. Further, an in-depth understanding of regional logistics innovation mechanism would help to identify the most inductive environment for supply chain innovation in the logistics industry, as well as helps to determine the most promising drivers in current logistics services. Theoretically, LSPs innovation relates to multiple stakeholders in the logistics and their interactions are influenced by various factors. It requires researchers to study the innovation process from multiple angles with various theories in the field of logistics. It needs a strong professional research team with good understanding of these theories, as well as strong integration ability. The in-depth case study, detailed survey data analysis, and model development and simulation all require a good understanding of the grounded theories and research expertise in the proposed area.

CONCLUSION
The research will create useful practical implications for managers which would be one of its first kinds of this region across GCC. In addition, this work will be the new innovative idea in this globalized world which can be used by various logistics industries, governments and public sectors for their operations. Uniqueness of this approach, survey findings and novelty of this proposed structural model will have better chances of succeeding in the current GFC scenario where, innovation is going to play an increasing significant importance in the way LSP's operate.

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EXPLORING VALUE CREATION AND APPROPRIATION IN THE REVERSE CLOTHING SUPPLY CHAIN

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ABSTRACT

Purpose of this paper:
The purpose of this paper is to explore the two processes of value creation and appropriation among companies in a retail reverse logistics system. The value concept has in recent years got increased attention in research on reverse logistics (Jayaraman and Luo, 2007). However, there is still a lack of more detailed understanding of the values created. There is also a need to not only consider the value creation, but also how the value is appropriated among supply chain members. Whereas the value creation process is concerned with the total amount of value created among supply chain members, the value appropriation process decides the involved companies' ability to extract money from the value created (Wagner et al., 2010).

Design/methodology/approach:
Grounded in the two fundamental processes of creating and appropriating value (Mizik and Jacobsen, 2003), this paper applies the value concept on retail reverse logistics practices. The paper is based on a case study of the take-back scheme for used clothes in the textile fashion industry. The case study includes collectors (clothing retailers) as well as specialised sorting companies responsible for sorting and further distribution of the used clothes.

Findings:
The retail reverse logistics system in the case study consists of multiple stakeholders in a complex network. Different types of values created are identified, and strategies for value appropriation among the different companies are discussed. A strong power position based on knowledge and/or financial strengths is here identified as a major factor in the value appropriation process.

Value:
The value concept has so far been discussed at a superficial level in research on retail reverse logistics. This research demonstrates that the value concept, including value creation as well as appropriation, helps to understand the rationale behind a certain supply chain structure in terms of participating supply chain members, types of activities conducted, and division of responsibility.

Practical implications (if applicable):
As a company's resources are limited, companies need to manage the trade-off between the value creation and appropriation processes, and strategically find a suitable mix between them.

INTRODUCTION
In accordance with an increased focus on environmental sustainability among end consumers as well as society in general there has been an increased interest in reverse clothing practices among practitioners as well as academics (Brooks, 2013; Hvass, 2014). Inspired by other industries, in which regulations for extended producer responsibility have forced manufacturers to take a life-cycle approach to their products and manage the reverse handling of these, also many fashion retailers have taken similar initiatives, often together with partner companies such as charity organisations. As a means to improve brand image, involvement in reverse supply chain practices could be considered as a complement to the previous, more established, upstream CSR and sustainability efforts. To focus on the end-of-life phase of the products could be seen as a logical next step in many companies' sustainability agendas (Hvass, 2014; Jayaraman & Luo, 2007).

The reverse clothing supply chain consists of a complex network of supply chain members, including among others fashion retailers, charity organisations, commercially oriented international recyclers, and specialised sorting companies (see e.g. Brooks, 2013). Through a series of complex reverse logistics activities among these supply chain members, waste clothes are recharged with new value for new purposes and customers, ranging from the creation of expensive, unique vintage clothes to be sold as high-street fashion, to charity in developing countries.

The value creation processes involved in reverse clothing supply chains have so far been discussed at a superficial level, despite their obvious importance for the existence of, and rationale behind, reverse clothing supply chains. A more in-depth analysis or empirical evidence of the value creation processes is still missing. In addition, given the complexity of the global supply chains involved in reverse clothing practices, the value distribution among different supply chain members, i.e. how the value created is captured among involved supply chain members, is not well understood (Brooks, 2013). Therefore, as a means to better understand the reverse clothing supply chains, *the purpose of this paper is to explore the two processes of value creation and appropriation among companies in a reverse clothing supply chain*.

Value creation as well as value appropriation can be addressed on different levels of analysis (Lepak et al., 2007). For the purpose of this paper, we focus on the organisational level, i.e. the involved companies in the reverse supply chain. Based on interviews and case studies at Swedish fashion retailers, Nordic charity organisations, international commercial recyclers, and Indian specialised sorting companies, this paper explores the processes of value creation and appropriation involved in the take back scheme for used clothes in the reverse clothing supply chain. Our contribution is particularly given to literature on reverse clothing supply chains, and to the overarching, emerging research field of reverse logistics. The Reverse Logistics Association describes reverse logistics to be "all activity associated with a product/service after the point of sale, the ultimate goal to optimize or make more efficient aftermarket activity, thus saving money and environmental resources" (Bernon et al., 2011, p. 486).

ON VALUE CREATION AND APPROPRIATION
Despite its central role in theory building, scholars acknowledge that the value concept still suffers from the lack of more rigid underpinning (Bowman & Ambrosini, 2000). There is still little consensus on what value creation really is, and value appropriation mechanisms are still to be explored. A common approach towards clarification is to

distinguish between *use value* and *exchange value* (Bowman & Ambrosini, 2000; Lepak et al., 2007). Use value can be defined as the customers' (i.e. the buying companies') "perceptions of the usefulness of the product on offer" (Bowman & Ambrosini, 2000, p. 15). It refers to the specific qualities of the offered product (or service) in relation to the customers' needs and is therefore a subjective measure pertained by the individual customer. The exchange value refers to monetary price at a given point of time, and is defined as "the amount paid by the buyer to the seller for the use value" (Bowman & Ambrosini, 2000, p. 15). Given the understanding of use value and exchange value, the customer's perception of the use value (including all possible values translated into monetary terms) must be higher than the exchange value. Otherwise, there will be no transaction (Lepak et al., 2007). Similarly, profit is hence realised when the sum of the prices of the inputted resources are less than the exchange values received from the customers (Bowman & Ambrosini, 2000). In more general terms, this definition results in an understanding that the value created is the accumulated benefits associated with buying the product, minus accumulated sacrifices involved.

From a value perspective, companies are with their limited resources engaged in the two fundamental processes of creating and appropriating value (Jayaraman & Luo, 2007; Mizik & Jacobson, 2003) that together shapes the company's competitive advantage vis-à-vis competitors. Whereas value creation influences the potential magnitude of this advantage, the value appropriation decides the share of the total advantage the company is able to acquire, and the length of time this advantage will persist (Mizik & Jacobsen, 2003). Below, the processes of value creation and appropriation are briefly described.

The value creation process
The value creation process consists of "actions of organizational members, who combine to transform the use values that the organization has acquired" (Bowman & Ambrosini, 2000, p. 5). Thus, given the distinction between use value and exchange value, companies are involved in creation of use value. Later on, when the product or service is sold, they are getting paid in the form of the exchange value that must cover their expenses they have had to create the use value (Bowman & Ambrosini, 2000).

The reverse logistics activities, typically including processes of acquisition, grading, re-processing, and re-distribution (Fleischmann et al., 2014), together create new value in returned goods (in this article waste clothes). In order to create value surplus, existing literature on reverse logistics especially stresses the importance of cost efficient reverse processes (e.g. Skinner et al., 2008; Bernon et al., 2011), both internally and externally towards other supply chain members (Bernon et al., 2011). Of particular importance for such a cost efficiency, Skinner et al. (2008) and Fleischmann et al. (2004) point out the sorting process in which the returned goods are graded and decided upon what to do with it (e.g. whether it should be scrapped, re-manufactured, or sold elsewhere). Without proper capabilities, processes and management of this critical decision point, reverse logistics flow may become a financial burden (Skinner et al., 2008).

The value appropriation process
As a reverse supply chain incorporate a number of individual organisations that together create value, the question of value appropriation, sometimes referred to as value capture, becomes essential. In order to have a stable, long term reverse supply chain, all involved organisations need to have a value surplus, but the size of the shares could be different. Decisive for how value is appropriated among supply chain members, is the bargaining power distribution among these (Cox, 1999; Bowman & Ambrosini, 2000). As

argued by Bowman & Ambrosini (2000, p. 10), "the carving up of exchange value captured from customers is purely a function of the perceived bargaining relationship between the resource supplier and resource buyer". Essentially the more power a supply chain member has relative the other member(s), the more of the total value could be appropriated by this supply chain member (Cox, 1999; Bowman & Ambrosini, 2000).

As a basis for a strong bargaining power position, Cox (1999) as well as Mizik & Jacobsen, 1999) suggest that the company needs to have some kind of "isolation mechanisms" in order to protect the value created (e.g. through an innovation) to instantly be distributed to other companies. Companies need to be able to "protect" their value created and appropriate it themselves (Mizik & Jacobsen, 2003). Important isolation mechanisms that can help a company to appropriate value, and built upon a power position, is for instance information asymmetry that may be utilised as a source of power, which in turn results in an advantageous value appropriation. Other important factors discussed are reputation and brand, customer switching costs, and advertising (Mizik & Jacobsen, 2003) and viable substitute products (Bowman & Ambrosini, 2000).

METHODOLOGY

This explorative study is based on 11 interviews conducted mainly during 2015 and 2016 (at Swedish retailers, Swedish and Norwegian charity organisations, a German profit-making recycler, and Indian specialised sorting companies). In addition to interviews, observations through visits, documents and other written reports form the basis for the findings in this study. All case companies included in the study are not directly connected to each other, but represents well the different stages in the supply chain and involved types of companies in the industry. Hence the empirical data presented in this study should be considered as a case study at an entire industry, rather than a unique, single supply chain (in which all case companies are connected through direct business relationships).

In this working paper, the analysis is based on the identification and description of the two fundamental processes of value creation and appropriation among supply chain members in the reverse clothing supply chain. The structure of the analysis, which follows in the next chapter, has been to investigate value creation and appropriation separately in the four types of supply chain members retailers, charity organisations, profit-making recyclers, and specialised sorting companies.

FINDINGS

An overview of the reverse clothing supply chain is shown in Figure 1:
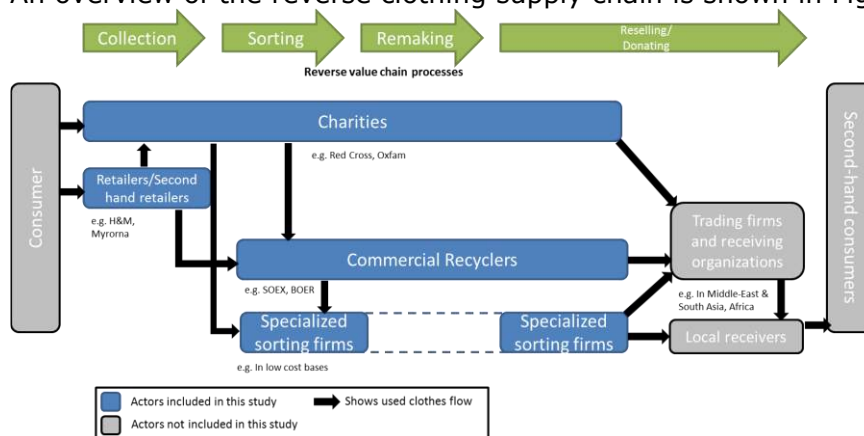
Figure 1: An overview of the reverse clothing supply chain

Retailers

Retailers are creating use value for brokers and charity organisations in the form of collecting used clothes (take back schemes) either by themselves or by helping charity organisations or other profit-making recycling partners to collect clothes in e.g. their stores and providing them with used clothes (and occasionally also new clothes that goes to charity organisations). In particular new clothes followed by high quality high-fashion branded clothes are given higher use value for the recyclers as well as the charity organisations. Interestingly the retailers are also creating use value for themselves in the form of image towards end customers. Decreasing environmental damage of the products and engagement in campaigns concerning e.g. take back schemes is expected to improve their image and an extended producer responsibility is slowly becoming a source for competitive advantage for the fashion retailers. Hand in hand with this also goes increased use value for the customers, indirectly created in the form of customer satisfaction that they buy and wear clothes produced by an environmentally friendly, responsible company. This value is expected to increase in the future, along with increased customer awareness of the need for environmentally friendly processes.

In terms of exchange value, our study shows that there are situations where the retailers gets paid for the clothes (often price per kilo) as well as situations when the retailers pays or take extra costs for the collection of clothes, for instance by providing the customers with a voucher when handing in used clothes and taking care of the transportations of the used clothes. In strict monetary terms the retailers normally strives for a zero-sum game: when the costs are too high, they tend to negotiate that involved costs should be taken by the receiving organisations (i.e. the charity organisations or recycling companies). On the other hand, the retailers are not engaged in take back schemes due to making monetary gains, and if the retailer makes profit, the surplus is normally given to charity organisations or other social activities. Major reason for this is to avoid being suspected to being engaged in take back schemes for profit making reasons. Instead, the major driving force behind the engagement is improved environmental and social responsibility image. Value captured for the retailers is hence made by advertising and improving their image on being a environmentally responsible company. This could typically be made by collection campaigns and other undertakings such as share of recycled material in new clothes.

Charity organisations
Important partners for many retailers involved in take back schemes are charity organisations of different kinds. In common for these companies is their interest in being involved in the reverse clothing supply chain as a means to make monetary profit that can be used mainly for charity activities, but also be able to directly provide clothes to developing countries and other people in need in their respective home countries. Activities conducted vary between different charity organisations, but spans normally from collection (sometimes in collaboration with retailers), sorting, remanufacturing, sales of clothes to consumers but also (both sorted and unsorted) to other recycling companies and sorting companies, and distribution of clothes to people in need (in the domestic market as well as development countries).

Through the general processes of collecting used clothes and sorting collected clothes, three different types of use value is created for three types of customers; (1) "high-street fashion customers" that are looking for unique, personal products, typically branded, vintage clothes of high quality, (2) second hand customers aiming at low price clothing with an environmentally friendly attitude as an extra bonus-value, and (3) poor people in either development countries and/or domestic receivers that are in direct functional need of the clothes provided by the organisations.

Considering the charity organisations' value appropriation, they are experiencing an increased competition in the reverse clothing supply chain both concerning getting people to donate clothes to them as well as sales in their stores. For instance, the organisations witness about increased advertising efforts to attract consumers. Value appropriation is

for these charity organisations mainly achieved by cost efficient, smooth collection and sorting processes. In particular efficient sorting process are indicated as key for efficient handling. The Swedish and Norwegian charity organisations included in this study have also put a lot of effort in education of their sorting personnel in terms of quality and fashion trends as a means to improve their outcome of the sorting process. This is for instance done in collaboration with the Swedish fashion council. In times of more competition, both by other charity organisation but also professional, profit-making, international recycling companies, the charity organisations have also had to develop themselves rapidly in recent years. New customer types such as the high street customers has been targeted by special vintage shops with high-quality clothes, sometimes remanufactured and repaired by the charity organisations. This type of customers is less price sensitive and value appropriation is here more easily achieved for the charity organisations.

Profit-making recycling companies
Except for charity organisation, there are also a number of larger, international brokers and recycling companies on the market who works in close partnership with the retailers. Through partnership collaboration, these companies offer the retailers to take a life-cycle perspective on their businesses and involvement in responsible recycling processes, which is becoming increasingly important for many retailers. Their overall task in the supply chain could be considered to be the matching of supply from retailers with demand from a wide range of other international players such as specialised sorting companies (discussed here below) and producers in need of recycled material. As a basis for this matching process, and the creation of use value, is grounded in above all (1) knowledge and relationship building with retailers, and (2) efficient sorting of collected clothes into all levels of the waste hierarchy, and (3) contacts and ability to merge clothes and ship containers to suitable sorting companies, producers and other customers.

As "match-makers" between supply and demand, these companies hence create value both partners on both sides in the supply chain. Towards sorting companies and producers, as well as towards retailers, the recycling companies major advantage in order to capture value, is information asymmetry. Towards sorting companies and producers, knowledge and ability on providing their customers with suitable sorted material, is considered to justify their presence in the supply chain. Towards retailers, the recycling companies are often able to offer a more complete offering and partnership compared to charity organisations. In terms of value appropriation, the importance for retailers to be involved in large-scale recycling business is increasing, and the offer from the recycling companies is therefore becoming more valuable. This has during the last years strengthened the negotiation position of the recycling companies (vis-à-vis the retailers). Thus, increased consumer expectations on the retailers' engagement in recycling activities reinforce the recycling companies' ability to appropriate value.

Specialised sorting companies
Another important commercially oriented member of the reverse clothing supply chain is specialised sorting companies. Such companies are to be found in many locations around the world, in particular in regions with relatively low wages, as the sorting procedures are often accomplished manually. The Indian sorting companies investigated in this study, are typically creating use value based on (1) appropriate, cost efficient sorting activities of used clothes, and (2) the purchase of high quality of the unsorted clothes in order to maximise the share of clothes that can be sold at the second hand market. These two parameters are together decisive for the amount of use value that is created for the customers. The higher use value created by the Indian sorting companies, the higher exchange values can be achieved, which in turn improves the monetary profit making of the sorting companies.

In line with these two parameters, the Indian sorting companies are having transaction-based relationships with suppliers as well as customers. Considering their supplier relationships an interesting paradox in terms of value creation emerges. On the one hand, in order to get directly access to collected clothes to better price, Indian sorting companies want to exclude intermediaries between retailers and themselves, e.g. commercial, larger recycling companies that function as brokers. Interviews show that the relatively small Indian companies from time to time have done this, i.e. initiated direct relationships with larger retailers in e.g. US and Canada. On the other hand, such direct relationships are costly to initiate and uphold, and the brokers' contacts and wide range of offering when it comes to used clothes (in terms of e.g. different quality and raw material) will be hard to replace. Thus, monetary value in terms of lower purchasing price (in case of direct purchasing from retailer) must be balanced against the advantages that follow from the use of a broker. Indeed a broker can create high use value for the Indian sorting companies through access to complementary assets – in our case mainly knowledge and contacts with retailers.

The Indian sorting companies' transaction-based relationships means that they appropriate value mainly through fierce price negotiation with the suppliers (e.g. commercial recyclers) as well as customers. The price is in turn a product of bargaining power of involved supply chain members. Except for economic supply and demand mechanisms, which can vary over time in this industry, the value appropriation is also determined by the fact that the Indian sorting companies must have a specific license for the trading with second hand clothes and are only allowed to operate in certain economic zones. The objective of these licenses is to control trading with foreign clothes and protect domestic production (Brooks, 2013). At the moment 14 companies holds such a license. The licenses partly outmanoeuvres the economic supply and demand mechanisms and could at least potentially in case of strong demand, be utilised by the Indian sorting companies as a weapon to appropriate more value.

ANALYSIS AND CONCLUSIONS

By the application of the two processes of value creation and appropriation, in the same research, this study offers a new theoretical lens through which a more complete picture of the reverse clothing supply chain can be gained. The value concept has so far been discussed at a superficial level in research on reverse logistics, and this research demonstrates that the value concept helps to understand the rationale behind a certain supply chain structure in terms of participating supply chain members, types of activities conducted, and division of responsibility. By focusing on the value creation processes, and the type of use value each supply chain member creates, and the tools available for value appropriation among the supply chain members, an improved understanding of the reverse clothing supply chain and its members has been gained.

In recent years, reverse logistics practices have increasingly been related to value creation in the supply chain, and end customer satisfaction (Skinner et al., 2008; Fleischmann et al., 2004; Jayaraman & Luo, 2007). Indeed, "a firm's ability to organize, coordinate, monitor, and execute advanced and complicated reverse logistics" (Jayaraman & Luo, 2007, p. 67) may constitute a strategic, distinctive capability. The results from this study supports this view. However, the results also emphasise the need for interaction among different supply chain members as a means to enhance competitive advantage and customer satisfaction.

Considering the value creation processes involved in the reverse clothing supply chain, the sorting and grading activities are of fundamental importance. During these processes the latent use value included in waste clothes are illuminated and regained. Our findings demonstrate that there are above all two major types of value created. First, thanks to

sorting, grading and the subsequent processes of sales and reuse (which may not be handled by the retailers themselves or even the direct supply chain partner) retailers are able to achieve improved brand image among consumers. Thus the major incitement for retailers to be involved in take bake schemes and provide clothes to the charity organisations are mainly related to improved brand image and trust from consumers. The other major use value created in the reverse supply chain is monetary profit, which is above all the major incitement for international commercial recyclers and sorting companies to be involved in the reverse clothing supply chain. Also this type of value is dependent upon the sorting and grading activities. In particular, efficiency in these processes are highlighted among sorting companies (commercial recyclers as well as charity organisations and specialised sorters).

In terms of value appropriation, it is clear from this study that the different members of the supply chain captures different types of value. As a result of the supply chain members' different interests, relatively little bargaining as is normally suggested by value literature is seen. Instead, some of the relationships can be described as collaborative and based on a win-win thinking. One such example is the relationship between retailers and charity organisations. In these cases the retailers appropriate value in the form of goodwill and image towards the customers, whereas the charity organisations secures clothes and economic benefits for their charity operations. However, there are also relationships in the supply chain where both members are focused on direct monetary profit making, e.g. the commercial recycling companies and the more specialised sorting companies, in our case study situated in India. Here bargaining and price negotiation is the main tool for value appropriation.

Another interesting implication for practitioners and society in general is the relatively great share of commercial interests involved in the reverse clothing supply chains.
Interviewees witness about the relatively poor knowledge and understanding of the business mechanisms and the structure of the entire reverse clothing supply chain, including the end consumers and donators of clothes. Similar findings were also found in a British study on the international second-hand clothing trade (Brooks, 2013). The image and reputation of the entire reverse clothing supply chain as a pure charity and sustainability project could be fuelled by retailers eager for improved image and charity organisations as a means for them to secure future access to donated clothes. In reality, as our study and the study conducted by Brooks (2013) clearly demonstrate, the reverse clothing supply chain is to a large extent commercialised. Here for instance global commercial recyclers with their main objective of financial profit making have been investigated in this study. Another important group of supply chain members not investigated in our study, but in Brooks' (2013) study, are profit making retailers in developing countries receiving second hand clothes. Brooks (2013) concludes from his study that an overwhelmingly amount of the collected clothes by charity organisations in developed countries are retailed for profit by local players in the developing countries.

In a discussion of value creation (and appropriation) it is important to consider not only value creation for customers as is often in focus when explaining the foundations of the value concept (Lepak et al., 2007; Brandenburger & Stuart, 1996). Lepak et al. (2007) claim that a widened "stakeholder perspective" should be taken in order to fully understand values created. This research has incorporated a large share of the supply chain members of the entire reverse clothing supply chain, and as a result value creation and appropriation processes among several supply chain members have been explored. However, several stakeholders have been outside the scope of this study (such as customers and retailers in receiving companies in developing countries, and the donators (consumers) in the developed countries. More research is needed in which the perspectives of these different stakeholders are included.

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CREATING VALUE THROUGH REVERSE LOGISTICS IN A MULTI-ECHELON USED CLOTHING CHAIN

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Abstract

Purpose of this paper:
Reverse logistics (RL) in retail value chains is an increasingly emerging phenomenon yet under-explored in research (Bernon et al., 2011). The literature becomes shallower while discussing the "process" of value creation in such context. Given the inherent complexity and differentiated value creation in many RL networks (Schenkel et al., 2015), e.g. in used clothing, such values are constituted by different actors by prioritizing and committing their strategic resources for developing distinct rent-earning competencies.
In this context, the purpose of this paper is to explore how differential value is created by firms embedded in a multi-echelon reverse value chain for used clothing, by successfully exploiting multi-level (intra- and inter- firm) resources, via various underlying rent-earning mechanisms.

Design/methodology/approach:
An explorative case study approach is adopted in reverse clothing value chain context to investigate the take-back scheme that includes multiple actor types and also spans globally. An abductive research process is adopted along two stages; Stage 1 (proposes a new theoretical framework on "how" value is created in reverse value chains based on resource-based (RB) and relational rent-earning views to exploit various RL attributes or capabilities) and Stage 2 (seeks real-life case observations to explore the empirical reality), and finally systematically combining these knowledge.
Data is collected through semi-structured interviews, observation and documented notes and reports, conducted with various actors, viz. retailers, social enterprises (charities and non-profit retailers), commercial brokers/sorters, and specialized sorting firms from India.

Findings:
Differentiated values are created by the actors involved with multi-echelon take-back network. The RB and relational theories underpin the rent-earning mechanisms further highlighting several key ways to sustain this value.
The VRIO model in the RB theory (Barney and Clark, 2007) shows how value is created *within* firm boundaries. The relational view highlights four rent-earning mechanisms: relational asset specificity and information sharing for the success of cost-neutral take-back agreement, along with resource and capability complementarities and trust in the relationship. Together they provide understanding of the entire "process" of rent generation.

Value:

This research contribute to exploring the "process" of rent-earning generated by critical intra- and inter- organizational enablers of value creation in complex RL networks.

Practical implications:
The paper improves the understanding of the key mechanism for value creation for actors working within the used clothing chain.

INTRODUCTION

In recent years, reverse logistics (RL) have gained growing prominence in many industries, vis-à-vis the increasing environmental and sustainability concerns. The clothing industry being one of the world's most resource draining and environmentally stressing industries, thus has received growing attention among both scholars and practitioners in terms of RL and recovery activities aimed at recovering higher value for all stakeholders (Tibben-Lembke & Rogers 2002). This has resulted in increasing post-consumer initiatives undertaken by various actors, by focussing on RL, through adoption of mainly two strategies, viz. product take-backs and resell/reuse and thus capture resell value . Amidst this growing strategic importance of take-back and reuse schemes, underlying RL activities are increasingly related to value creation (Jack, Powers & Skinner 2010, Skinner, Bryant & Richey 2008), and firms have strived towards using RL for constituting strategic, distinctive capability (Jayaraman & Luo 2007).

Despite this growing need and practice of RL, and its role to generate value (Jayaraman & Luo 2007), the research is still limited as the existing literature on manifestation of value creation in reverse value chains is very scattered and lacks a holistic industry-wide view covering major value types (Schenkel, Caniëls, Krikke & van der Laanc 2015a, Bernon, Rossi & Cullen 2011). Hence the rewards and advantages from efficient RL still remains to be exploited fully in terms of value creation (beyond only economic value) in many sectors (Skinner, Bryant & Richey 2008, Bernon, Rossi & Cullen 2011), as in the case of used clothing underpinned by its inherent complexities in a multi-echelon, consisting of diverse actors types: retailers, charities, commercial sorters, brokers, recyclers, specialized processing firms, etc., each with different set of resources, opportunistic behaviour and endeavour for value creation and benefits. Further the relationship between these actors are not always straight-forward as in buyer-seller.

In studying RL, the resource-based view (RBV) of firms provides a helpful lens for examining the impact and commitment of specific firm resources (e.g. IT, facilities), on the value creation and performance (Jayaraman & Luo 2007). Such values are constituted and captured by different actors by prioritizing and committing their strategic resources as highlighted by Jayaraman and Luo (2007). Given the inherent complexity and differentiated value creation in such RL networks, e.g. in used clothing as mentioned above, this has received little attention, however is essential for developing distinct rent-earning competencies. Only recently Schenkel, Krikke, Caniëls and van der Laan (2015b) have studied the aspect of integral value creation in closed loops through the role of internal and external stakeholders, but only from the focal firm's perspective. Additionally, in such complex RL networks, value creation and the distinct competencies underlying them leverage not only on firm's individual resources, but equally on shared and complementary resources of its network alliances. However, as highlighted by Morgan, Richey Jr and Autry (2016) "it still remains unclear as to how firms might manage, create, and deploy such competencies across the multi-organizational supply chain." The recent development of RBV into relational view theory of interconnected networks has so far been given little attention in RL literature, even though the role of relationship and collaboration is highlighted in some occasions, the literature does not provide a comprehensive view of how it is linked to value creation in this context.

In this context, the purpose of this paper is to explore how differential value is created by firms embedded in a multi-echelon reverse value chain for used clothing, by successfully exploiting multi-level (intra- and inter- firm) resources, via various underlying rent-earning mechanisms.

METHODOLOGY

An explorative case study approach (Yin 2009) is adopted in reverse clothing value chain context to investigate the take-back scheme for used clothes that spans over multiple actor types and also spatially. The case of take-back chain has been chosen theoretically, meaning that it provides a ground to replicate or extend a theory (Eisenhardt 1989), related to value creation in reverse value chains. The case can be termed as extreme in nature because such a used clothing networks include: (i) multiple actor types (profit-making and non-profit, large multi-nationals and small firms), (ii) globally stretched over

many continents, (iii) influenced by differential external factors, e.g. legislations, (iv) involves different relationships (buyer-seller, donations), and principally (v) types of value created, hence beneficial for exploring relationships and logics essential for theory emergence.

An abductive research process in line with Kovács and Spens (2005) is adopted here, aimed at generating "new" knowledge along two stages; Stage 1 (proposes a new theoretical framework on "how" value is created in reverse value chains based on resource-based and relational rent-earning mechanisms to exploit various RL attributes or capabilities) and Stage 2 (seeks real-life case observations to explore the empirical reality), and finally systematically combining these knowledge. Prior theoretical knowledge with regards to RL design attributes and value creation types (Schenkel et al. 2015a) serves as the basis for constructing the interview questions and guide the observations made, for exploring the value creation aspect along the case study context. The Stage 3 (theory testing and validation) is beyond the scope of this paper.

Data was primarily collected through 14 semi-structured interviews (4 with retailers, 4 with social enterprises (charities and non-profit retailers), 2 with commercial brokers/sorters, and 4 with specialized sorting firms from India), focusing on the firms' RL activities, strategies and business logic, value types, competitive advantages, and partner relationships. This consisted of ~6 hours of recorded and transcribed interviews. The questions were devised in such a way that they can capture pieces of information on the phenomenon, which was then reconstructed by the researchers in a grid of analysis in accordance to the RBV and relational view theories. In addition, multiple site observations were made (through visit to the sorting and storage facilities of the charities, 2nd hand retailers, commercial sorters and the sorting firms), email follow-ups and consulting documented reports (8 field notes and informal interviews) to get complementary data. Communication activities via websites and other media coverages were retrieved where necessary.

TOWARDS A PROCESS FRAMEWORK FOR VALUE CREATION THROUGH RL

The Value concept in RL

Traditionally, it has been established that efficient RL is essential for reducing total supply chain costs (Bernon, Rossi & Cullen 2011), and that RL contributes to customer satisfaction and increased customer value (Jack, Powers & Skinner 2010, Skinner, Bryant & Richey 2008). However, the values created are multifaceted and goes beyond just lower costs and improved services; for instance it can also enable better corporate image (through philanthropy and goodwill) that can be used by companies for improving relationship with the customers or suppliers and also market share (Jayaraman & Luo 2007). Further such reverse value chains are inherently environment-friendly, and have proven to be profitable, with clear environmental motivation in terms of higher resource efficiency and at the same time reduced costs of waste disposal, considering that recovery is often cheaper than building or buying new virgin materials. Thus in line with the above discussion, five major categories of value creation are identified in accordance to Jayaraman and Luo (2007) and more recently Schenkel et al. (2015a). These are economic value, information value, customer value, environmental value and image value.

Intra- and inter- organizational enablers of value creation in RL

In RL context, several intra-organizational enablers of value creation have been highlighted in previous research. Key among them are strategic acquisition of 'waste', multiple collection channel and sales structures, and clear post-retail communication strategies. Strategic and consistent acquisition results in collection of the best quality with low variability thus ensuring better bargaining power for the collector (economic value), also ensuring higher product reusability and long relationship with actors downstream (customer value) (Schenkel et al. 2015b). In many reverse value chains, while economic and customer values can stand alone, environmental and social values are almost exclusively created in win-win situations; however whether recovery of

'waste' always create environmental values or whether actors are able to create value for the larger stakeholders such as societies and non-governmental organizations, is unclear and requires deeper studies (Schenkel et al. 2015b). Along the chain, key knowledge and process capabilities related to disposition and grading is also highlighted as a major value creating attribute (Fleischmann & Kuik 2003). Another important attribute ensuring quality flow of products into the RL chain is multiple collection channels and to support it clear communication with the "donors" to generate a lot of public and media attention towards the actions and activities undertaken (image value) thus ensuring better customer orientation (Skinner, Bryant & Richey 2008).

Key inter-organizational enablers, on the other hand, are mainly related to collaboration for undertaking reverse value chain activities and training (Bernon, Rossi & Cullen 2011). Outsourcing various RL operations results in particularly gaining higher efficiency and skilled knowledge, essential in reducing costs (economic value) and also create learning (information value) (Fleischmann & Kuik 2003). Several forms of collaborative relationships can be noticed in reverse value chains, e.g. supplier relationship management aimed at lowering supplier opportunity costs, while other coordinating mechanisms through information sharing and joint decision-making ensures higher transparency, interaction and hence efficient RL (Jayaraman & Luo 2007, Bernon, Rossi & Cullen 2011). In this context trust and commitment is a must. Further workplace training predominantly in collaboration with various organizations, like governments and municipalities generate learning and process know-how (information value) and environmental value.

However, as argued above, the RL research is limited in underpinning these key success enablers or attributes to specific rent-earning mechanisms, which is essential in generating the value competitively and sustainably. To illuminate this gap it can be compared to while these enablers represent the "structure" that is interesting in terms of how actors involved perceive them, and how and why they act upon these aspects to create value; the literature lacks in capturing and explaining the "process" of how these enablers lead to sustained value creation.

Resource-based and Relational views towards value creation in RL

From strategic management perspective, value creation relies on critical bundles of resources, and can develop and span both inside and outside firm's boundaries (Dyer & Singh 1998, Barney & Clark 2007, Barney 1991). The Resource-based View (RBV), suggests how heterogeneous resources (both tangible resources – physical, financial, technological, and intangible resources – know-how, reputation, talent) bundled as valuable, rare and difficult to imitate capabilities *within* a firm creates superior rents, hence sustainable competitive advantage (Barney 1991, Barney & Clark 2007). Such V(aluable), R(are), I(mperfectly imitable) and O(rganized) view of intra-firm resources generates the mechanism of developing Ricardian rent, and have been widely studied in logistics and supply chain management contexts, and more recently in RL (Jayaraman & Luo 2007), but mainly to illustrate the resource commitment in the "structure" of RL capabilities leading to better performance. Consistent with the RBV, this recognizes higher resource commitment, along various RL activities, e.g. disposition (Skinner, Bryant & Richey 2008) or retailer's return (Jack, Powers & Skinner 2010) or wider RL programs, however most literature relate this only to economic performance outcomes (cost, responsiveness and quality). However, it can be concluded that even though RBV has been used in RL research to underpin resource commitment, the discussion still lacks a perspective of their inherent rent-earning mechanisms.

Additionally, as an extension of the RBV, it has been argued that value is not only a result of Ricardian or quasi rents but may be generated through the transactions and exchanges with network partners (Dyer & Singh 1998, Lavie 2006). Determinants of such relational rents in an inter-organizational context are based upon: (i) creating relation-specific physical and human assets, (ii) sharing of knowledge and information to create sufficient inter-organizational learning, (iii) complementary resource endowments, and (iv) effective governance through goodwill and trust to reduce transaction costs (Dyer & Singh 1998, Zaheer, Gözubuyuk & Milanov 2010, Touboulic & Walker 2015). In line,

Lavie (2006), highlights three fundamental mechanisms for a firm to leverage resources for value creation in alliances; (1) access to complementary assets and resources, (2) new resource combinations, and (3) indirect benefit making of the partner's resources and enrichment of own firm's resources, e.g. in the form of legitimacy.

In line with the above discussion, Figure 1 depicts the proposed framework, from a process-based perspective.
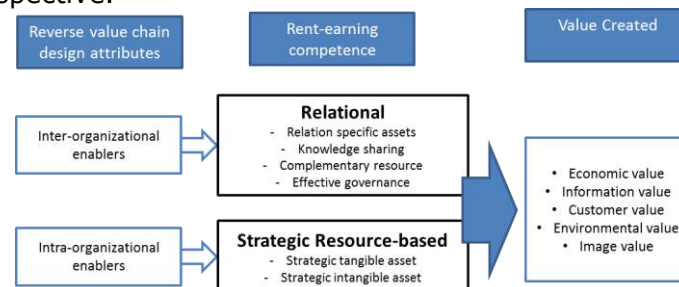
Figure 1. Proposed framework for value creation in reverse value chain

CASE FINDINGS: VALUE CREATION THROUGH RL IN USED CLOTHING NETWORK

Differentiated value creation and its enablers

A multi-echelon for used clothing involve multiple actors and their relational alliances along different RL activities and is shown in Figure 2.
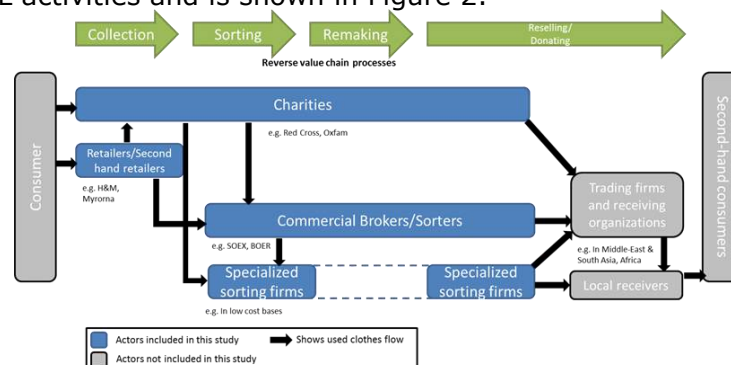
Figure 2. A multi-echelon used clothing chain

The retailers are predominantly involved in the used clothing network by organizing the take-back through their stores, with or without collaboration with for-profit partners or non-profit charities, who takes the used clothes to the next RL activities beyond collection. The used clothes are not owned by the retailers and in most cases, if the in-store collection is by branded retailers, the clothes are despatched first to a country-level warehouse (of the sorter) via the same 3PL used for incoming goods delivery, before being transported to a consolidated sorting facility. Collaborative agreement with commercial sorter/broker results in retailers earning per volume of collection, while all costs are borne by them. To reduce cost, as one of the retailers reported:

"After collection these are delivered by the same 3PL as we use for incoming delivery of goods. This improves cost efficiency." **(1)**

The agreement follows cost-neutrality (for the retailer), meaning that the commercial sorter bears the excess cost, while in case of surplus the money is mostly donated for charitable and social activities. Unlike the contrasting collection system by charities and second-hand retailers, one of the retailers explicitly indicated:

"[…] we have always communicated to be commercial in collaboration […] unlike the donation model. (It is the) commercial attitude what we like." **(2)**

On one hand this highlights the interest of the retailers in engaging with profit-making take-back arrangement, but also increasingly show their vouch on environmental and social responsibilities, thus improving the image (in terms of corporate citizenship and brand) thus gaining customers' trust towards retailer's extended responsibility. Tagging along with the commercial players also contribute to this extended responsibility image

by gaining higher information transparency (about the fate of these used clothes). On the other hand, customer relationship also plays a crucial role for the collectors as one of the retailer reported:

"[…] we get feedback through web & shops, like environmental idea, it is practical and informs of consumer attitude. […] this is important as it is not easy to "say" the customers". **(3)**

Further environmental value is also generated by initiating the process of "from waste to value" (along the EU waste hierarchy). However, the issuance of discount vouchers to consumers giving back used clothes could create a rebound-effect (triggering new purchases thus reducing the environmental value) but in contrast generate more economic value.

Charities (in collaboration with some second-hand retailers), on a different note, convey their engagement in used-clothing networks to be purely non-profit making, even though they are directly engaged with selling a large portion of the collected clothes (of highest quality) through their own stores or selling them to commercial sorters/brokers, to finance other charitable and RL activities. Activities conducted vary between different charities, but can span over collection, sorting, repairing, and sales of clothes to both consumers and to commercial sorters and recyclers globally. Crucial in this context, is the wide collection network (via own stores, partner collections, kerb-side containers etc.) and communication via media about different events to make it easier for people to donate clothes. In addition, competence related to quick sorting (with minimum handling) and best pricing is also essential in an attempt to reduce operating costs. As said:

"We are always testing different ways (colour maps, standard price segments, categories). How to do more effectively, better, economically? […] We think a lot is about the knowledge. We want special employees be able to stand in many different stations. It comes out to spread knowledge so everyone can work pretty much at all station." **(4)**

At another point it was said:

"[…] there are a lot of second-hand shops in Sweden, many small companies or NGOs who do not know how to set the price. We always say that we have great set up, so we know how much to price." **(5)**

In an attempt to reduce operations costs, however they sometimes partner with both large retailers and global sorters. One can always argue that charities being the largest collector of used clothes generate a lot of impact through their take-back engagement vouching on their social image. However, interview with one of the retailers, suggested that agreements with commercial brokers/sorters are much more transparent for them, as put:

"We know via [commercial firm] where the collected clothes are destined. Also (they) communicate what it is doing." **(6)**

Apart from the social enterprises, there are a number of large international sorters and brokers, dominating the sorting, grading and disposition activities in the network, but commercially. Being commercially oriented, profit making to generate economic value is a major requirement for these firms. As an intermediary between the retailers (collectors) and many international players (e.g. international sorting firms, traders and other receiving organizations) in the multi-echelon network, these firms are able to create economic value, on one end by gaining access to large volume of used clothes via partnership with retailers (or sometimes by collecting themselves) while on the other side provide traders and recyclers with suitable sorted materials. Their position in the network at the middle of the chain provides them with complete knowledge of the processes and information related to product market and location. Key to this economic profit generation is their knowledge of sorting, upheld by automatized system to handle large volume of diverse items. As put forward:

"We have a lean way to work with a big volume. We can categorize items more systematically […]. This way we can be more efficient on the sorting job (faster). Also we are training (them). We have special people who go to the sorting plant and educates on how to be faster and efficient to reduce cost. This creates praxis." **(7)**

Finally at the end stream of the multi-echelon take-back network are the "specialized" sorting firms in the low cost bases, like India, which buy the used clothes from the global brokers and sorters, further sort them and sell them either in developing country markets (e.g. Africa) to local trading firms and receivers, for reuse, or sell them to

recyclers. Some of these firms, are highly specialized not only in the sorting capabilities, through access to highly experienced sorters, but also develop skills to mutilate the clothes and develop recycled yarns, thus fetching them 12-15 times higher price. In order to maximize economic profits these sorters develop trusted relationship with the suppliers/brokers:

"We pay for good quality of garment but some time supplier give us low quality mix rags. […] if we will not maintain good relationship then how can we get good value products? […] if we need high quality material then need to speak broker or visit the company, […] now we have relationship with 2-3 suppliers who deliver on a regular basis." **(8)**

However, governmental legislations in these countries have restricted the number of firms that can enter this sector, by issuing few licenses, further, the licensed firms are not allowed to sell the used clothes in the local market instead export them out totally.

ANALYSIS AND DISCUSSION

The above discussion generates two comparing and complementary perspectives toward the differentiated value creation in used clothing networks, based on resource-based and relational views, which is a result of a unique combination of available resources and capabilities, to generate distinct rents.

Resource-based view towards differentiated value creation

From a RB perspective, different sets of VRIO resources and capabilities were spotted in the involved actors.

Source of unique rent generation for the collectors could be perceived in the running of a simple, innovative and convenient in-store collection system, where the everyday consumers in their daily shopping routine can get involved. This has yielded higher collection volumes hence economic value supported by integrated return logistics which has improved cost efficiency of the system *(Valuable)*. Collaborative installation of such a system is essential for yielding higher information transparency (value) (Schenkel et al. 2015a), regarding destination of the used clothes. The large retailers have been also at the forefront of communicating this as a showcase of responsibility in the textile-fashion industry *(Valuable)*. Even though these take-back schemes are based upon cost-neutral agreements for the retailers, which largely depends on trust generated in them among the global sorters due to their leading role in industry's sustainability campaigns *(Rarity)*, it still requires cost-intensive communication efforts to establish a trusted consumer relation (customer value) which is necessary to generate feedback (3), as also highlighted in Jayaraman and Luo (2007), hence proving its *imperfect imitability*. Many retailers who have failed to secure this have not been able to generate large volumes. Further, the take-back scheme has created value beyond economic value for the retailers; successful retailers have been able to connect it to their *organized* social activities and communicate via CSR reports generating good image (Jayaraman & Luo 2007).

The rent-earning mechanism in the social enterprises has a strong foundation in their vertically integrated structure (Barney & Clark 2007), due to their solitary long history of working with used clothes. This is acquired from VRIO capabilities created through (i) extensive collection and reselling networks, and (ii) sorting operational capability and knowledge (4). Developing an easy but extensive multi-channel collection system (including both traditional and innovative ways to reach out to consumers), has generated value in many ways. In connection, campaigns conducted by charities via public events generate significant impact in influencing consumer attitudes towards used clothes (customer value), through education and inspiration, possible only because of their social enterprise model (*rarity*), compared to other actors. These front-end RL activities are supported by back-end sorting process efficiency enhanced by quick, automatized systems to minimize handling (7) and *(Valuable and Rare)* process knowhow required to improve productivity (4). This is largely based upon the knowledge and skills of the experienced sorters (5), which *cannot be imitated* causally and is a result of many years of practical training and consolidated programs, essential to generate high quality (economic value). Further latest use of technologies, e.g. scanners in the store for product tracking has added to the economic profits *(Valuable)*, however, the success of

such systems largely depend upon the knowhow of consolidated product categories, right pricing, dynamic SKU variants, created via years of experience *(Rare and imperfectly imitable).* The commercial sorters and brokers, similarly value their sorting capabilities and knowhow (7) as a VRIO resource thus earning profits (economic value). Further their position as a 'middleman' provides them sufficient knowledge on the whereabouts of the clothes in such a globally dispersed network, ensuring higher traceability (information value), which is valued by both the retail partners and end consumers (creating image and customer value).

Downstream in the used clothing network, rent-earning for the specialized sorting firms in low cost bases largely depend upon their specialization in the sorting process capability, rendering sufficient (economic) value *(Valuable)*, and developed through experienced workforce *(ensuring rarity and imperfectly imitability)*. *Rarity* is an outcome of long history associated with sometimes two generations of family business, functioning efficiently with an *organized* management structure. Such long term association has generated enough knowhow and profits to some of the larger ones who have eventually reorganized their structure by undertaking more value-adding RL activities (e.g. mechanical recycling). Further the owners of these firms are well connected with the suppliers which they value by establishing good communicative relation through personal contacts (8), ensuring *rarity* and *imperfectly imitability* of the product information (value), which in turn leads to high quality material access (economic value). However, in this context, many adjudged that the monopolistic rent created through limited licenses issued by the government along with some other locational advantages is most crucial to sustain resource-based rent generation.

Relational-view towards differentiated value creation
Various dyadic relational rent earning mechanisms can be spotted along the network by sharing/complementing and exploiting the RL capabilities and resources possessed by the actors.

Relational asset specificity through take-back agreement
Asset specificity induced through the take-back agreement plays a significant role in creating value in the retailer-sorter dyad. Such take-back agreements, in majority, are cost-neutral for the retailers which provide a large incentive to join. This generates a safeguarding mechanism for the retailers from making any economic loss. Further, this creates opportunity for the retailers to make higher profits while on the other hand higher collection volume urges the sorters to make investments in enhancing their sorting capabilities and efficiency (7) for supporting the high inflow. This clearly demonstrates the need to attain economies of scale to sustain such relationships (Dyer & Singh 1998). In turn, this incentivizes the retailers to upscale their take-back schemes in more store locations (economic value) and invest more into communication with consumers (consumer value) which can further be deployed for social activities (increasing image value).

Resource and capability complementarities
Complementarity of resources and capabilities play a key role in developing relational rents in dyads involving retailers and charities. In such relational dyads, goodwill image and environmental (values) attract the retailers in collaboration; relational rent created surpasses the image value and economic profits that would otherwise be created without this intangible complementary asset. Generally the in-store collection are better in quality of used clothes hence providing the opportunity to the charities in receiving good collection, which is further appropriated through economic rent generation.

Another way of leveraging on complementary skills and expertise can be observed between the charities and commercial brokers, in an attempt to reduce cost. Even though many charities run RL activities all by themselves, outsourcing activities, e.g. logistics increasingly provides them with access to complementary capabilities running large collection and distribution networks with the support of global logistics services of

the sorting companies, thus enhancing the operational performance (Bernon, Rossi & Cullen 2011), compared to when charities run them single-handed.

Such complementarities are also crucial to retailer-sorter relationships, in the take-back arrangements. The in-store collection boxes owned by the sorters are installed at retailer's strategic store locations aiming at increasing the collection volume; such complementary resource exchange benefits the sorters from attaining high economies of scale volumes and at the same time generating higher profits for the collecting retail partners.

Information sharing in take-back arrangement
As a part of the take-back agreement, the retailers engaged in a dyadic relationship with commercial sorters are able to achieve higher information transparency (value) regarding where and how the used clothes ends up (compared to if they partner with charities) (2), which when communicated to the consumers earns considerable customer trust (value), which in turn can be perceived as a motivator for higher collection volume. The commercial sorters, on the other hand, are able to benefit from this information-rich position in the network (with a view of both up and down stream actors – collection and destination markets).

Trust in dyads
Trust, as can be seen in multiple dyads, is a consistent determinant of good relation (Touboulic & Walker 2015, Zaheer, Gözubuyuk & Milanov 2010). Mutual trust is crucial for the commitment through the take-back arrangement. While downstream it is a measure of consistent quality of imported items for the specialized sorters (8). The high level of expertise and knowledge of sorting renders the global sorters possession of high quality sorted material, which in turn suffices trust among the sorters (thus reducing their material search costs) (information value). Instead they can reply on a few with whom they have developed long-term relations. However, this results in scope of opportunism taken by the brokers/sorters in increasing the price.

CONCLUDING REMARKS
This research contribute to exploring the "process" of rent-earning generated by critical intra- and inter- organizational enablers of value creation in complex RL networks. First, in line with (Schenkel et al. (2015a), Schenkel et al. (2015b)) our findings show that differentiated values are created by the actors involved with used-clothing chains. Further, it extends the findings of extant research which have by far investigated mostly the "structure" of value creation in RL (i.e. key enablers and resource commitment) (Bernon, Rossi & Cullen 2011, Jack, Powers & Skinner 2010, Skinner, Bryant & Richey 2008) but not the underlying rent-earning mechanism. As a matter of fact, this "process"-based view also reveals that some of the enablers may not be possessing rent-earning ability, hence may not be competitive and sustainable, unless under the influence of other factors, e.g. the role of restricted licenses for specialized sorters in low cost bases.

The RB and relational theories adopted in this research to underpin the rent-earning mechanisms further highlights several key ways to render sustaining value. The VRIO model in the RBV shows how value is created *within* firm boundaries, but this may not be sufficient to understand the entire "process" of rent generation, hence is complemented by a relational view in dyads. The relational view highlights four rent-earning mechanisms: relational asset specificity and information sharing for the success of cost-neutral take-back agreements, along with resource and capability complementarities and trust.

Future research can further investigate how and how much value can be appropriated by these actors. Deeper analysis of the rent-earning mechanisms in RL is also essential to validate the "process". Further, network theory approach can be utilized to study the network-level relations (Zaheer, Gözubuyuk & Milanov 2010), beyond the dyadic relations. Dynamic capabilities approach would also provide a critical lens to understand

of how these organizations can renew their rent-earning competencies over time, essential to combat the growing competition.

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A STUDY OF THE SERVICE QUALITY OF SCIENTIFICALLY PROCESSED CHINESE HERBAL MEDICATION (SPCHM) LOGISTICS: A CASE OF THE LARGEST TAIWANESE LOGISTICS SERVICE PROVIDER FOR SPCHM

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ABSTRACT
Purpose of this paper
This paper aims to investigate the customer demand of Scientifically Processed Chinese Herbal Medicine (SPCHM) logistics and to prioritize strategies to improve service quality.
Design/methodology/approach
A Structural Equation Modelling (SEM) model is used to examine the impact of service quality on customer satisfaction and loyalty for SPCHM logistics service providers. Afterwards, we use the quality function deployment (QFD) to determine the priority of quality improvement strategies according to customer demands.
Findings
The results indicate that service quality has significant impact on customer loyalty. In light of logistics service of SPCHM, customers are concerned about the capabilities of service providers to control the temperature, humidity and prevent access by pests. Moreover, we also discover that the switching barriers in this industry are higher than in other industries.
Research limitations/implications (if applicable)
This study only selects the largest Chinese herbal medicine logistics company as a representative investigation. For future studies, more logistics service providers as respondents are more comprehensive and complete to represent a country or an area.
Practical implications (if applicable)
"maintain existing customers", "shorten the process for dealing with anomalies", "inspecting operating process regularly", "Set up packaging examination mechanism" and "Provide competitive rates to customers" are of high priority to improving the service quality.
What is original/value of paper
QFD has been commonly applied to analyze service quality (e.g. Wang, 2007; Liang et al., 2012), however, we make use of SEM model to verify the relationship between the service quality and customer loyalty first , then conducting QFD analysis. It's unprecedented in the studies of logistics service in Chinese herbal medicine.

INTRODUCTION
Chinese herbs have been used for thousands of years in China and the practice of using Chinese herbal medicine (CHM) has been brought to other countries by immigrants. Although the main purpose of using CHM is to treat diseases, many popular herbals—such as Chinese red wolfberry and Chinese jujube—are also used widely for making teas, soups and other various tonic foods. In Taiwan, most of the raw materials for making CHM are imported from distant places. According to the statistics published by the Custom Administration of Taiwan, there were over 30,000 tonnes of raw materials imported

annually from other countries in the past three years—most of which were imported from China, accounting for up to 80%. CHM imports for the most part are used in two modalities: raw material and patent medicine, of which the supply chains are illustrated in Figure 1. The raw material of Chinese herbals is the traditional modality, in which patients obtain the herbs from clinics or traditional pharmacies. However, as the procedures for boiling the raw materials is complicated and time-consuming, some manufacturers have started to develop a so-called Scientifically Processed Chinese Herbal Medication (SPCHM). Based on exact procedures certificated by the government, raw materials are turned into various tablets, powders and medicinal liquids, which can be consumed conveniently. Meanwhile, the quality of SPCHM is more reliable than the raw materials because impurities and noxious substances have been removed during the production and many advanced techniques have been developed and applied to produce various SPCHM. According to the statistics announced by the Department of Statistics of Taiwan, the annual production value of SPCHM in Taiwan went from 6.7 billion in 2010 to 8.6 billion in 2014, and 80% of the products were sold in the domestic market, with 20% exported to other countries. As a result, SPCHM has become more popular than raw materials, and it has been widely used in clinics and is available in pharmacies.
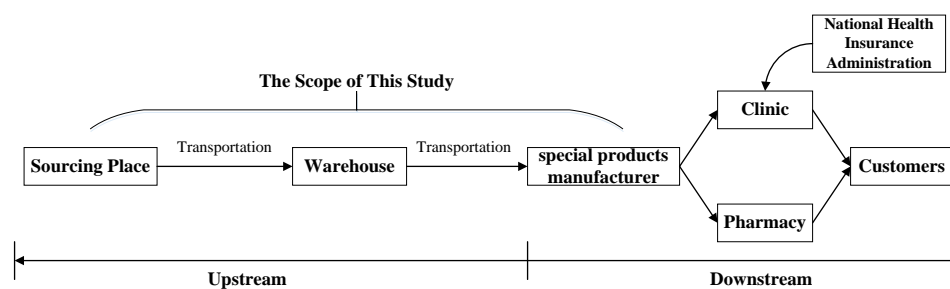
Figure 1. The supply chain of SPCHM

As Figure 1 illustrates, in producing SPCHM, manufacturers must purchase various raw Chinese herbals, most of which grow in rural or distant mountain areas. Therefore, the complexity and risk in transporting these raw materials have increased due to long transit times and inconvenient connections between transportation modes. Moreover, as the raw materials are used to produce medicine, the quality must be maintained in the supply chain. Temperature and humidity must be controlled to prevent the materials from spoilage. Pest eradication is also a critical issue. Operators of transportation and warehouses must take measures to control and reduce damage caused by pests. Considering the complexity and risk of the logistics of handling the raw materials, several large SPCHM manufactures have outsourced such logistics operation to professional third party logistics (3PL) operators who are capable of handling these special commodities. Such an outsourcing strategy enables manufactures to focus on developing and producing the SPCHM without dealing with complicated logistic operations. For a SPCHM manufacturer that intends to outsource its raw material logistics, it is important to evaluate and select a 3PL operator that is qualified to provide logistics service that satisfies the requirements of the company. Accordingly, this study attempts to systematically investigate the main service attributes of raw Chinese Herbal Logistics from the aspect of a 3PL operator and identify strategies for improving the quality of the service attributes.

LITERATURE REVIEW
Characteristics of CHM
The World Health Organization (WHO) estimates that up to 80% of the world population is using herbal medicine for some kind of primary healthcare. (Masand et al., 2014) The global herbal supplements and remedies market will reach 93.15 billion US dollars by 2015 (GIA, 2015). This shows that CHM has become a potential market attracting research studies. With the increasing adoption of CHM worldwide, materials are transported all over the world and a controlled logistics process is important to ensure product quality. Moreover, herbal materials must be stored under appropriate environmental conditions to prevent

contamination and deterioration. Materials must be protected from insects, pests, fungi and pesticides, and they should be prevented from abnormal odour, colour, mould or deterioration. Besides, the temperature, humidity and extent of rainfall during harvesting periods, the handling practices and the storage environments are the key factors to prevent microbial contamination of medicinal herbal products. Temperature must be controlled between 15 to 25 °C or, depending on the climate conditions, 30 °C with low humidity is required (Masand et al., 2014; WHO, 1998).

Service quality definition and application in logistics
Service quality is not only an abstract and multidimensional concept but also an attitude of service superiority; even while the nature of 'quality' it is still obscure (Abdullah et al., 2011). Measurements of service quality come from customers' appraisal after receiving service. On the basis of Total Quality Management (TQM), Parasuraman et al. (1985) developed a SERVQUAL model comprising ten constructs to query customer satisfaction. Additionally, Parasuraman et al. (1988) simplified these constructs into five to approach customer demand in reality. These five areas are: tangibles, reliability, responsiveness, assurance and empathy. Some scholars examined the advantage of collaboration in logistics operations in retail firms. They indicated that collaboration with supply chain partners could bring out great competitive advantage within the supply chain and that technological innovativeness, technological complementarity and flexibility are indispensable in the collaboration relationship (Richey et al., 2012).

The foregoing literature indicates that SPCHM has become more important nowadays. However, to the authors' knowledge, the service quality of SPCHM logistics has not been investigated in the literature. Therefore, focusing on the service quality of SPCHM logistics, this study aims to identify the impact of service quality, and rank the strategies that can improve the service quality

METHODOLOGY
Most papers related to HOQ focus on how to improve service quality. However, we think the ultimate goal of such a study is to enhance customer satisfaction and loyalty. Therefore, it's meaningful and necessary to validate the impact of service quality towards customer satisfaction and loyalty. Accordingly, we conducted an SEM analysis before building an HOQ. In this study, question items were used to measure service quality first. After the significant positive impact of service quality on customer satisfaction and loyalty were confirmed, then the same items were used to build an HOQ. The methodology is described as follows:

Structural Equation Modelling (SEM)
Structural Equation Modelling (SEM) is a statistical approach combining factor and path analyses to investigate the relationship between latent constructs. Service quality was regarded as the gap between expectation and experience (Parasuraman et al., 1991). Colwell et al. (2009) regarded customer loyalty as a positive reaction to a service company, which could be used to maintain the relationship in the foreseeable future. Jones et al. (2000) defined switching barriers as a situation in which more difficult or costly behaviour was needed for customer to change their providers. According to the above-mentioned concept, we propose three hypotheses. First, in terms of impact of service quality on customer satisfaction, Parasuraman et al. (1988) pointed out that there was high positive correlation between service quality and customer satisfaction. Shanka (2012) conducted a study on banking to prove a significant positive impact of service quality on customer satisfaction. As the logistics of SPCHM is also used in the field of the service industry, accordingly, we establish the following hypothesis:

H_1: Service quality of SPCHM logistics providers has a positive effect on customer satisfaction.

Second, in terms of the influence of customer satisfaction on customer loyalty, Fornell (1992) pointed out that enhancing customer satisfaction was a method to enhance customer loyalty. Mohsan et al. (2011) found out there was a positive effect between customer satisfaction and customer loyalty in banking and cell phone instant messaging

service industries. For the manufacturers of SPCHM, high satisfaction about logistics may increase their loyalty to the service provider. Therefore, we establish the following hypothesis:

H_2: Customer satisfaction has a positive effect on customer loyalty towards SPCHM logistics providers.

Third, as the complexity of SPCHM logistics is much higher than that of general goods—once a customer is well serviced by its service provider—the intention to change service providers may be lower due to switching barriers. Aydin and Özer (2005) and Kheiry and Alirezapour (2012) found that switching barriers has a positive effect on customer loyalty in the cell phone service industry. Accordingly, we propose the following hypothesis:

H_3: Switching barriers of SPCHM manufacturers has a positive effect on customer loyalty to logistics providers.

The two-stage procedure proposed by Anderson and Garbing (1988) is applied in this study. That is, we first establish a measurement model to ensure the reliability and validity of the research model and the fitness of the collected data. Further, a structured model is constructed to examine the hypothesized paths among the constructs.

Quality Function Deployment (QFD)

QFD is a way to transfer customers' demand into the process for developing a product or service. The house of quality (HOQ), developed by Bossert (1991) as a basic tool known for QFD, enables a company to improve existing services quality under limited resources and reallocate resources to new product or service. The basic structure of an HOQ is divided into six parts: Voice of customer (VOC), solutions, relationship matrix, priority order of customer demand and solutions.

Questionnaire design and sampling

In this study, we designed two questionnaires. One was used to collect the VOC based on the five aspects in the SERVQUAL scale. A 5-point Likert scale was applied to measure the importance and satisfaction of each item and the overall perception of satisfaction, loyalty and switching barriers. The other questionnaire was developed to investigate the relationship between the left wall and the roof of the HOQ. The ordinal scale 0-1-3-5, which is one of the most commonly used scales (Wang, 2007; Samah, 2012), was applied to measure the relationship from low to high. The draft of the two questionnaires had been reviewed and revised by two managers of the logistics service provider (LSP) of the largest SPCHM manufacturer in Taiwan (hereafter called Company A) and two professors in the field of logistics management to ensure the content validity of the questionnaires. We conducted two questionnaire surveys in January 2014 to establish an HOQ. Company A supported the first survey and 250 questionnaires were sent to employees who were involved with logistics activities. Their jobs include inspection, quality control, manufacturing, packaging, inventory control and marketing. A total of 202 questionnaires were returned. Most respondents were between the age of 26–45, accounting for 78.7% of the overall samples. Overall, 41.6% of employees had 2–5 years working experience and 24.7% of employees had over 10 years working experience, which ensures reliable expertise for this study. There are 34 question items in the first questionnaire, in which 27 items categorized according to the SERVQUAL scale are used to measure service quality. These 27 items were developed by this study based on the characteristics of SPCHM logistics and SERVQUAL scale proposed by Parasuraman et al. (1988). In addition, three items sourced from Miller (1979), Roos et al. (2004) and Flint et al. (2011) were used and refined to measure customer satisfaction. The last construct, customer loyalty, was measured by four items sourced and refined from Oliver (1999), Gronholdt et al. (2000) and Kheiry and Alirezapour (2012). The first questionnaire was used to collect respondents' opinion on the importance and performance of each item for two purposes. The first purpose is to validate the three hypotheses proposed in this study. The other purpose is to determine the weights of the 27 items (right wall of the HOQ). For the second survey, 15 managers of the LSP of Company A were invited to provide expertise to determine the relationship matrix (middle of the HOQ).

EMPIRICAL ANALYSIS

Validity and reliability analysis

As in most sampling-related studies, the reliability and validity of the returned questionnaires were tested to ensure the representativeness of the measurement model. In this study, we adopted composite reliability (CR) and average variance extracted (AVE) as measures to examine the reliability. The CR value of each construct were greater than 0.85, exceeding the recommended level of 0.7 (Bagozzi and Yi, 1988). Moreover, all AVE values were greater than 0.5 (Bagozzi and Yi, 1988). Hence, the collected data and the measurement model in this study have reliability. Additionally, discriminant validity was used to evaluate if there was a significant difference between different latent constructs. The discriminant validity of our model was achieved, as all χ^2 differences are significant. Finally, the six goodness-of-fit measures of the measurement and structure models are in compliance with the acceptance thresholds. Namely, there is a sound fitness between the data and these two models.

Results

After a sound measurement model was obtained, a structural model was established to test the proposed hypotheses. Figure 2 illustrated the result of the structural model. It is clear that there are significantly positive impacts of service quality toward customer satisfaction, customer satisfaction toward loyalty and switching barriers to customer loyalty. With a range from 0 to 1, a higher value of R^2 shows that the amount of variance of a specific construct is well accounted for by other constructs. As Figure 2 shows, customer satisfaction has an R^2 value of 0.318, well accounted for by service quality, as well as customer loyalty has a higher R^2 value of 0.836, indicating that it is well accounted by service quality, customer satisfaction and switching barriers. All proposed hypotheses in this study are accepted. After SEM analysis, this study uses QFD to investigate the service quality systematically and prioritize the strategies to improve the service quality of LSP of SPCHM. By interviewing the managers of all departments of the LSP of Company A and referring to ISO 9001 documents, thirty strategies were proposed as the roof of HOQ. The weight vector located in the right wall of the HOQ was obtained by ranking the difference between importance and satisfaction of each item. Finally, the weighted sums of the relationship matrix were listed at the bottom of the HOQ, which were used to rank the priority of all strategies. The HOQ built by this study is illustrated in the appendix. The priority shown at the bottom indicates that "maintain existing customers", "shorten the process for dealing with anomalies", "inspecting operating process regularly", "Set up packaging examination mechanism" and "Provide competitive rates to customers" are of high priority to improving the service quality.
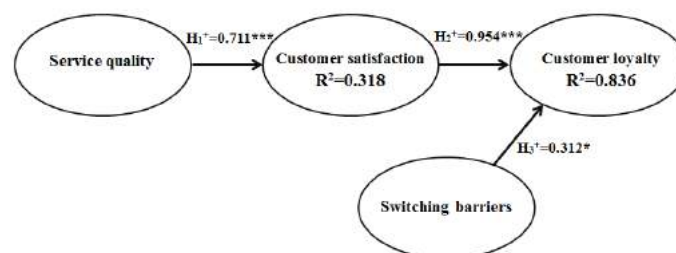
Figure 2. Results of path analysis

Note: significant at the P < 0.1, **significant at the P < 0.05, ***significant at the P < 0.01.

Discussion

Our empirical study indicates that the top five items in the VOC are "Warn and handle immediately once temperature and humidity is in abnormal condition", "Prevent insects and mice on site", "Temperature and humidity requirements in transit are in accordance with SPCHM regulation", "Temperature and humidity can be monitored and traced in real time" and "Operators can follow the standard procedures and regulation". According to the relationship matrix, the impact made by a strategy on each item of VOC can be identified

respectively. Hence, we take two items of VOC as examples. First, if the LSP of Company A wants to improve the item "Warn and handle immediately once temperature and humidity is in abnormal condition", the three strategies of "Maintain existing customers", "Provide competitive rates to customers" and "Establish quick response mechanism to customers", are deemed to be the most useful due to their high scores of 1.25. Another example is the item of "prevent insects and mice on site" needs to be improved, then two strategies of "Set up annual operation target" and "Set up packaging examination mechanism" are thought to affect the item preferentially with scores of 0.83. Moreover, we discovered the demand of logistics service of SPCHM is not similar to that of general goods. In other words, VOC items related to the fundamental facilities or mechanism to operate a warehouse are of low priority in our empirical study. It implies that the concern of SPCHM manufactures focuses on whether their LSP can handle their special goods considerately, especially in maintaining temperature, humidity and in quick response issues.

CONCLUSIONS

The conclusion and implication of this study is summarized in four aspects. First, many studies applied QFD to investigate service quality. Such studies built HOQs directly without identifying the impact made by service quality on customer satisfaction and loyalty. However, in this study, we conducted an SEM analysis before building an HOQ to validate the impact of service quality towards customer satisfaction and loyalty. That is, we think such a two-step procedure is necessary and more meaningful than building an HOQ directly. Second, according to the result of our empirical study, the LSP of SPCHM manufacturers should reinforce the careful controlling of temperature and humidity of the raw materials and the products. Moreover, professional facilities and equipment for rat and insect prevention are also necessary to be in compliance with the regulation. Third, in this study, the investigated LSP providing logistics service for SPCHM business is different from general goods. The HOQ built in this study contains several issues on temperature, humidity, real time control and special requirements of the environment. The VOC items, solutions and the result in the HOQ might be applied to future studies related to investigating the service quality of logistics service of similar product such as medicines, fresh foods or refrigerated foods. Fourth, the path coefficient between switching barriers and customer loyalty is as high as 0.312 in this study. Actually, based on the same research model, we have also sampled the users of international express carriers. The same path coefficient is only 0.252. It is clear that the path coefficient obtained from the SPCHM industry is much higher than that in the international express industries. This implies that customers may switch to other express carriers easier than customers will switch to other LSP of SPCHM. In other words, it's useful for an LSP of SPCHM to strengthen customer loyalty by raising the switching barriers of their customers because the logistics of SPCHM is complicated.

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Appendix: Quality function deployment of Company A

SERVICE QUALITY REQUIREMENT	Management						Marketing						Operation						IT						Administration						Importance			Satisfaction			Satisfaction attitude	Difference index	Original priority	Original weight	Standardized weight
	Set up annual operation target	Make annual budge	Increase on-the-job training	Recruit more employees	Re-equipment	Shorten equipment maintenance period	Maintain existing customers	Develop new customers	Set up annual business target and auditing mechanism	Provide tailor-made service	Provide competitive rates to customers	Establish quick response mechanism to customers	Improve inbound operation process	Improve outbound operation process	Enhance accuracy of picking process	Set up packaging mechanism	Shorten the process for dealing with abnormal situations	Inspect operating process regularly	Set up an information security team	Upgrade hardware to increase the efficiency	Increase the speed for data transmission	Backup data regularly	Upgrade warehouse management system	Maintain system regularly	Audit trucking company regularly	Install vehicle monitoring system	Enhance the accuracy of temperature control system	Provide online monitoring system to customers	Enhance the tracking of abnormal orders	Shorten the process for dealing with customer complaints	Before transformation	After transformation	Rank	Before transformation	After transformation	Rank					
Intangibles Temperature and humidity requirements in storage environment are in accordance with SPCHM regulation.	0.83	0.5	0	0	1.25	1.25	1.25	1.25	1.25	0.75	1.25	0.25	0.83	0.83	0.83	0.83	1.33	1.33	0	0	0	0	1.08	0	0.17	0	0.5	0.5	0.83	0	4.49	1.49	3	3.96	0.96	10	1.43	-7	6	22	0.0582
Temperature and humidity requirements in transit are in accordance with SPCHM regulation.	0	0	0	0	0	0	0.75	0.75	0.25	0.58	1.08	0.75	0.83	0.83	0.83	0.83	1.33	1.33	0	0	0	0	0	0	0.17	0.17	0	0.5	0.5	0.17	4.41	1.41	10	3.86	0.86	22	1.21	-12	3	25	0.0661
Certified security mechanism in storage facilities.	0.83	1	0	0	0.5	0.83	0.58	0.25	0.58	0.25	0.58	0.25	0.5	0.5	0.17	0.91	0.17	0.17	0	0	0	0	0	0	0	0.17	0	0.5	0.5	0	4.29	1.29	19	4	1	5	1.29	14	26	2	0.0053
Certified fire-fighting system in storage facilities.	0.5	1.08	0.83	0	1.08	1.25	0.75	0.25	0.25	0.25	0.75	0.75	0.5	0.5	0.5	1.08	0.5	0.5	0	0	0	0	0	0	0.17	0	0.5	0	0.17	0	4.52	1.52	2	4.02	1.02	4	1.55	-1	15	13	0.0344
Exact temperature and humidity control during transportation.	0	0	0	0	0	0.75	0.75	0.75	0.75	1.25	0.75	1.25	0.83	0.83	0.83	0.83	1.17	1.17	0	0	0	0	0	0	0	0.5	0	0.17	0	0.5	4.28	1.28	21	3.82	0.82	26	1.05	-5	8	20	0.0529
Full-time surveillance in warehouse.	0.5	1.08	0	0	1.25	1.25	1.08	1.08	0.25	0.75	1.08	0.75	0.5	0.5	0.83	1.08	0.83	0.83	0	0	1.5	1.67	1.08	0.83	0.83	0	0.5	0.17	0	0	4.25	1.25	22	3.91	0.91	17	1.14	5	21	7	0.0185
Efficient warehouse management system.	0	0.5	1.08	0	0	0	1.25	0.75	1.25	0.75	0.75	1.25	1.67	1.67	1.67	2.08	1.67	1.67	0	0	0.58	1.33	0.5	0	0.17	0	0	0.5	0.75	0	4.38	1.38	13	3.97	0.97	9	1.34	4	19	9	0.0238
Assurance Orders could be picked and shipped in time.	0	0	0.83	0	0	0	1.08	1.08	1.25	1.08	1.25	1.25	1.67	1.67	1.67	1.67	1.67	1.67	0	0	0	0	0	0	0.83	0	0.17	0.17	1.08	0.83	4.45	1.45	6	3.95	0.95	11	1.38	-5	9	19	0.0503
Temperature and humidity in storage environment can be provided.	0.5	0	0	0	0.5	0.5	1.25	0.75	0.58	0.58	0.68	0.75	0.83	0.83	0.5	0.83	1	0.83	0	0	0	0	0	0	0.5	0.5	0.5	0.17	0	0	4.35	1.35	14	3.98	0.98	8	1.32	6	22	6	0.0159
Temperature and humidity during transportation can be provided.	0	0	0	0	0	0	1.08	1.08	0.58	0.25	0.25	0.58	0.5	0.5	0	0.5	0.67	0.67	0	0	0	0	0	0	0.17	0.17	0.17	0.17	0.5	0	4.21	1.21	27	3.77	0.77	27	0.93	0	16	12	0.0317
Reply delivery situation in time.	0	0	0.83	0	0	0	1.25	1.08	1.08	0.75	1.25	1.25	0.25	0.58	0.5	0.5	0.67	0.67	0	0	0.75	0	1.25	0.83	0.17	0.17	0.83	0.91	0.83	0	4.35	1.35	15	3.9	0.9	18	1.22	-4	10	18	0.0476
Reliability Handling returned cargo in time.	0	0	0.83	0	0	0	0.75	0.58	0.58	1.25	1.25	1.25	0.83	0.5	0.83	0.5	0.67	1.17	0	0	0	0	0	0	0.17	0	0.17	0	0.58	0.5	4.25	1.25	23	3.86	0.86	23	1.08	0	17	11	0.0291
Operators can follow the standard procedures and regulation.	0	1.25	0.83	0	0	0	1.25	0.75	0.25	0.58	0.75	0.75	1.67	1.67	1.67	2.08	1.67	1.67	0	0	0	0	0	0	0.5	0.17	0	0.17	0	0	4.46	1.46	5	3.94	0.94	12	1.37	-7	5	23	0.0608
Temperature and humidity can be monitored and traced in real time.	0	0	0.83	0	1.08	1.25	0.75	1.25	1.08	0.75	1.08	1.25	0.83	0.83	0.5	0.83	0.83	0.83	0	0	0	0	1.08	0	0.17	0	0	0.83	0	0	4.44	1.44	8	3.93	0.93	15	1.34	-7	4	24	0.0635
Temperature and humidity conditioning system can work smoothly.	0	0.5	0	0	0.83	1.25	1.25	0.75	0.75	0.75	1.25	1.25	1.33	1.33	0.83	1.33	1.33	1.33	0	0	0	0	1.08	0.75	0.17	0.17	0.5	0.5	0.5	0.17	4.58	1.58	1	4.02	1.02	3	1.61	-2	14	14	0.0370
Data and records can be traced.	0	0.5	0	0	0.83	1.25	0.75	0.25	0.25	0.58	0.75	1.25	1.67	1.67	1.67	1.67	1.67	1.67	0	0.75	0.83	0.83	1.25	1.25	0.83	0.17	0.17	0.5	0.5	0.17	4.42	1.42	9	3.94	0.94	13	1.33	-3	12	16	0.0423
Responsiveness Warn and handle immediately once temperature and humidity is in abnormal condition.	0	0	0.83	0	0	0.5	1.25	1.08	1.08	1.08	1.25	1.25	0	0	0	0.58	0.58	0	0	0	0	0	0	0	0.17	0.17	0.5	0.5	0.5	0.4	4.48	1.48	4	3.87	0.87	19	1.29	-15	1	27	0.0714
Reply the condition of inventory immediately.	0	0	0.83	0	0	0	0.58	0.58	0.58	0.58	0.75	0.75	0.58	0.58	0.58	1.17	0.75	0.58	0	0	0	0	0	0	0.17	0	0.5	0.17	0	0.83	4.31	1.31	16	3.92	0.92	16	1.21	1	18	10	0.0265
Streamlined the procedure for responding customers' requirements.	0.5	0	0.91	0	0	0	0.75	0.75	0.25	0.25	0.25	0.75	0.58	0.58	0.58	1.17	0.58	0.58	0	0	0	0	0	0	0.17	0.17	0	0.5	0.5	0	4.25	1.25	24	4	1	6	1.25	17	25	3	0.0079
Deal with rush orders and anomalies in time.	0	0	0.83	0	0	0	1.25	1.25	1.08	1.08	1.25	1.25	1	1	0.83	0.83	0.83	0.83	0	0	0	0	0	0	0.5	0.17	0.17	0.17	1.08	0.5	4.39	1.39	11	4.15	1.15	2	1.60	9	24	4	0.0106
Deal with customer complaint in time.	0	0	0.83	0	0	0	1.25	0.25	0.75	1.25	0.25	0.75	1.17	1.17	1.17	1.75	1.33	1.17	0	0	0	0	0	0	0	0.17	0.17	0.5	0.83	0.5	4.32	1.32	16	3.87	0.87	21	1.15	-3	11	17	0.0450
Provide on-line information inquiry system.	0	0	0.83	0	0	1.08	0.75	0.75	0.25	0.75	0.75	0.75	0.17	0.5	0.5	1.08	0.17	0.17	0.83	0.83	0	0	0	0	0.17	0.17	0.5	0.5	0.58	0.5	4.29	1.29	20	3.94	0.94	14	1.21	7	23	5	0.0132
Empathy Sterilize before using the manufacturing and logistics equipment.	0	0	1.08	0	0	0	0.75	0.25	0.25	1.25	0.75	0.75	0	0	0	0	0	0	0	0	0	0	0	0	0.17	0.5	0.5	0.83	0	0	4.3	1.3	18	3.84	0.84	24	1.09	-6	7	21	0.0556
Prevent insects and mice on site.	0.83	0	0	0	0	0	0.75	0.75	0.25	0.75	0.25	0.25	0	0	0	0.83	0	0	0	0	0	0	0	0	0.17	0.17	0.17	0.17	0	0	4.45	1.45	7	3.87	0.87	20	1.26	-13	2	26	0.0688
Inventory control follows the principle of first in first out.	0	0	0.83	0	0	0	1.25	0.75	0.75	0.75	1.25	1.25	1.5	1.5	1.5	1.5	1.5	1.5	0	0.83	0	0	0.5	0	0.5	0.5	0.17	1.25	0.83	0	4.39	1.39	12	3.99	0.99	7	1.38	4	20	8	0.0212
Update and repot inventory condition regularly	0	0	0.5	0	0	0.5	1.25	0.58	0.58	1.08	0.58	1.08	1.5	1.33	1.33	1.33	1.33	1.33	0	0.5	0.83	0.83	0	0	0.17	0.17	0	1.25	0.83	0	4.24	1.24	26	4.19	1.19	1	1.48	25	27	1	0.0026
Report the process of dealing with customers' complaints	0	0	0.83	0	0	0.5	1.25	1.25	1.25	1.08	1.25	1.25	0.83	0.83	0.83	1.21	0.83	0.83	0	0	0	0	0	0	0.17	0	0.17	0	0.91	1.08	4.25	1.25	25	3.84	0.84	25	1.05	-2	13	15	0.0397
Absolute Weight of service technique	0.16	0.21	0.51	0	0.31	0.49	0.99	0.79	0.69	0.79	0.92	0.86	0.79	0.80	0.77	0.94	0.95	0.95	0	0.06	0.08	0.09	0.30	0.17	0.22	0.18	0.22	0.36	0.44	0.33											
Relative Weight of service technique	1.24	1.69	3.40	0	2.43	3.84	7.80	6.26	5.40	6.23	7.25	6.78	6.25	6.31	6.05	7.42	7.51	7.51	0	0.47	0.64	0.67	2.34	1.32	1.72	1.44	1.71	2.87	3.44	2.62											
Priority	25	22	15	29	18	13	1	8	12	10	5	6	9	7	11	4	2	2	29	28	27	26	19	24	20	23	21	16	14	17											

VALUE CO-CREATION IN MAINTENANCE AND MODIFICATION OPERATIONS: AN EXCHANGE ECONOMY PERSPECTIVE OF ENGINEERING SERVICE PROVISION
CASE STUDY

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Abstract

Purpose of this paper: Develop understanding regarding what constitutes "value co-creation" from an operations perspective useful in relation to supply chain management.

Design/methodology/approach: A single case study of maintenance and modification operations in the petroleum industry provides detailed narrative of interaction and reciprocal interdependency. Following contingency theory, interaction is viewed as embedded in interdependencies.

Findings: the distinction between operant and operand resources is unimportant when analysing value co-creation from a contingency theory viewpoint. In addition, value is evoked as a moving target adding to uncertainty. Value co-creation si called for in cases of reciprocal interdependencies using intensive technology.

Value: This study points to value co-creation as exchange economy process that may be improved through grouping as well as improving connectivity. Another strategy would be to lessen reciprocal interdependency.

Introduction

Maintenance and modification operations (MMO) are a vital form of engineering associated with sustaining oil and gas production. This represents a service that is commonly outsourced and thus undergoes purchasing by the oil and gas producer. Value co-creation represents a mode of interaction between firms embedded in a collaborative relationship involving iterative and dialectical learning to create customer value; especially called for in cases of reciprocal interdependencies caused by heightened uncertainty (Engelseth and Zhang 2016). While literature on value co-creation within the field of marketing (e.g. Prahalad and Ramaswamy 2000, Vargo and Lusch 2004) places focus on what may be considered a normative imperative of business integration as strategic objective, within logistics and supply chain management (SCM), Hammervoll (2014) directs focus to what technically constitutes this co-creation effort as a form of economy. How may business co-create value in supply chains? This implies searching for what constitutes "value co-creation".

From a resource-based view of the firm, Penrose stated already in 1959 (p. 25), moving away from applying the term factor of production, which was commonplace in economics, that "it is never resources themselves that are the 'inputs' of the production process, but only the services that the resources render." She uses services as the plural form of service, and not denoting type of industrial sector. This implies more than superficial re-labelling of what constitutes the produced object in supply chains. "Value" is in line with Lusch and Vargo (2014, p. 188) regarded as "ultimately derived and determined by the service beneficiary, through use." The concept of "value-in-use" is central to S-D logic; a human perception associated with consummation and not with economic exchange. Value is regarded by Lusch and Vargo (2014) as always co-created "…because resources from multiple sources are always integrated to create value". Value co-creation cannot, however, be limited to human cognition. Using S-D terminology, service must be produced and production does impact importantly on customer value.

A starting point for clarification on this issue is founded on Parson's (1960) view organizations classified having three levels of responsibility and control: (1) technical, (2) managerial, and (3) institutional. This indicates what may be interpreted as features of interaction; understood as associated with these levels of responsibility and control. Taking a SCM perspective, the technical level concerns what organizations do; their "production", workflow as called within information technology (IT), or flow of goods and services. The managerial level includes directing the flow of resources towards what constitutes a receivable service from the viewpoint of the customer. Following Perrow (2014), the institutional level concerns relating to the environment, how patterns of behaviour develop associated with supply purpose; a functionalistic aspect of organizations that evokes patterns of behaviour. Hammervoll (2014) follows this line of thought in discerning between a production economy supported by an exchange economy. These two realms in supply chains are associated with transforming "value" into a perceivable from a supply chain customer perspective; production associated with value as deliverable leading to "value in use" and exchange associated with value in interaction. This evokes a question as to what constitutes "value co-creation" as an "exchange" economy; what is the nature of value in interaction with function to support value in use objectives? Through the provided case study of MMOs of an on-land gas producing terminal facility linked with sub-sea supply in the petroleum industry value co-creation is exposed as existent, though not explicit, organizational behaviour.

Frame of reference

Value co-creation is cornerstone in service dominant (S-D) logic (Lusch and Vargo 2014). Founded importantly on Penrose's (1959) resource-based view of the firm, S-D logic has been a major force in developing understanding of what constitutes value co-creation as a "service" provision to customers through customer-supplier interaction. Hammervoll's (2014) paper is founded in-part on this stream of literature elaborating on how an exchange economy is different and therefore complementary to a production economy. Creating value is the explicit purpose of production when taking a functionalistic view of supply chains, typical of systems thinking. SCM includes in most research applying systems thinking (Lambert and Cooper 2000). "Co-creation" in a supply chain indicates from systems perspective, a function of production associated with achieving value through inter-firm collaboration. This implies a need to collaborate, to technically interact in a business relationship. According to Croom et al. (2000), the context of supply-related interaction refers to different levels of analysis, i.e. "dyads", "chain" or "network". Value co-creation is interpreted as dyadic interaction in the context of chains. The supply

chain is understood as a task environment (Dill 1958) integrated through explicitly shared supply objectives. "The task environment, as information inputs, and tasks, as cognitive formulations to guide action…" (Dill, 1958, op. 411). In the supply chain actors perceive and negotiate continues a common purpose. Chains may to varying degrees be integrated denoting stronger or weaker perception of commonality in supply purpose. Interaction lacking this form of interaction may be described as taking place in the network. The supply chain is accordingly understood as the dynamic functionalistic environment of the relationship dyad. Networks are then understood in line with Hammervoll et al. (2014) as a task environment encompassing dyads that are linked together regardless of degree of supply purpose integration.

In line with systems theory, various social relations entail interdependence between actors (Emerson 1962). This also means that technical resource interdependency encompasses issues regarding power and trust (Pfeffer and Salancik 1978). Value co-creation must therefore be negotiated: it demands focused and functionally-led use of time. It also depends on a certain level of achieved mutual trust between at least two firms creating the needed inter-organizational integration. Following Alderson (1965), the purpose of production is associated in inter-organizational structures of where goods are transformed providing time, place and form utility through a series of intermittently directed transformations. This implies, following Thompson (1967), a long-linked form of technology typical of the goods supply Alderson (1967) modelled. This also implies a notion of purpose adjustment founded on transformation of deliverables through production. Production involves also in all cases mediating technology and in cases of heightened uncertainty, intensive technology. Mediating technology involves pooled resource interdependency, a need to combine resources to produce. Intensive technology involves reciprocal interdependencies typically found in dyadic structures. In cases of reciprocal interdependency Thompson (1967) describes a need for mutual adjustment of purpose as well as producing process through exchange. In part this adjustment is demanded as production transforms the deliverable service stepwise through intermediary customers. Production is accordingly at core associated with resource change creating receivables valued by the customer.

Lusch and Vargo (2014, p. 57) define "value" as "…benefit, an increase in the well-being of a particular actor". From a contingency theory perspective "…human action emerges from interaction of (1) the individual, who brings aspirations, standards, and knowledge or beliefs about causation; and (2) the situation, which presents opportunities and constraints" (Thompson, 1967, p.101-102). Value co-creation is accordingly viewed as a dialectic activity found in dyadic relationships. It is associated with value cognition, value being a dynamic entity impacted by iterative sense-making (Weick 1995). This sense-making follows a timeline of dyadic exchange activity involving constructing, filtering, and framing to thus create a perception of "factity" (Turner, 1987); associated with the engineering service, its design and its operation. It is also necessary to interpret "dyad" widely, since interaction may be in "teams" involving multiple actors that are grouped together. Dyadic relationships are viewed as potentially complex; not limited to two actors involved in mutual adjustments. They are rather representations of complex interaction, dyadic at core, that create discourse in the form of narratives concerning supply-related purposeful information exchange. Value co-creation is accordingly understood as a boundary-spanning dyadic iterative sense-making supply chain activity where actors are closely grouped together in location or through media.

S-D logic points to the distinction between operant (exchange-related) and operand (production-related) resources (Hammervoll 2014). "Operand resources are resources that must be acted on by some other resource to create ab effect. Operant resources are resources that are capable of acting on other resources" (Lusch and Vargo 2014, p. 123). According to Lusch and Vargo (2014, p. 123 "…the distinction between operand and operant resources can provide an important perspective for understanding how customers and employees are approached and treated by firms". Lusch and Vargo (2004) also highlight this distinction to differentiate a goods-dominant logic, predominant in management thinking, from their alternative S-D logic. In operations this distinction seems to wither away taking a contingency theory perspective. According to Thompson (1967, p.-101-102) "…human action emerges from interaction of (1) the individual, who brings aspirations, standards, and knowledge or beliefs about causation; and (2) the situation, which presents opportunities and constraints". Thus situation is, however not limited to one or more actors. Since interaction encompasses, also in line with Actor Network Theory (Law 1994) the impact of technical artefacts, the distinction between man and machine being unclear. Value is "enacted"; the subjective meaning of value changes in a realm of inter-subjective interaction that includes perception of technology (Weick 1969). All resources may accordingly be characterized as operant since they are all perceived, and impact accordingly on sense-making, are enacted upon leading to particular forms of human action.

In a supply chain relationship, customer-perception of "value" concerns weighing service benefits with service costs – understood as a time-prolonged totality including price. In supply chains, value-in-use is one of several aspect s of "value". This perception of value in use is associated with different time-related perceptions, before, during and after contracting a purchase. A "value proposition" given by the marketer is one such aspect. What actually constitutes "value" is proposed as in a supply chain context as an entity in transformation likewise as the service output of production; a moving target.

Method

The following case description is based on an on-going single case study. It provides an 'as-is' description of the MMO at the gas producing terminal. Semi-structured interviews were carried out with informants. Interviews lasted on average one hour. Interviews were taped and transcribed. A research protocol was created to register choices, main findings in individual interviews and provide preliminary analysis. This protocol was also used to design following up interviews. The study followed accordingly an emergent design where the research issue gradually became more precisely formulated as the research project evolved. The findings of this study are regarded transferable to similar industrial settings provided careful taking into considerations particularities of the industrial setting of this case study. Credibility is sought through providing a detailed case narrative where the level of interpretation is kept at a minimum level allowing for variation in interpretation. Furthermore, the narrative construct and analysis has been discussed with informants as well as subject to a peer review. Analysis has also been supplemented by empirical evidence and insights provided through three separate student-group term projects involving different topics related to petroleum logistics carried out by both undergraduate as well as graduate level students in logistics management. Applying a case study strategy involves limitations regarding the transferability of findings to other business cases.

Case

The case of minor modification and maintenance (MMO) operations at an on-land production terminal i for receiving this natural gas from subsea installations located on an island on the North-Western coast of Norway. There is a continuous need for MMO to ensure the smooth running of the gas terminal and production. Most of this subsea production-related facility transforms the gas by sending to European markets through pipelines. A minor portion is transformed into liquid natural gas (LNG) that is transported by specialised LNG tankers to customers. The contract for these MMO services is held by an engineering service provider.

The oil company has chosen to outsource the studied MMOs to the specialised engineering firm. MMOs range from pure services (pure maintenance operations) to modifications involving installing and implementing a large new component. Since Norway as a member of the European Economic Area companies in Norway agreement must comply with European Union procurement transparency regulations. All transactions in the petroleum sector are considered as public procurement, and must accordingly comply with these regulations. Purchasing is publically announced to secure fair market conditions. This has impact on transactions both with the engineering firms' customers as well as their sub-suppliers. A 4-year contract between the engineering service provider and its petroleum company customer, with a 2 year option for prolonging this contract, regulates this relationship.

Contracting a MMO arrangement between the engineering firms is a process lasting approximately one year. The petroleum company must first provide a documentation of its needs at the gas terminal and production facility. This involves a lengthy cross-functional process where different functions report MMO needs in the coming period. Documents are paper-based and organised into binders containing several hundred pages with technical requirements, specifications and technical drawings associated with the gas terminal needs for sustaining its production. Prior to tendering, communication between the petroleum company and competing engineering service suppliers may flow freely. After making the offer public communication must follow strict rules governing interaction in this transaction process. These documents represent a vital part of the bidding processes in negotiations. In case of changes in the tender, the oil company may invite suppliers to a meeting to inform all market actors of the amendments in the publicised tender.

The engineering firms then create documentation stating how they intend to solve the customer needs as well as pricing their offering. This offering must be in the hands of the oil company within a stated deadline. Three MMO suppliers listed in the Achilles (www.achilles.com) database are chosen to compete. These companies are ranked in accordance with a rating system where suppliers are apportioned points in accordance with various weighted factors. The creation of this offering is carried out by the central organisation of both the oil companies as well as the engineering companies. These agreements commonly involve, from the perspective of one of these oil companies, MMO contracts for all their related needs within the given contract period. This contract provides accordingly the formal context of choosing a MMO supplier.

The engineering company, upon winning the bid, commences MMO-related activities at the gas production terminal. This involves purchasing of goods and services from sub-suppliers. These companies represent a number of different engineering specializations

or functions that are involved in their MMO. Examples of such specializations are within fields of electronics, structures, instruments, piping, noise control, and steel. Purchasing involves combinations of service and product supplies. Contracts are negotiated much in the same way as these companies' sales contracts with the oil companies. The main contracts run for varying periods depending on technical features of the delivery. These may typically run a specified number of months and up to 2 years. These agreements bind purchasing to this sub-supplier in the contract period. Thus purchasing is also costly to administer, e.g. a component costing 5000 NOK may demand NOK 30000 in administrative resource use due to complicated and changing rules of purchasing demanded predominately by the petroleum company customer. The smaller purchases are contracted individually through a simpler process. This involves use of the Achilles database and supplier ranking. The engineering companies also carry out quality inspections of their suppliers to verify quality features of different processes. The MMO service supplier commonly spreads supplies to a limited number of major supplier accounting for 80-90% of the total value. The value of this main project tender is about 70-80 % of the project. This supplier supplies accordingly a technical package. In addition there are between 10-20 minor suppliers. In all there may be about 50 projects running simultaneously in each engineering company involving different companies, people and competencies. All purchasing is handled in principal in the same manner. However, the bidding process may be simplified in the case of minor supplies through standardising requirements.

During the contracted period of running MMOs projects are designed and these are managed through routine meetings. A set of different meetings takes place each week. These meetings consist of approximately 5-8 representatives of the engineering company and 2-3 representatives of one supplier and 2-3 representatives of the oil company. Such meetings are operationally focused and always involve only one supplier. These meetings are personal and the different sub-suppliers may in some cases go directly from one project meeting to another. These meetings are often located in the offices of the MMO service supplier or at offices located at the gas production terminal. Each project involves at least a weekly meeting. In periods with intense operations meetings may be carried out daily. In these meetings the engineering company runs through a checklist describing supplies (products and services), logistics and current operations affiliated with the project. The plan is sought verified and potentially adapted based on communication at the meeting.

MMOs involve using on-site combinations of engineers and skilled workers. Termination of projects does not always fall in line with plans. In some cases the petroleum company decides to change priorities between projects, keep one project on hold, while advancing in time another project. One such project, started in 2010, was accordingly still on hold. In addition, various factors may create delays demanding operational coordination through the described project meetings. All the interviewed actors describe their business as relatively unpredictable. This includes daily operations. However, while search operations (not the focus in this study) are extremely unpredictable, demanding organisational forms centred on handling logistical uncertainty, daily production involves uncertainties handled with varying degrees of adjustments to plans. One petroleum company informant stated that logistics solutions in this industry requires, in a long-term perspective, developing predominantly modes of inter-organisational networking rather than optimising micro-level operations. The organisation of MMOs at the gas production terminal is shown in fig. 1:
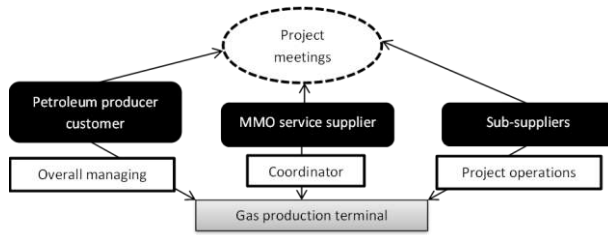
Fig.1. MMO functions and networking through project meetings

Conclusion

The case reveals an "as-is" state of interaction; "value" and "co-creation" not explicit in actual discourse. "Value co-creation" is therefore rendered an analytical tool to scrutinize real interaction. In this case production is predominately an engineering service. This service is, however, networked through complex interactions with sub-suppliers as well as the petroleum company customer. The narrative exposes few details about details regarding production exposing details regarding what we term an "exchange economy". It is in this economy "value co-creation" takes place seen through the analytical lenses of the researcher. From a functionalistic viewpoint it is the quality of production that is associated with purpose, achieving customer value through production as economy. Discerning between operand and operant resources is of lesser importance when understanding how value is co-created since also the operand resources (physical objects) communicate with us humans in their own subtle manner. Resources, accordingly are in terms of how value is created, classified at a lower level of abstraction, e.g. related to features of the resource, its function and actual use. Distinguishing between operand and operant resources has explanatory power limited to the strategic level, to point to that exchange processes in themselves need to be developed, directing, as Vargo and Lusch (2004) postulate, move paradigmatically from a goods-dominant view of supply to a service-dominant one.

This study is founded on this S-D logic presupposition of value in use as service objective. This approach evokes though applying theoretical perspectives from mainly organization theory, that value co-creation is solved in line with Thompson's (1967) recommendation regarding use of intensive technology, through grouping. An exchange quality is sought to support production quality. Both production and exchange involves actual mixing of operant and operand resources since tools cannot be detached for the human in both actors as labour and as managers. However, in relation to value creation, the distinction between operant and operand resources is unimportant. Taking a people-focused perspective, both exchange and production involves knowledge and skills. The difference between exchange and production is that exchange is associated with a different purpose. Exchange economy is associated with supporting production through management functions. The production economy is associated with transformation to create service (Penrose 1959) laying grounds for "value in use" (Lusch and Vargo 2014). As fundamentally dynamic resource pooling, value co-creation is facilitated by interaction, a mutual adjustment. One way of improving interaction, would be to lessen reciprocal interdependencies to plan and automate interaction. However, give high uncertainty and limited work as in the case in solving this, reciprocal interdependency is stable. This reciprocal interdependency incurrences value complexity since through exchange value is a moving target. Given this stable state of reciprocal interdependency, the case reveals how through grouping customer value is re-negotiated through grouping

people. This renegotiation concerns operational goals which are embedded in more stable overall goals. These overall goals are associated with logistics quality, simply achieving service provision to the right, time, place and format a right price. "Customer value" is accordingly proposed as a concept that resides at two level of aggregation, 1) the more stable strategic and the more dynamic operational. Developing value co-creation is associated with two prime factors: 1) understanding the nature of inter-dependencies in the exchange economy impacting on the importance of intensive technology, and 2) develop quality exchange processes through supply chain integration mechanisms found in SCM adapted to the degree of need for mutual adjustment in dyads.

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CUSTOMER VALUE MANAGEMENT FRAMEWORK FOR SUPPLY CHAINS

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Abstract
Purpose of this paper
Customer value has been a relevant topic in marketing research for a long time but it has only recently got attention in logistics and supply chain management (Lin & Ou 2011). Research on customer value has been focused on how to recognise value and how to classify value determinants in general, and a more precise viewpoint into supply chain interfaces is needed. In this paper we present a model that helps companies and researchers to identify and manage customer value as a part of supply chain management.

Design/methodology/approach
The paper consists of a literature review of customer perceived value and supply chain management and a multiple case study of six companies. Three rounds of theme interviews were conducted in the companies, and in addition some stakeholders were interviewed. Customer value was examined as both tangible and intangible value both in B2C- and B2B-markets.

Findings
It was discovered that the systematic identification and management of customer value is uncommon, and its emphasis is on personal relations with customers. Supplier's product promise, customer's freedom of choice and appropriate e-services were identified as key factors of customer value in deliveries. It was also observed that the employees of the supplier companies can more effectively comprehend customer value if the concept is supported by a structured model, although usage of such a model may limit or direct attention to certain aspects.

Value
Customer value has been previously looked into and seen mostly from the company's direct customer's perspective only (Lindgreen et al. 2012). The results provide a new way to detect customer value and its influence through supply chain. The created framework divides the determinants into three classes – point-form, through-going and transferring customer value and these classes provide a basis to manage different customer value determinants variously without fastening on other value classifications (e.g. Rintamäki et al. 2007).

Research limitations/implications
Customer value determinants in service business were not separately investigated and more research on the framework's applicability on pure service delivery will be needed.

Practical implications
As a result, a framework was developed that can be used by companies to identify factors affecting value in different parts of supply chain. This model enables companies to find value determinants that affect not only its own business interfaces but also their far-reaching consequences. The framework can also be used to analyse the effects of the value factors from the end user's perspective throughout the supply chain. That enables companies to better proportion and target their actions on customer value determinants

depending on their effects for final customer's experience. The research and framework creation process helped companies to understand that customers don't see all value determinants equal and therefore also different management processes for different types of determinants are needed.

INTRODUCTION

Customer value is the holistic experience of the customer from a product or service. It is a combination of the resources that customer uses for the purchase and the benefits that the customer receives by making the purchase.

Customer value has been a relevant topic in marketing research for a long time (Banyte & Dovaliene 2014; Payne & Holt 2001) but it has only recently got attention in logistics and supply chain management research (Lin & Ou 2011). Research on customer value has been focused on how to recognise value and how to classify value determinants in general, and a more precise viewpoint into supply chain interfaces is needed.

The purpose of this study is to review the current literature on customer value in the context of supply chain management and to analyse the role of customer value in developing supply chains. Furthermore, we aim to identify factors affecting the customer value especially in the transport and distribution functions of the supply chains of case companies. The research questions are as follows:

1. What does customer value mean in the context of supply chain management?
2. What factors in the supply of products or services affect the customer value experience of a customer?
3. How can these factors be managed as a part of holistic supply chain management?

CUSTOMER VALUE

Various definitions for customer value have been proposed by a number of researchers. Zeithaml (1988) created a purchasing model which combines product price and quality into value. Webster (1994) defined customer value as a service or product promise, which meets customer needs, matches company's core competencies and enables a shared perception of the product or service between the company and the customer. Woodruff (1997) highlighted the importance of the needs of the end use of a product at customer's home and developed a three-level hierarchy of customer expectations. At the bottom level are expected and imagined product features, at the second level the features that appear in the use and at the top level the customer's need and purposes for the product. These needs and purposes in the end succeed or fail to meet the experience of the use of the product and lead to experienced customer value. Rintamäki et al. (2007) categorize the factors affecting customer value into economic, functional, emotional and symbolic values, while Anderson et al. (2009) use economical, technological, service and social benefits. These aspects can be presented as a customer value matrix (Figure 1). A company can use the matrix to identify and develop its customer value by evaluating whether each step in the matrix is the primary motivation for the customers to purchase their product or service.
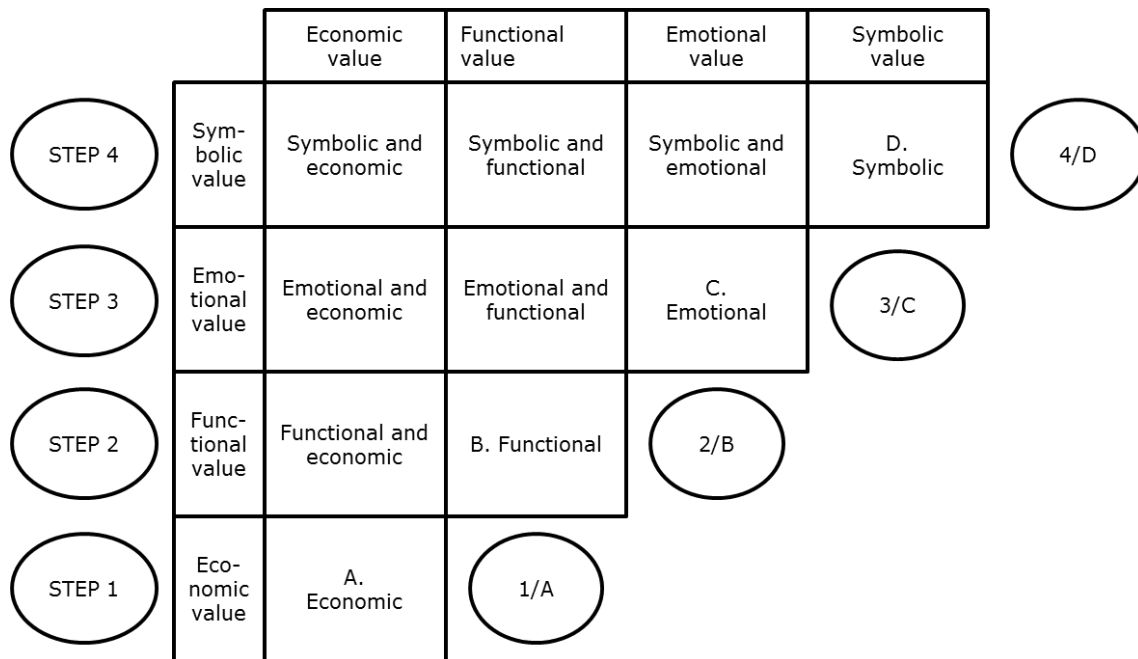
		Economic value	Functional value	Emotional value	Symbolic value	
STEP 4	Symbolic value	Symbolic and economic	Symbolic and functional	Symbolic and emotional	D. Symbolic	4/D
STEP 3	Emotional value	Emotional and economic	Emotional and functional	C. Emotional		3/C
STEP 2	Functional value	Functional and economic	B. Functional			2/B
STEP 1	Economic value	A. Economic				1/A

Figure 1: Customer value matrix (according to Rintamäki et al. 2007).

Economic value includes essentially the customer's perception of the life cycle costs of a product or service. It is commonly the most important factor of customer value and its effects are difficult to overturn by other values. *Functional value* is based on the customer's perception of the practicality of the product or service but also the practicality of the purchasing process. The economic and functional values are tangible values and can be fairly easily measured and managed. The intangible values, on the other hand, are more difficult to measure and are more commonly measured by comparing alternative products or services. *Emotional value* can be experienced even though the economic or functional value of the product would be low. Emotional value may also be increased if the purchasing process is pleasant. *Symbolic value* relates in the consumer markets to the customers need of self-expression and in the business markets to the customers need to differentiate their product. Symbolic value is often related to brands, but it may also be achieved through more common features, such as environmental aspects. Symbolic value means that the product or service has a purpose beyond its actual utilitarian purpose. (Rintamäki et al. 2007)

Regardless of the variety of definitions of customer value common features of customer value definitions are, firstly, recognition of its strategic significance in creating competitive advantage and, secondly, recognition of customer orientation in developing it (Rintamäki et al. 2007, Anderson et al. 2006). Sanchez-Fernandes & Iniesta-Bonillo (2007) reviewed customer value literature and analyzed the use of related terms. According to their findings terms *perceived value* or *customer perceived value* would the most accurate for the definition presented in the beginning of this paper. These terms are widely used in literature. However, some researchers (e.g. Flint et al. 2002) include the *experienced value* as a part of customer value and this broad definition and the term *customer value* are used in this study. This study also utilizes the customer value matrix by Rintamäki et al. (2007) to identify and manage the factors affecting the customer value.

CUSTOMER VALUE IN SUPPLY CHAIN MANAGEMENT
Francis et al. (2014) used content analysis to investigate the meaning of 'value' in purchasing, logistics and operations management literature. They concluded that there is no common definition of value within these fields. Several parallel terms are used and there is a lack of theoretical and definitional rigor. Rintamäki et al. (2007) argue that

competitive advantage and customer value are connected through value creation and value supply. This connection highlights the need of studying supply chain management, because service promises, such as 'we will deliver the product within a week from order', are a significant part of product promise. Slater & Narver (1994) point out that a company may lose its competitive advantage if it fails the delivery.

Even the term supply chain management has been redefined or even replaced in the 21st century to include value creation and supply, hence the terms value chain management or value network management. Al-Mudimigha et al. (2004) see value chain management as an addition to supply chain management and propose two solutions for companies to enhance their value chain management. Firstly, supply chains should be optimized in order to maximize the customer value in relation to costs. Secondly, value management and customer orientation should be seen as important within all functions of the company. Holweg & Helo (2014), on the other hand, see value chain management as an alternative aspect of supply chain management and see that successful value chain management includes both measures for enhancing customer value and measures for improving operational supply chain. Additionally, they include purchasing and production decisions, risk management and customer service strategy (including delivery and inventory strategies) to their definition of value chain management.

Within the marketing literature value supply is commonly overlooked by stating that value is created and transferred in the relationship between customer and the company (Lindgreen et al. 2012, Ford 2011). Also Anderson et al. (2009) explain the value supply to consists mainly of developing new products and services and managing the after-sales services. However, supplying products includes physical distribution which also affects the customer value. Pawar et al. (2009) created a value supply process which consists of three phases: value definition, planning and delivery. The delivery phase includes evaluating and choosing the partners for delivering products and services. Choosing the right partners is essential, because the delivery partner represents the company in the customer interactions (Prior 2013).

There are usually several customer interactions within the product or service supply process and each interaction is an opportunity to enhance customer value. Customer value creation is a continuous process and every phase of the supply chain affect it, even if the customers do not see every phase. Hence, all partners in the supply chain should have a common understanding of the end customer's needs and customer value experience and show the importance of meeting those needs in their operations. (Christopher et al. 2011.)

CASE STUDIES
This paper is based on a research project "Determinants of value and vulnerability in customer-oriented service networks" that started at the beginning of year 2014 and was closed in June 2016. The main goal of the project was to develop a management model for multi-actor supply network, and this framework is an independent part of the final results. Multiple research methods were used during the project to investigate the nature of customer value in six company cases (see e.g. Kallionpää et al. ISL 2015).

For this part of the research, three rounds of theme interviews were conducted in the companies in late 2014 and early 2015. Additionally, some stakeholders of the case companies were interviewed (two customer companies and one supplier company). Case companies represent both B2C- and B2B-markets.

All six companies were interviewed with at least two persons from each case company participating the study. The semi-structured interviews were based on questions about customer value recognition, analysis and management. The respondents were asked to first outline how they define customer value, and how the customers of the particular company benefit from their products or services. Additionally, questions like "what kind

of methods do you use to recognize the customer value" were asked, and value management practices were studied from the standpoint of information systems, contact persons and company's network.

FINDINGS

Identifying the customer value in the case companies

In the literature the first common feature of customer value definitions was the recognition of the strategic significance of customer value in creating competitive advantage. Some case companies had taken customer value into account in their strategy with statements such as: 'customer service is our passion' or 'we work for our customers'. However, most strategy statements emphasize aspects which are important to the company internally and irrelevant or even conflicting with the marketing statements. Furthermore, most interviewees at expert or worker levels did not recognize the link between strategy and customer value.

None of the case companies had systematically identified the factors affecting customer value. However, all companies recognized the importance of customer experience and have in practice considered measures to improve customer service and develop products and services that meet customer's needs. Hence, the case companies fulfill the second common feature of customer value definitions, i.e. recognize the importance of customer orientation in developing customer value.

Many interviewees initially praised their company or some features of their product when asked about the benefits for the customer when buying their products or services. As further questions were asked based on the various aspects of customer value it was found that managers had a different view of customer value than workers at more operative level. Managers emphasized the features of the products and efficiency of product manufacturing whereas workers in production, purchasing or sales defined customer value in terms of fulfilling customer's needs. Customer value was defined as, e.g., providing holistic solutions, quality, knowing your customer, good reputation, professional customer service, providing alternatives and competitive price. The answers included somewhat evenly all four aspects of customer value as defined by Rintamäki et al. (2007).

Logistics and customer value

All case companies recognized the importance of having a service promise and fulfilling it. The service promises of the case companies were commonly related to giving a timeframe for services and deliveries, such as home delivery or response from customer service. Service promises should be realistic, but also have some level of ambition. One company had a supplier which always delivered their products in just one third of the delivery time they had promised. If the company begins to rely on this and promises shorter delivery times to customers, it takes the risk of fulfilling a service promise its supplier has not made. If a company fails to fulfill the service promise, it should immediately contact the customer, even before the customer notices the delay. Delivery tracking services were seen as very important in increasing customer value, especially so in B2C markets but also in B2B markets with critical components or project deliveries.

The case companies who use third party logistics service providers (3PLs) expect the companies to give them customer value by developing new services and solutions and are also keen to be involved in the development by testing new information systems, for example. Another important aspect of customer value from 3PLs is an ability to offer the right price in accordance to the service level. Reliability of delivery times and reliability in cargo handling to avoid breakages are important factors. 3PLs should also designate a contact person for each customer and respond quickly to customer service requests. Furthermore, the companies had had several issues with 3PLs requesting price changes during contract periods and this was considered particularly negative in terms of customer value.

Some case companies highlighted that the 3PLs also represent the company to customers and the customer service skills of the driver, maintenance of delivery vehicles and efficiency of loading operations are hence factors of customer value. The role of 3PLs as representatives of shippers has also been identified in the literature (Prior 2013).

SYNTHESIS
Customer value recognition was challenging for company employees in all levels. Particularly so without any framework to simplify the recognition and outlining of value determinants. Customer value cannot be managed if it's not recognized. From the supply chain perspective customer value is created in multiple interfaces and steps throughout the chain, not just in the last supplier-customer interface or in the seller's actions. Because of this, customer value recognition should be extended beyond the company and notice also value determinants formed in the previous steps and interfaces. Value vulnerabilities appear similarly throughout the chain.

Each of the companies in a supply chain try to use their best competencies to provide suitable commodities for potential and current customers. Commodities are often combinations of many components or service and goods. A supplier collects a selection of products and services for customers and sells those for customers refined or directly. Figure 2 illustrates how a supplier provides the alternatives and customer chooses what to buy from the selection. If the supplier has successfully recognized customer needs, the chosen customer value goes through the interface between supplier and customer. A customer combines valuable commodities from multiple sources and again builds offerings for its own customer. In B2C-markets the hourglass of offerings is usually wider because of customer's individual preferences vary more than in B2B-markets.
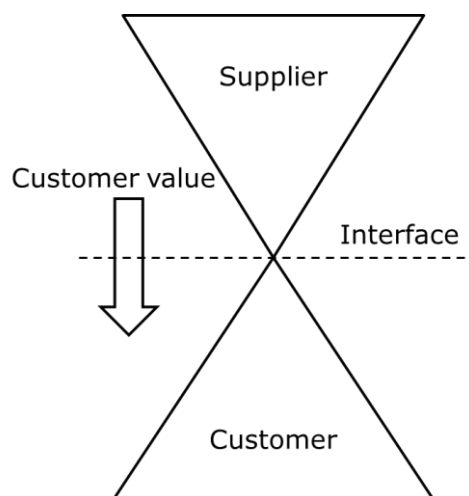

Figure 2: Hourglass of customer value in a supplier-customer interface.

The hourglass illustrates value in one interface but studies from the supply chain management perspective resulted also in another figure to describe a new way of thinking in value management. Customer value determinants can be divided into three types from the supply chain and value management viewpoint (Figure 3). Our supply chain value determinant classification framework can be used with previous classifications such as Rintamäki et al. (2007) value matrix to identify immaterial/material customer value determinants or value in B2B- and B2C-markets throughout supply chains.
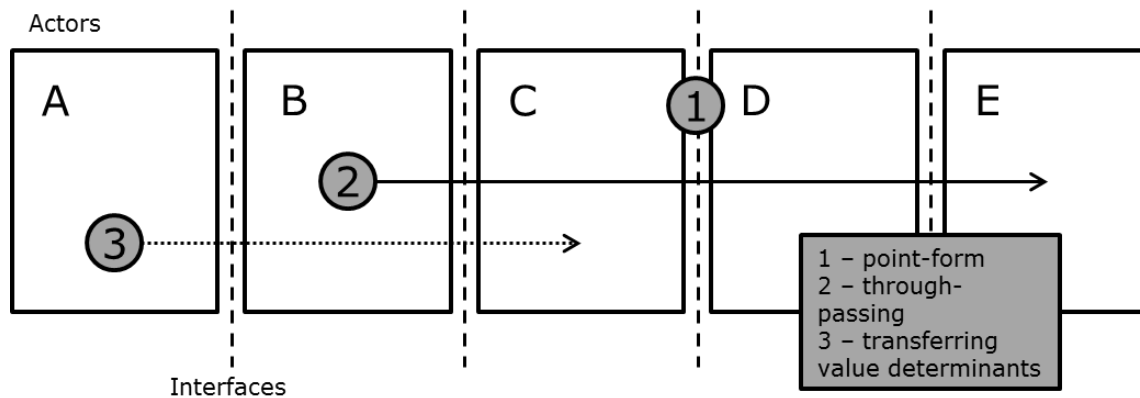
Figure 3: Value determinant classification framework for supply chains.

This framework is shown for a chain but it can be applied to complex supply networks as well. We will now introduce point-form, through-passing and transferring value determinants and the basis and benefits of this classification.

Point-form value determinants
Point-form value determinants appear only at one interface in a supply chain and are not visible for other supply chain actors. Especially emotional value determinants are often point-form since a feeling cannot spread to other actors if they are not in the same situation or they are not told about it. Therefore, managing these value determinants takes place only in this particular interface, and the final customer usually does not care about determinants which appear prior to the last interface, despite of their positive or negative consequences. A point-form value determinant sometimes needs lots of attention to ensure smooth operation in one interface, particularly if it has negative effects on e.g. the well-being of the employees. Point-form value determinants are the easiest to identify because those are close to the analysing actor (C) and the other actors in the supply chain do not need to be involved in the consideration and only the closest interfaces need to be studied. However, it's often valuable to discuss with indirect customers and suppliers too, to enhance cooperation and understanding in every interface of the supply chain. From a supplier's perspective it's always important to serve direct customers well. Customers like tailored service but it's wise to consider how much emphasis to put on point-form value determinants compared to other classes.

Through-passing value determinants
Through-passing value determinants are important to the final customer (E) of a supply chain but other stages in the value chain often miss the importance. These value factors may originate in any stage of the chain but these are not involved the product or process until the end customer. Symbolic value determinants, for example the brand of a component or equivalent are often through-passing from the supply chain management viewpoint. Also functional value determinants are usually designed for the use of final customer and are therefore through-passing value factors. Through-passing value determinants need attention and management because of their high importance for the end customer. The level of actions should be then planned to commensurate with the end customer's perspective.

Transferring value determinants
Transferring value determinants appear in any part of supply chain and may cause actions in multiple interfaces. The difference between transferring and through-passing value determinants is that transferring value factors face the final customer only if other parties fail to stop it to move on (negative determinants) or success to convey it further (positive determinants). Delays in deliveries are typical transferring determinants and those affect the chain as long as the delay is caught up and if it is not possible, also the

final customer suffers value losses resulting from delayed delivery. The significance of transferring factors should be based on possibilities to and the investments needed for management action but also the service for final customer should be considered.

CONCLUSIONS

This research provides a new way to detect customer value and its influence through supply chains. The created framework divides value determinants into three classes – point-form, through-going and transferring customer value and these classes provide a basis to manage different customer value determinants according to their influence on supply chain and customer value beyond a company's immediate interfaces. Supplier's product promise, customer's freedom of choice and appropriate e-services are examples of identified key factors of customer value in deliveries. The framework can also be used to analyse the effects of the value factors from the end user's perspective throughout the supply chain. That enables companies to better proportion and target their actions on customer value determinants depending on their effects on final customer's experience. The research and framework creation process helped case companies to understand that customers don't see all value determinants equal and therefore also different management processes for different types of determinants are needed.

There was no clear difference between B2B- and B2C-markets in understanding customer value or practices to identify and manage it. B2C-companies were more active to survey their customer satisfaction but B2B-companies found close personal relations with customer companies to partly substitute more formal ways to chart customer value. Among the six case companies the two logistics operators were more aware than others of the importance of supply chain management and transportation as a customer value source. That was partly expected because it's their core business, but other companies saw deliveries more as a necessary evil than a possibility for gaining competitive advantage. Customer value determinants in service business were not separately investigated and more research on the framework's applicability on pure service delivery will be needed. Also consumers were not interviewed in this study and that limits the direct applicability to B2C-markets. It was also observed that the employees of the supplier companies can more effectively comprehend customer value if the concept is supported by a structured model. This brings about the question if this kind of frameworks may limit or direct attention to certain aspects of value, and therefore more research on the topic is required.

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Section 9: Smart logistics

ESTIMATING LAST-MILE DELIVERY IMPEDANCE: A CITY LOGISTICS CHALLENGE

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ABSTRACT

Purpose: This paper estimates the potential transportation network impedance to last mile delivery using spatial measures of planning controls. The transport network last mile impedance is defined as the amount of resistance imposed to traverse through a route in a network from the point pick-up to the point of delivery.

Methodology/Design: Impedance to last mile delivery is computed as the potential hindrance or obstruction to last mile delivery as imposed by transportation and planning constraints to movement of goods on a network and not in terms of time or monetary value. A matrix of key urban and transport planning measures is first generated and then aggregated to compute and visualise the last-mile delivery impedance. GIS tools are used to produce overlays to represent transport and planning control measures such as road congestion, parking restriction, loading/unloading bay, speed limit, land use, school zone, dedicated bike/bus path, and proximity to activity centres. Data variables are standardised and converted into same unit (0 -100). An overlay function is used to generate a new layer of last mile delivery impedance. Multi-criteria tools are applied to generate the potential last-mile delivery impedance for Maribyrnong City Council in the city of Melbourne.

Research Findings: The key findings from the study reveal the spatial variation of last mile delivery impedance in different part of the study area and how last mile delivery is impeded by compactness within the Activity Centres, retail zones, pedestrianized streets, the transport infrastructure related constraints. Based on the mapped outputs, a new logistics zoning system is developed to demarcate areas of high impedance to freight flows to help improve the efficiency of last mile delivery to retail businesses within the council.

Research Limitations: The use of static measures of urban planning restricts the robustness to estimate dynamic and real-time last-mile delivery of freight for business to business transactions. The spatial approach is valuable for broader urban planning at a metropolitan or council level but its use is somewhat limited to assist in daily operational and logistics planning.

Practical Implications: The planning and Transport Systems contributes to the severity of last mile delivery problem in urban areas through different land use control measures resulting from city compactness (Alho et al., 2015). The mapped outputs will help urban planners and logisticians in mitigating potential delay in delivery of goods. Localised strategies can then be deployed to improve the delivery lead time to retail businesses particularly in Central Business District experiencing development intensification.

Originality/value of the paper: The relationship between urban planning measures and last mile delivery has neither being theoretically evaluated nor empirically tested. Micro-scale mapping at the street level adds an innovative urban planning dimension to research in last-mile delivery problem.

Keywords: Last miles, city logistics, retail logistics, planning controls and land use.

INTRODUCTION

The 'last mile' delivery in cities is not merely a logistics problem, but also a significant city planning challenge. Last mile deliveries are expected to escalate as a result of increased online retail transactions, changes in demand for global products, and the increased complexity of logistics and supply chain networks. In addition, there are request for a greater variety of goods by consumers, with the reduction in life cycle of products, and limited capacity of warehousing sales floor. The increased demand and the reduction in warehouse capacity results into increased last mile demand frequency in business to business (B2B) last mile delivery and business to consumer (B2C) deliveries. The business to business are last mile delivery that includes retailers and distributors, suppliers of groceries, parts, and large items (furniture and electronics etc.).

Survey of the Australian Bureau of Statistics (2013) indicated that between 2000 and 2012, the volume of last mile delivery by road increased from 139.4 billion 201.5billion tonne kilometre. This is projected to be 1.8 times its 2010 level by 2030. Christopher (2011) estimates last mile city logistics to account for 20 to 30 per cent of all vehicles kilometres. Overall, according to Goodman (2005), last mile delivery accounted for 28% of of all transportation within the supply chain. In addition, last mile delivery has continued to increase in terms of volume, distances and fuel consumption. These developments, together with the need for an agile, lean and just-in-time logistics have accelerated last mile delivery problems (Stratec, 2001).

To add to last mile delivery complexity, government are seeking urban intensification designs based on compact city model with the aim to contain and manage urban growth (Chhetri et al., 2013) and to increase population within the inner city and Activity Centres (Melbourne 2030). Chhetri et al. (2013), highlighted the general purpose of city compactness to include reduction in urban sprawl and support greater utilisation of existing infrastructure and services in more established areas, particularly in the inner and middle-ring suburbs. As a result of the increased densification of housing, and greater concentration of employment and retail services, roads are getting narrower; parking spaces are getting reduced, with increased congestion resulting into delays and loss of productive time and impedance to last mile delivery. Han et al. (2005), estimated that in large urban areas in the U.S, a total delay caused by illegally parked pickup/delivery vehicles to be 500 million vehicle hours annually, costing about $10 billion in lost time. Hence, repeated cycling of the last miles trucks can be attributed to the lack of parking space (curb space) or insufficient off-loading facilities, (Morris 2009), or lack of manoeuvring space as a result of poor road designs and engineering. In addition it has been established that land-use policymakers considered population growth and spatial spread of city separately or in isolation from each other. By extension, last mile logistics characteristics are neglected in policy making process by policy makers (Angel et al., 2011).

In this study, the transport network last mile impedance is defined as the amount of resistance required to traverse a route in a network from the point pick-up to the point of delivery. Resistance may be a measure of transport distance, travel time, transport cost or speed of travel multiplied by distance. Higher impedance scores indicate more resistance to last mile delivery, and a value of zero indicates no resistance. An optimum freight route in a transport network is the path of lowest impedance, also called the path of least resistance or least-cost path. Impedance to last mile delivery is computed as the potential hindrance or obstruction to last mile delivery as imposed by transportation and planning

constraints to movement of goods on the network and not in terms of time or monetary value.

This paper therefore aims to estimate the potential transportation network impedance to last mile delivery using spatial measures of planning controls. The transport network last mile impedance is defined as the amount of resistance imposed to traverse through a route in a network from the point pick-up to the point of delivery. To achieve this aim, the following research questions are set out.

i. What is the key impedance to last mile delivery in an urban setting?
ii. How can urban and transport planning systems linked to last mile delivery in a compact city model?
iii. What methods can be applied to estimate and map the transport network last mile impedance to freight delivery?

This paper begins with a brief review of literature in the city logistics discussion, with particular focus on last mile delivery. The theoretical underpinning of compact city as relates to last mile delivery is carried out. The research methodology is then presented the description of the datasets used and methods employed. Results and analysis are then outlined. The paper finally concludes with a summary of major findings.

LITERATURE REVIEW

City logistics is "the second leg of the logistics network includes pickup and delivery of goods to customers in terms of last mile (LM) delivery Ehimke (2012). This includes the last part of the delivery process. Anderson et al. (1996) consider LM as an integral part of city logistics and characterise it as being the delivery of final products in low volumes and at high frequencies and involves a series of activities and processes that are necessary for the delivery process from the last transit point to the final drop point of the delivery chain. Hence Gevaers et al. (2014), sees it as the "the last part of the supply chain". Given the need for de-bundling of large container load into smaller parcels prior to the final delivery, Gonzalez-Feliu (2015), see LM as "small scale distribution of goods in an urban environment", while Morris et al. (2003), defined LM as the "pick-up /drop-off point to the end customer in commercial buildings". Aized and Srai (2014), considers LM as the final step in business to customer logistics and confirmed that LM is one important step in supply chain in terms of business to business (B2B) and business-to-customer (B2C) paradigms and is responsible for efficient and economical final delivery of goods to customers.

While other aspect of the supply chain can be carried out via different modes of transportation including sea, air and rail, the last mile delivery is carried out mostly via the road. And last mile delivery typically has an average share of 10% in the total urban transport. (London, 2012) confirmed that 90% of last mile delivery are made by road. Thus, Ehmike, (2012) identified last mile delivery to involve transportation over short distances with smaller trucks. It should be noted that the last mile delivery via water or rail is possible in locations where the urban transport infrastructure enables it through the existence of suitable canals or urban rail terminals. Due to the interaction between last mile delivery vehicles and other road users, studies on LM generally concentrate on its negative impact on the environment and transport networks, Anderson (1996).

Policies often formulated by local authorities have hindered last mile delivery by placing restrictions on city logistics (Anderson, 2000; and Dablanc, 2007). Many of these restrictions, if not all, create impedance to last mile delivery. While less efforts has been made by local council in Australia. In Europe, a large number of policy measures have been used, and that local authorities are slowly beginning to acknowledge the need to consider freight in their overall transport planning processes. They demonstrated the requirement for greater interaction between local authorities and freight transport stakeholders with regards to last mile delivery issues. Also local authorities are getting the awareness that that last mile delivery planning can be improved by involving a wider range of stakeholders.

Last Mile and The Compact City Argument.

The concept of compact city is a planning tool that has been widely used in developed countries for cities. The use of the compactness concept often combines various principles of city planning (Jenks et al., 1998). Compactness has been seen as a mechanism for controlling and regulating urban sprawl by promoting a relatively high-density, mixed land-use city structure, supported by a more efficient public transport system and increased opportunities for walking and cycling Chhetri et al., (2013). While compactness is defined as high-density or monocentric development by Gordon and Richardson (1997), Ewing (1997) defines it as means concentration of employment and housing and a greater diversity of land uses. Galster et al. (2001), defined compactness as the degree to which development is clustered to minimise the amount of land developed per square mile. The last mile problem is not solely dependent on the operational efficiency of supply chains and logistics infrastructure and service. They are also influenced by the elements of the built and regulatory environment. Figure 1 shows the interlocking systems within which the
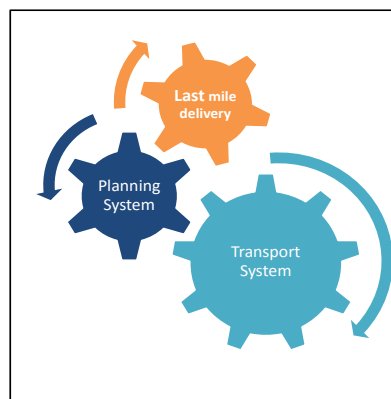
operational efficiency of last mile delivery is dependent. These include: metropolitan planning system and transport system.

Figure 1: Inter-locking interactions between Planning System,
Transport System and last mile delivery.

The strict regulatory environment in most metropolitan cities is largely driven by the intention to mitigate negative aspects of city logistics. Song et al, (2009) identifies growth in vans and large goods vehicles and stated that such vehicles accounted for only 29 per cent of the total growth in vehicle miles CO_2 emissions in the UK. Allen et al., (2012) investigates relationships between road freight transport, facility location, logistics management and urban form in UK. Bozzo et al., (2014) are of the opinion that last mile delivery accounts for 32% of energy consumption, and for 40% of all CO_2 emissions of road transport, and up to 70% of other pollutants from transport. Gonzalez-Feliu et al., (2012) evaluates the impacts of urban goods transport in terms of road occupancy in the city of Lyon, in France. Gonzalez-Feliu et al., (2012) established that last mile delivery amount to 20% of the total road occupancy rates by running vehicles, and to 25% CO_2 emissions of the overall urban transport. However, Morris (2009) observed that the repeated cycling of the last miles trucks can be as a result of lack parking spaces (curb space) or insufficient off-loading facilities. She concluded that space restrictions in CBDs, compounded by increased land values foster compact development, that negatively impact last mile city logistics.

DATASETS USED

For the purpose of this study, Maribyrnong City Council is selected as a case study due to its proximity to the Melbourne Ports and identification as gateway to the western part of Melbourne Metropolitan areas. Datasets are generated through Geographical Information System for planning and transport systems. (See table 1)

Planning and Transport Systems attributes identified are as presented in Table 1. This includes Zones and Particular Provisions in the Planning System. This is as contained within the Victoria Planning Provisions. These two attributes are can directly impact last mile delivery. The type of zone influences the hierarchy of Roads. (Eppell et al, 2001). The hierarchy of road subsequently determine the speed limit. Loading and unloading are as required by the particular provisions of the Victoria Planning Provisions. The availability and adequacy of loading and unloading will impede last mile delivery positively or negatively. Within the Transport System, attributes identified are as identified in Table 1.

Systems	Dimensions	Attributes
Planning System	Planning Controls	Zones – Industrial mix • Residential, Commercial, Activity Centre, and Industrial.
		Particular Provision: • Loading and Unloading
Transport System	Transport Controls	• Speed limit • Road width • Number of lanes • Intersections • Traffic lights • Railway crossing • Zebra crossing • Tram and Train crossing • School Zones • Truck curfew and restrictions • Parking Restrictions • Overhead restriction (bridges, power lines and trees) • Surface type • Bicycle lanes • Kerb side • Service lanes

Table 1: Planning System and Transport System Attributes

METHODS
The proposed research method consists of 5 stages.

Stage 1: Identification of the key attributes of last mile impedance.
The last miles attributes are as listed in Table 1 above. The attributes are categorised into Planning and Transport Controls. The attributes includes zoning and particular provisions (Planning System) and speed limit, road width lanes, intersections and traffic light etc. (Table 1)

Stage 2: Standardisation of attributes
Data standardisation involves the process of converting a batch of data values into standardised units by removing the effects of the average size of the values in the batch and the size of the spread of values of data. For example, data such as speed limit in kilometre per hour or dwelling density per square kilometre are standardised using a common technique of 'max-min procedure'. The original data are converted into measures ranging from 0 - 100 to 0 - 1, based on minimum and maximum values in a set of reference points.

The new set of values are derived by subtracting the minimum value in the distribution from each observed value for each data layer (variable) and expressed as a percentage of the difference between the maximum (max) and minimum (min) values in the distribution.

Formally: *I = [(V-min)/(max-min)] x 100.*

Where, *V is the observed indicator value (after imposition of bounds), and I is the new, rescaled, index-number representation with a value ranging from 0 to 100.*

The formula is reversed for data variables, which have a negative impact on last mile delivery. For these variables, the formula is:

I = [(max-V)/(max-min)] x 100.

The measures are then calculated in such a way that the higher the value of the component variables, the higher the level of last mile delivery impedance (and vice versa).

Stage 3: Assessment of attributes for its potential impact on last mile impedance
The identified attributes are examined in relation to road segments as the independent variable. Other attributes are assessed against the identified roads. A segment is a stretch of road between two intersections. Each segment can thereafter be separated into sub segments as a result of intersection, roundabouts, speed limits and traffic lights. The number of separated segments is considered as a ratio of the overall length of the road segments which form different level of level of impedance to last mile delivery. For example, the higher the number of traffic lights, roundabouts, intersections, etc. and expressed in ratio of the overall road segments.

Stage 4: Development of the last mile network impedance index
Once the data variables are standardised and converted into same unit (0 -100), an overlay function is then employed to generate a new layer of last mile delivery impedance and a composite index applied to define the mathematical function, whereby each of these layers are added and divided by the total number of layers. The formula for composite index described as follows: *Last mile impedance = $V_1 + V_2 + V_3 + ... V_n$*

Stage 5: Mapping of the last mile network impedance
Mapping of the last mile network impedance are carried out using geographic information systems (GIS). Impedance levels are mapped at the road network of the city council using thematic mapping technique. Visualisation of impedance enables the key transport hotspots to be identified. Based on the mapped outputs, a new logistics zoning system are developed to demarcate areas of high impedance to help improve the efficiency of last mile delivery to retail businesses within the Council.

RESULTS AND ANALYSIS
A transportation network last mile delivery impedance index is mapped using a thematic technique. Figure 2, 3 and 4 shows that different segment of the transport networks have different impedance scores due to their attributes which acted as hindrances to movement. Three maps are generated to show the impedance levels in high freight activities. These are: Barkly street linear strip with an agglomeration of retail, restaurants and shopping outlets, West Footscray with limited retail outlets and West Gate Highway-Melbourne port freight route, Figures 2, 3 and 4. The calculated last mile impedance scores are classified into High, Medium and Low impedance.

In figure 2, Barkly Street, Hopkins Street, Droop Street, Geelong Road are with high impedance Index due to their proximity to Footscray Activity Centre – the Maribyrnong Council City Centre. Barkly Street, Droop Street, Hopkins Street, Paisley Streets are within the Footscray Activity Centre and shopping strip with reduced speed limit, high number of traffic lights, pedestrian crossings, tram crossings/stops and bus routes/stops. The entire length of Droop Street is shared with tram line accounting for the high impedance index.

Figure 3 reveals an overall medium impedance index. Somerville Road, Francis Road returns high impedance. The mapped area is in proximity with the Port of Melbourne and warehouses serving the western suburb of Melbourne. Road network in the mapped area traverse through residential developments with reduced speed limit, crossings, overhead bridges (from train tracks) truck restrictions, more traffic lights and bus routes.

Figure 4 reveals a low impedance index. Most of the roads in the map return a low impedance scores. The road network in the mapped area are characterised with less intersection, traffic lights. The mapped area does not have any shopping strip, tram routes and less bus routes/stops resulting in an overall low impedance index.
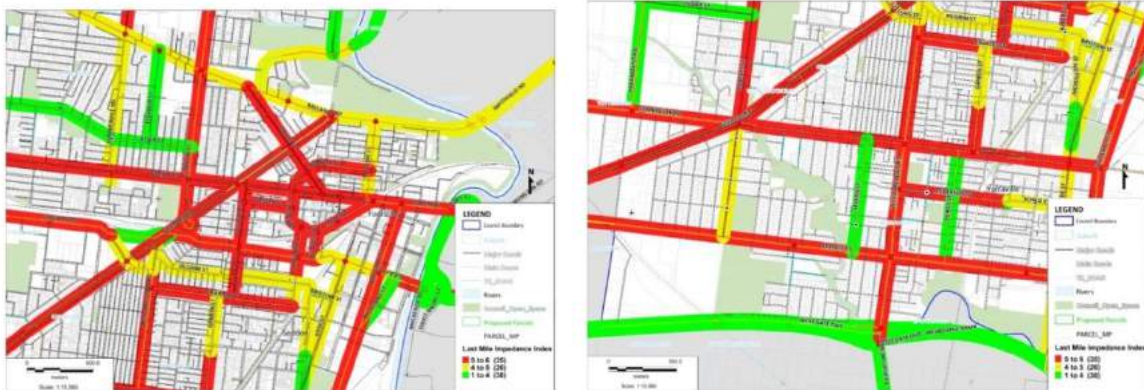

Figure 2 and 3: Barkly Street Last Mile Impedance Index and West Gate Last Mile Impedance Index

Figure 4: West Footscray Last Mile Impedance Index

CONCLUSION

The paper identified the potential planning and transport systems attributes of the last mile delivery impedance for B2B delivery. GIS is proposed as the key tool to map the last mile transport network impedance.

The key findings from the study reveal the spatial variation of last mile delivery impedance in different part of the study area and how last mile delivery is impeded by compactness within the Activity Centres, retail zones, pedestrianized streets, the transport infrastructure related constraints. Based on the mapped outputs, a new logistics zoning system is developed to demarcate areas of high impedance to freight flows to help improve the efficiency of last mile delivery to retail businesses within the council.

The mapped outputs will help urban planners and logisticians in mitigating potential delay in delivery of goods in the last mile component of supply chains. Localised strategies such as the designing of a dedicated delivery corridor, alternative routing and time-window

based loading/unloading can then be deployed to improve the delivery lead time to retail businesses, particularly in the Central Business District or a pedestrianised precinct.

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EXPLORING THE DEVELOPMENT OF AN INTERNET OF THINGS (IOT) ENVIRONMENT FOR VALUE GENERATION IN THIRD-PARTY LOGISTICS OPERATIONS

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Abstract
Purpose of this paper:
Advances in sensor technology and ubiquitous broadband communication have set the foundation for Internet of Things (IoT). In the IoT paradigm, many of the things that surround us will be on the network in one form or another (Gubbi et al., 2013). Xu et al. (2014) state that the integration of sensors/actuators, RFID tags, and communication technologies serves as the foundation of IoT and explains how a variety of physical objects and devices around us can be associated to the Internet and allow these objects and devices to cooperate and communicate with one another to reach common goals.

In IoT, unstructured data generated by users' mobile devices and sensors can be used to generate value through new business models and efficient operations. For example in IoT, smart meter data exchange for residential, office, industrial and electric and plug-in hybrid vehicles can be used for better data analytics for the smart grid and management of supply chains. The aim of this work is to investigate the feasibility of developing a value generating environment by using wireless sensors to support IoT and related initiatives such as the smart grid and electrification of vehicles involving a third-party logistics provider (3PL).

Design/methodology/approach:
This paper has considered the use of an industry case comprising a 3PL which provides catering services to the airline industry. The 3PL assembles food and drink trolleys which are sent to a nearby airport using trucks. In this scenario there is the potential for increasing the numbers of sensors, smart meters and use of electric plug-in vehicles. Wireless Sensor Network (WSN) theory can simulate the use of smart meters and sensors. These can transmit meter readings to a cloud-based big data platform as the information exchanged is non-structured. The low-energy adaptive clustering hierarchy (LEACH) algorithm is suitable to test the use of WSN for the common network platform requirements of IoT. A Matlab implementation of the LEACH algorithm was used in this work. The model considered an area of 2500 m X 2500 m, which represents the area between the preparation warehouse and the airport terminal.

Findings:
WSN offers several advantages such as low network clustering which allows bandwidth reuse, better resource allocation and better energy management/power control. According to the values obtained for 135 iterations, the number of packets sent by 8 nodes to the base station reached 6, for 16 nodes the number of packets sent reached 18 for 40 nodes the number of packets sent to the base station reached 25. For 20 nodes the number of packets sent to the cluster head is equal to 6. For 16 nodes the number of packets sent is equal to 16 and for 40 nodes the number of packets reaches 52. For 8

nodes the initial energy supplied is equal to 10 J, for 16 nodes is 30 J and for 40 the amount is 50 J. In the scenario presented here, the number of packets sent can be related to data traffic associated to metered readings required in the delivery of goods to an airport terminal. The adequate management of energy in the network means nodes will have enough energy left to complete the iterations associated to the task of going to the airport to deliver the trolleys.

Value:
The scenario presented in this paper involving a 3PL preparing food and drink trolleys delivered to an airport terminal show the scale of the potential impact of WSNs in logistics and transportation in general. Within the paradigm of IoT, we can see WSNs being adopted for other applications including sensor deployment in urban downtown areas or in the highway network. These scenarios may benefit extensively from the existence of a convergence platform capable of serving the needs of various types of users. Finally, research in IoT involving logistics and supply chain has great potential but at the same time IoT poses new challenges for privacy and security which they need to be addressed.

Research limitations/implications (if applicable):
IoT represents a major paradigm which is influencing several sectors and transport/logistics is one of them. WSNs represents one technology among a myriad of different technologies that can be used in IoT. What is important to highlight is that WSNs need to be integrated to other technologies to support IoT ubiquitous access to information. WSNs can be part of convergence network platforms, grouping different technologies for IoT. This work demonstrated that WSNs can be considered as an essential components of the sensor layer comprising the IoT paradigm and support the network and application layers.

Practical implications (if applicable):
IoT is closely related to other major initiatives such as smart grid and intelligent transport systems. Hence, future research work needs to investigate the associated economic impact of adopting a convergence network platform to support the integration of IoT with other paradigms.

INTRODUCTION

In 1999 Kevin Ashton coined the term 'Internet of Things' (IoT) in the context of supply chain management (Gubbi et al., 2013). IoT is the ability to collect instant information of anything and everything. According to Li et al. (2015) the future of the Internet will consist of heterogeneously connected devices that will further extend the borders of the world with physical entities and virtual components.

Information and communication technology (ICT) plays a fundamental role in the support of supply chains and global logistics and in the growth of IoT in supply chain management. Recent developments in the field of ICT have further revolutionized the ways information is shared and supply chains are structured (Harris et al., 2015). In transport logistics the application of ICT is to facilitate activities such as cargo tracking, warehousing, and shipment notice forwarding, in support of product movement in the supply chain (Wong et al., 2009).

Xu et al. (2014) state that the integration of sensors/actuators, RFID tags, and communication technologies serves as the foundation of IoT and explains how a variety of physical objects and devices around us can be associated to the Internet and allow these objects and devices to cooperate and communicate with one another to reach common goals. Advances in sensor technology and ubiquitous broadband communication have set the foundation for IoT. In the IoT paradigm, many of the things that surround us will be on the network in one form or another (Gubbi et al., 2013).

Furthermore, IoT is a paradigm that is closely associated to other important concepts such as the smart grid. The smart grid relies on the use of network platforms where meter readings and data can be transmitted. The smart grid has been defined as an 'electricity network that can cost efficiently integrate the behaviour and actions of all users connected to it in order to ensure an economically efficient, sustainable power system with low losses and high levels of quality and security of supply and safety (ERGEG, 2009).

In IoT, unstructured data generated by users' mobile devices and sensors can be used to generate value through new business models and efficient operations. For example in IoT, smart meter data exchange for residential, office, industrial and electric and plug-in hybrid vehicles can be used for better data analytics for energy management in logistics and transportation. The aim of this work is to investigate the feasibility of developing a value generating environment by using wireless sensors to support IoT and related initiatives such as the smart grid and electrification of vehicles involving a third-party logistics provider (3PL).

LITERATURE REVIEW

In the view of Li et al. (2015) the emerging wirelessly sensory technologies have significantly extended the sensory capabilities of devices and therefore the original concept of IoT. According to the authors a number of technologies are involved in IoT, such as wireless sensor networks (WSNs), barcodes, intelligent sensing, Radio frequency identification (RFID), low energy wireless communications, cloud computing, among others.

In recent years transport logistics operations have witnessed the adoption of various technologies. For example, RFID tags are widely used to track and trace different types of cargoes. The RFID tag may be attached directly to the cargo or carried by the driver/operator of a haulage vehicle. Technologies broadly used to link haulage vehicles include cellular networks and satellite systems and in a lesser scale Wi-Fi, UMTS, 4G/LTE and WiMax. Satellite systems are good for traffic data applications but unusable for tolling and mileage based user fees. For many years in the logistics industry satellite systems have been used for real-time track and trace of trailers and cargo. In logistics and transportation cellular networks are commonly used to forward instructions to drivers and operators. Cellular networks comprising 4G/LTE can be used for probe data but unusable for vehicle-to-vehicle safety. Wi-Fi is optimized for indoor use rather than motor vehicles. WiMax supports high-speed data transmission but it cannot be used for vehicle-to-vehicle safety. A comprehensive review of the above technologies can be found in the works by Marousek et al. (2008) and Ribeiro (2006). Despite the proliferation of all these technologies, significant challenges still persist in terms of reliability and connectivity, problems due to difficulties associated with limited range, scalability and security (Coronado et al., 2009).

Wireless Sensor Network (WSN)

According to Chi et al. (2014) wireless sensor network (WSN) theory has been employed to collect data about physical phenomena in various applications such as habitat monitoring, and ocean monitoring, and surveillance. Ubiquitous connectivity has been made possible by advancements in Internet technologies and WSNs (Kelly et al., 2013). Sensor data acquisition interface equipment is one of the key parts in IoT applications. Data collection is the essential application of WSN and more importantly it is the foundation of other advanced applications in IoT environments (Chi et al., 2014). WSN is one key smart sensor technology that is driving the future of IoT (Kelly et al., 2013). Since IoT is associated with a large number of wireless sensor devices, it generates a huge number of data (Chi et al., 2014).

Wireless sensor networks (WSNs) have several common aspects with wireless ad hoc networks as in a WSN the data is forwarded, possibly via multiple hops, to a *sink* (sometimes denoted as *controller* or *monitor*) that can use it locally or is connected to other networks (e.g., the Internet) through a gateway/base station (Buratti et al., 2009). A WSN can be generally described as a network of nodes that cooperatively sense and may control the environment enabling interaction between persons or computers and the surrounding environment (Verdone et al., 2008). In a WSN, the activity of sensing, processing, and communication under limited amount of energy, ignites a cross-layer design approach typically requiring the joint consideration of distributed signal/data processing, medium access control, and communication protocols (Verdone, 2008). The theory of WSN offers significant advantages in the context of a common network platform that supports IoT and other initiatives such as smart grid in logistics and transportation.

Wireless sensor network (WSN) theory can be used to simulate the operation of a common network platform for IoT. In WSNs the nodes can be stationary or moving, they can be aware of their location or not and they can be homogeneous or not and alternatively, it is possible to have a scenario with multiple sinks in the network (Buratti et al., 2009). In a WSN a *sink* is commonly known as *cluster head*. Given a certain level of node density, a larger number of sinks will decrease the probability of isolated clusters of nodes that cannot deliver their data owing to unfortunate signal propagation conditions (Buratti et al., 2009).

In IoT the interaction of various technologies can be represented as layers which reflect the tasks and functionality enabled by them. For example WSN can be located at the sensor layer where all the measuring activity takes place. At the same time WSN interacts with the network layer comprising access points, switches, routers, etc. which will transmit data to the applications run by the user. At the most upper level we can find the application layer where application servers and clients are located. Figure 1 depicts the three technology layers in the context of IoT.
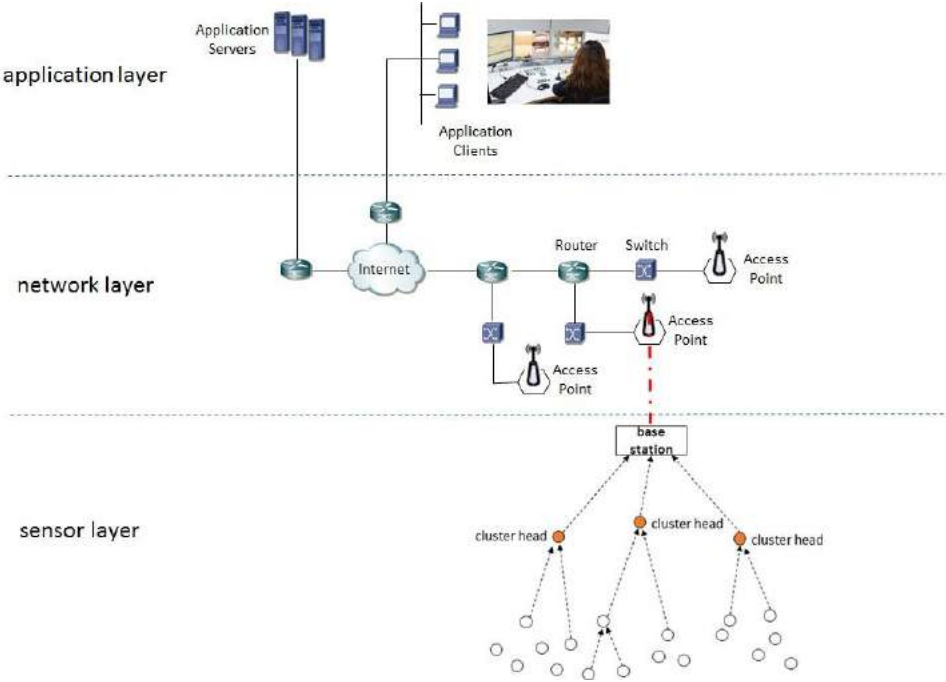

Figure 1. Proposed sensor, network and application layers in the context of IoT.

In a common network platform for IoT and based on WSN theory, sensors are present in the meters that transmit readings for power consumption or communicate data about

energy storage to the grid. Sensors can be used in vehicular applications to receive traffic and non-safety commercial information and transmit vehicle-status information to other vehicles and roadside units.

The sensor layer is particularly important as it must meet good protocols for wireless micro sensors. Wireless micro sensors are key to support ubiquitous access and transmission of data. Hence, according to Kwon and Gerla (1999) a sensor network protocol may include metrics such as ease of deployment (nodes being able to communicate with each other even in the absence of an established network infrastructure and predefined node locations); system lifetime (all aspect of nodes designed to be extremely energy efficient); latency (reception of data in a timely manner) and quality (protocols designed to optimize for the unique, application-specific quality of a sensor network).

The low-energy adaptive clustering hierarchy (LEACH) algorithm is suitable to test the use of WSN for the common network platform requirements of IoT. The algorithm is a protocol architecture for micro-sensor networks that combines the ideas of energy-efficient cluster-based routing and media access together with application-specific data aggregation to achieve good performance in terms of system lifetime, latency, and application-perceived quality (Coronado et al., 2012). According to Heinzelman et al. (2002), LEACH is characterized for using: a) randomized, adaptive, self-configuring cluster formation; b) localized control for data transfers, c) low-energy media access control (MAC) and d) application specific data processing. Based on WSN theory, in the LEACH algorithm the cluster head node receives data from all the cluster members, performs signal processing functions on the data (e.g., data aggregation), and transmits data to the remote base station and all non-cluster head nodes transmit their data to the cluster head.

The use of the LEACH algorithm makes a number of assumptions according to Heinzelman et al. (2002): all nodes can transmit with enough power to transmit to reach the base station, power control to vary the amount of transmit power, computational power to support different MAC protocols, nodes always have data to send to the end user and nodes located close to each other have correlated data. The assumptions listed in the previous paragraph are suitable for the requirements of a WSN-based common platform to support the exchange of messages for IoT. The use of the LEACH algorithm enables to test the reliability of the packets sent from sensors to the base station and also test energy management/power control through randomized rotation that prevents draining the battery of any one sensor in the network.

DESCRIPTION OF THE PROBLEM

WSN can be used to support myriad of applications for IoT involving logistics and transportation. WSN theory based on the LEACH algorithm can simulate the use of smart meters and sensors to transmit meter readings to a cloud-based big data platform. To illustrate the use of WSN theory in a particular logistics application in the context of IoT, we have considered the use of an industry case comprising a 3PL which provides catering services to the airline industry. The 3PL assembles food and drink trolleys which are sent to a nearby airport by truck. Figure 2 depicts an IoT scenario based on the use of WSN theory comprising a base station, cluster heads and sensors for the transport of food and drink trolleys that go into aircraft.
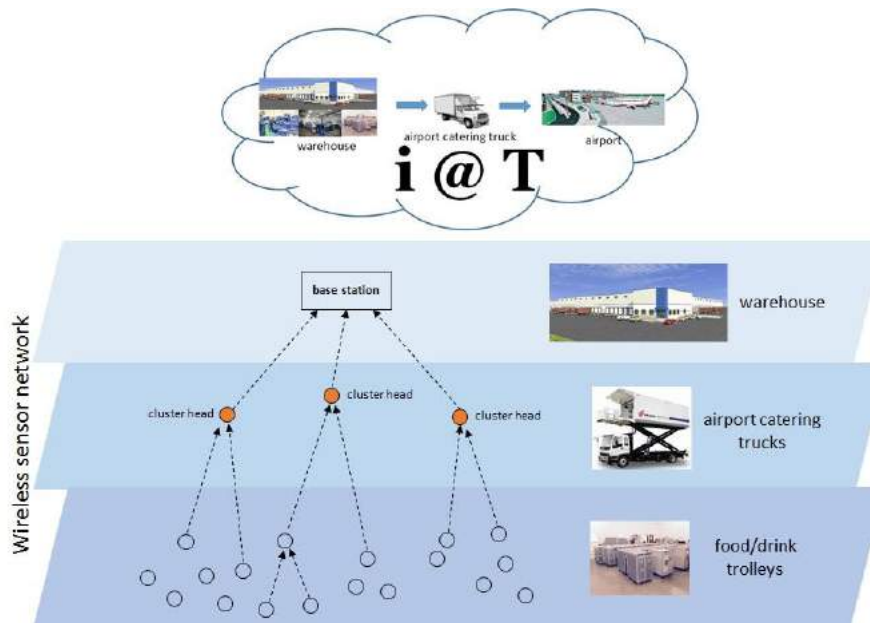
Figure 2. Representation of WSN use for airport catering application.

It takes 15 minutes for a truck to drive from the preparation warehouse to the airport terminal where the food and drink trolleys are delivered. A truck is dispatched 17 times a day. Each truck transports enough food and drink trolley carts for two flights. In this scenario there is the potential for increasing the numbers of sensors attached to various pieces of equipment such as the food and drink trolleys rather than having them attached to the truck only.   In figure 2 the base station can be based at the preparation warehouse and the sensors represent cluster heads are set in each of the eight trucks used to make the deliveries. One flight comprises four trolleys, therefore each truck transports 8 trolleys that will be loaded into the aircraft. This configuration gives the possibility of creating clusters comprising the trucks and the trolleys transported. The use of clustering offers several advantages including bandwidth reuse, better resource allocation and better energy management/power control (Kwon and Gerla, 1999). A simple configuration could have comprised sensors attached just to the trucks. However, WSN allows high levels of granularity, hence sensors can be attached to food and drink trolleys resulting in more accurate readings and monitoring. A value-generating environment for this operation may comprise the use of sensors to monitor the energy state in real time, the condition of the goods transported (i.e. food and drink), security of good transported (i.e. that they have not been tampered) and smart metering for power consumption associated to the operation of the refrigeration system among others. Furthermore, smart metering capabilities will be extended if catering trucks adopt electric or plug-in hybrid powertrains. That means better control of power consumption and monitoring of battery degradation.

RESEARCH WORK

A Matlab implementation of the LEACH algorithm was used in this work. The results shown in figure 3 considered an area of 2500 m X 2500 m, which represents the area between the preparation warehouse and the airport terminal. The LEACH algorithm places nodes randomly throughout the designated area which can represent the catering trucks and the transport of food and drink trolleys they transport. The LEACH model parameters include the initial energy supplied to each node (E_0) equal to 0.5 J. For each one the energy required to transmit/received a message over the designated distance (E_{elec}) is equal to 50 nJ/bit. The energy used for data aggregation (E_{DA}) is equal to 5 nJ/bit/signal. The bandwidth of the channel was set to 1 Mb/s and each data message was 500 bytes long (Heinzelman et al., 2002).

RESULTS/ANALYSIS

The simulations comprise three cases of 8, 16 and 40 nodes randomly distributed with the probability of a sensor to become a sink/cluster head rated at 0.1. The distance between the cluster and the base station is 2500 m. The number of iterations simulated was 135 as these are the number of trips the trucks make on a given day.

The results show that when the number of nodes is low, say 8, the number of packets sent to the base station experience a high growth rate as iterations increase. On the other hand, when the number of nodes present is higher, say 16 and 40, the increase in the number of packets to the base station experience a low growth rate which tend to stabilize as iterations increase and it does represent an attractive proposition for the purpose of real time track and trace. The number of packets sent between clusters was simulated as this has an effect on the performance of a WSN. The values plotted in figure 3 shows that when the nodes present in the network is low, say 8 for an area of 2500 m X 2500 m, the number of packets exchanged between clusters experience high growth levels.
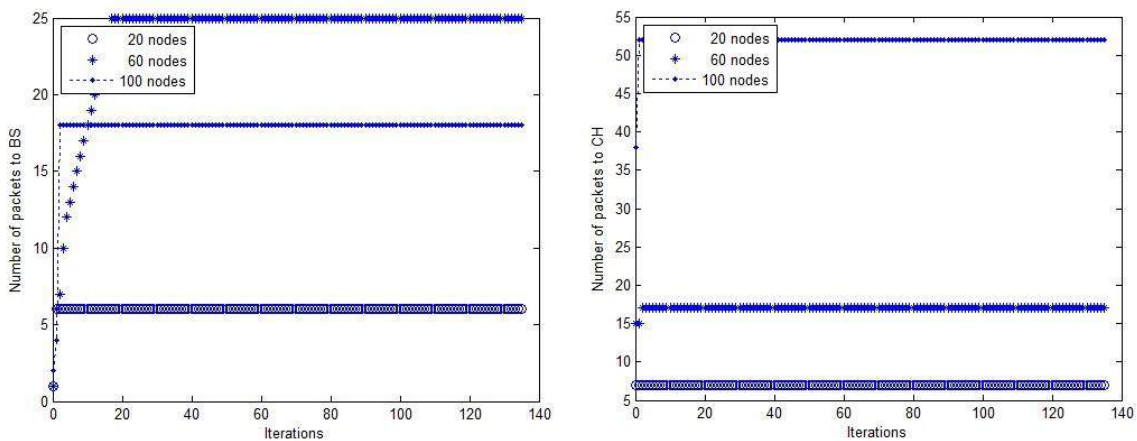

Figure 3. Results from simulations using WSN based on LEACH algorithm

According to the values obtained for 135 iterations, the number of packets sent by 8 nodes to the base station reached 6, for 16 nodes the number of packets sent reached 18 for 40 nodes the number of packets sent to the base station reached 25. For 20 nodes the number of packets sent to the cluster head is equal to 6. For 16 nodes the number of packets sent is equal to 16 and for 40 nodes the number of packets reaches 52. For 8 nodes the initial energy supplied is equal to 10 J, for 16 nodes is 30 J and for 40 the amount is 50 J.

In the scenario presented here, the number of packets sent can be related to data traffic associated to metered readings required in the delivery of goods to an airport terminal. The number of iterations can be spread for the total duration of the working day, which is about 17 hours or 270 flights. The more nodes present in the network the more packets and frequent readings can be sent, however this will entail an increase in energy consumption. The adequate management of energy in the network means nodes will have enough energy left to complete the iterations associated to the task of going to the airport to deliver the trolleys. The amount of energy supplied to the network of sensors is still negligible as for 40 nodes the total amount of energy supplied was 50 J which equals 0.0138 watt-hour. Finally, for the deployment of WSN in industrial environments, it is important to consider the physical obstructions present in the site however in the case of the area between the warehouse and airport terminal there are few obstructions or tall buildings present.

DISCUSSION

Based on the principles of WSN and their increasing importance for IoT, this paper looks at the sensor layer and proposes a common network platform that makes use of the the low-energy adaptive clustering hierarchy (LEACH) algorithm. Given the needs of IoT and ubiquitous access to information, the use of WSN offers several advantages such as low network clustering which allows bandwidth reuse, better resource allocation and better energy management/power control. These are important characteristics required to support the operation of delivering of catering services to an airport terminal given all the security regulations in place.

Mirroring vehicle movements between the warehouse where food and drink trolleys are prepared and the airport terminal, WSN nodes can be stationary or moving, they can be aware of their location or not and they can be homogeneous or not. Low-energy consumption and data transmission capabilities make WSN nodes suitable for around the clock track and trace requirements. Moreover, WSNs are suitable for environments where energy consumption needs to be under control due to continuous energy price updates.

Given the magnitude of the challenges ahead, future research work associated to IoT will have to investigate more scenarios where WSNs can be deployed. On the other hand key information to be exchanged needs to use secure communication protocols for the transmission of meter readings, customer details and transactions linked to commercial service applications supported by WSNs.

CONCLUSIONS

IoT represents a major paradigm which is influencing several sectors and transport/logistics is one of them. WSNs represents one technology among a myriad of different technologies that can be used in IoT. What is important to highlight is that WSNs need to be integrated to other technologies to support IoT ubiquitous access to information. WSNs can be part of convergence network platforms, grouping different technologies for IoT. This work demonstrated that WSNs can be considered as an essential components of the sensor layer comprising the IoT paradigm and support the network and application layers.

WSN offers several advantages such as low network clustering which allows bandwidth reuse, better resource allocation and better energy management/power control. These are important characteristics required to support the operation of sensors, smart meters and in some cases electric and plug-in hybrid vehicles used in jobs performed by 3PLs.

IoT is closely related to other major initiatives such as smart grid and intelligent transport systems. Hence, future research work needs to investigate the associated economic impact of adopting a convergence network platform to support the integration of IoT with other paradigms. These may include among others: economic outcomes, sustainability, resilience and security. For example, we can see that in the future WSNs can assist organisations in the electrification of vehicles, replacing diesel-powered equipment with the use of electric power/battery operated.

The scenario presented in this paper involving a 3PL preparing food and drink trolleys delivered to an airport terminal show the scale of the potential impact of WSNs in logistics and transportation in general. Within the paradigm of IoT, we can see WSNs being adopted for other applications including sensor deployment in urban downtown areas or in the highway network. These scenarios may benefit extensively from the existence of a convergence platform capable of serving the needs of various types of users. Finally, research in IoT involving logistics and supply chain has great potential but

at the same time IoT poses new challenges for privacy and security which they need to be addressed.

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AN EXPLORATORY STUDY OF INTERNET OF THINGS (IOT) ADOPTION INTENTION IN LOGISTICS AND SUPPLY CHAIN MANAGEMENT

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Abstract
Purpose of this paper:
Internet of Things (IoT) envisions a global infrastructure of networked physical objects that render radical transparency to the supply chain. Despite perceived advantages of IoT, IoT-enabled logistics and supply chain management are still not widely adopted in industry. To understand the incentives and concerns behind firms' decisions to adopt IoT, the primary purpose of this paper is to explore determinant factors affecting IoT adoption in logistics and supply chain management.

Design/methodology/approach:
This study uses mixed methods research to explore determinants of IoT adoption intention in logistics and supply chain management. A qualitative analysis using grounded theory methodology is used to reveal underlying perceptions regarding logistic innovation with IoT. Quantitative hypotheses are then developed based on qualitative investigation and adoption literature. Survey data were collected from the managerial staff of Taiwanese firms across various industries. Structural equation modelling with partial least square is used for data analysis.

Findings:
The results of qualitative study identify uncertainties and issues regarding firms' intention to accept or reject IoT technology in logistics and supply chain management, including benefit and cost aspect of adopting IoT, perceived trustworthiness of IoT technology, and external pressure to embrace IoT. The resulting quantitative model shows that perceived benefits, perceived costs, and external pressure are significant determinants of IoT adoption intention, while technology trust is not. However, technology trust will indirectly influence IoT adoption intention through perceived benefits.

Value:
This paper is among the first known to examine IoT adoption intention in logistics and supply chain management using mixed methods research. The mixed methods approach offers a better insight in understanding incentives behind firms' decisions to adopt IoT than the use of either qualitative or quantitative methods alone.

Practical implications:
The empirical findings of this study can provide some guidelines for logistics and supply chain managers to evaluate IoT adoption in their firms.
Likewise, IoT solution providers can also benefit from this work by improving their solutions to mitigate the IoT adoption concerns addressed by this paper.

INTRODUCTION

The Internet of Things (IoT) has inspired many innovative applications of logistics and supply chains in recent years, and will have far-reaching influences on future supply chains. The ideal IoT is that each Object has its own Digital Object Identifier (DOI), which is able to connect to the internet (Gershenfeld, Krikorian, & Cohen, 2004); it is no longer

unachievable to establish a global network with Objects as the infrastructure through IoT (Kortuem, Kawsar, Fitton, & Sundramoorthy, 2010). In order to achieve this goal, the main task for IoT is to establish a global network infrastructure, which is favourable to the exchange of commodities and service information (Liu & Sun, 2011). IoT has been applied by many enterprises to assist in the collection of on-site real-time information, which has successfully improved and promoted operating efficiency. Yan et al. (2014) also specified the design of IoT in practical application. The innovation of logistics, such as IoT, benefits companies in fields related to logistics, and affects the operations of enterprises (Grawe, 2009). Although enterprises understand the advantages and benefits of IoT in logistics and supply chain fields, and the overall expenditures of IoT hardware, such as RFID tags and readers, has dropped significantly in recent years, many firms still hold hesitant and conservative attitudes toward the application of IoT in supply chain management. The aim of this paper is thus to explore factors affecting the enterprise's adoption intention of IoT in logistics and supply chain management.

LITERATURE REVIEW

The infrastructure of the application of IoT in global logistics and supply chain management mainly includes an Electronic Product Code (EPC) and an EPC global Network. The Massachusetts Institute of Technology established the Auto-ID centre in 1999, and put forward the infrastructure of the EPC encoding scheme and EPCglobal Network in order to ensure intercommunity Radio Frequency Identification (RFID) in the supply chain field (Thiesse, Floerkemeier, Harrison, Michahelles, & Roduner, 2009). The design of the EPC Code applies to all countries, where all codes are unique, and each object (product) has its own EPC Code; IoT has many choices in product tagging, such as the Barcode or RFID technology, and RFID is most often used as EPC tags. RFID reads the information in a volume tag through radio waves, with no line of sight operation, and allows batch scanning for products; compared with other tagging methods, RFID allows data to be repeatedly written in the different memory blocks of a tag, which can carry more information and is not easily damaged by external force, such as deliberate damage; moreover, it can survive harsh environments, and not be easily contaminated or damaged. The overall operations of the EPC global Network relies on the integration of the IoT system. If RFID readers are widely placed in a supply chain, supply chain members can inquire, update, or exchange information in a timely manner (Bo & Guangwen, 2009); the reason why IoT is taken seriously and seen as the solution for many industries is that IoT can interconnect the information in the virtual world with products and supply chain members in real life (Chen, Tu, & Jwo, 2010; Kawsar, Kortuem, & Altakrouri, 2010). IoT has been applied in the fields of logistics, manufacturing, and supply chains for a period of time, and was initially applied in Closed Loop Supply Chains in order to improve automation and efficiency of enterprises. Most applications of IoT technology in Closed Loop Supply Chains are in pallets and cartons, such as Wal-Mart and the United States Department of Defense, where the main purpose is to promote the efficiency of warehousing and logistics, and reduce labor and warehousing costs. However, to realize a truly IoT-enabled supply chain, item-level tagging should be considered as opposed to only carton or pallet level tagging.

Research Methods

This paper adopts mixed research methods to discuss the key factors affecting the adoption of IoT in logistics and supply chain management of enterprises. The mixed method uses two or more kinds of research methods during one research, such as, quantitative and qualitative methods.

Introducing IoT into a supply chain is a complicated process, and different companies alone a supply chain have different expectations and attitudes toward accepting the new technologies. Some qualitative researches have explored the adoption process of IoT (Boeck & Wamba, 2008; Fisher & Monahan, 2008; Hellstrom, 2008) to find key factors driving the IoT adoption. For example, Boeck and Wamba (2008) conducted research of 10 companies in the retail supply chain for 3 years regarding the IoT adoption process

utilizing various qualitative research methods, such as Participant Observation, Grounded Theory, and Action Rearch.

The quantitative research method is still the major research method for technology adoption in the logistics and supply chain domain. Many quantitative researches explore the intention to adopt IoT from the perspectives of technology, organization, and social views (Cheng & Yeh, 2011; Fazel, Forouharfar, & Fazel, 2011; Kim & Garrison, 2010; C.-P. Lee & Shim, 2007; M. S. Lee, 2009; Schmitt & Michahelles, 2009).

Each research method has its potential weakness, and the mixed type research method can complement the short-comings of research methods to better reveal the characteristics of various research methods.

Most studies about technology adoption use only a single research method, there are few articles employing the mixed research method. This leads us to conduct this research based on the the mixed research method.

Our research process is divided into two successive phases. The first phase is qualitative research, where the Grounded Theory is used to analyse the conceptual framework of the application intention of IoT technology in a supply chain; Focus group interviews and in-depth personal interviews are carried out with the top-level managers of different industries in Taiwan. Then the Grounded Theory is used to discover and classify the concepts from interview transcripts. Finally, conceptualize views regarding the decision making processes of IoT adoption are derived. The second phase is quantitative research, where the research model and hypothesis are constructed after analyzing the qualitative research results and related literatures about technology acceptance models, then data is collected through a questionnaire survey and Partial Least Squares (PLS) is used to analyze the data and test hypothesis.

QUALITATIVE DESIGN AND DATA ANALYSIS (Phase I)

Focus group interview and in-depth interview are the main methods for data collection in this research. Interviews are important information sources for qualitative research, as researchers can obtain the personal cognition of respondents regarding social phenomena and issues through the dialogue process. The main purpose of qualitative research is the in-depth understanding of issues, thus, most researches adopt non-random sampling (Auerbach & Silverstein, 2003). The Grounded Theory of the qualitative research method is used in this paper to investigate the cognition of enterprises regarding IoT adoption. The Grounded Theory was first developed by two sociologists, Barney Glaser and Anselm Strauss (1967). Essentially, the Grounded Theory attempts to develop a theory from the model, theme, or category, as found in the observed data (Earl Babbie, 2010). In other words, the Grounded Theory is a theory construction method that is famous and popular in qualitative research, and uses the method of induction to analyze and sort phenomena to obtain results. As researchers generally have no theoretical hypothesis before the start of the research, they conclude the concepts and propositions directly from the original data through systematic data collection and analysis, and then, develop the theory. In terms of the research process of the Grounded Theory, this paper adopts the views of Pandit (1996). Pandit divided the research programs of the Grounded Theory into five phases, including Research Design, Data Collection, Data Ordering, Data Analysis, and Literature Comparison.

Qualitative Data Collection

The number of interviewed persons in this research is 15, including 10 men and 5 women, with ages ranging from 27 to 56, and position distribution of 2 assistant managers, 8 managers, 2 directors, 2 chief information officers (CIO), and 1 chief executive officers (CEO). The industrial distribution is electronic manufacturing, which accounts for 70%, and the retail channel and logistics industry, which accounts for 30%.

The data collection time for this research is from November 2013 to September 2014. The interview method adopts Semi-Structured Interviews. The interviews processes are carried out as the researchers first prepare a syllabus before the interviews, ask the interviewees about their own opinions, and then, flexibly adjust the interview direction and contents according to the interview situations. The contents of the questionnaires are divided into three areas for discussion: enterprise/organization's understanding of IoT; (2) enterprise/organization's expectations for the adoption of IoT system; (3) the impact of adopting IoT system on the enterprise/organization. A total of 12 interviews and focus group interviews are conducted, including 7 personalized in-depth interviews and 5 focus group interviews, where each personalized in-depth interview interviews 1 person, and each focus group interviews 2 to 4 persons. The interviewees previewed the contents of the questionnaire before the formal interview and each interview required 45 minutes to 85 minutes.

Qualitative Data Analysis

After the recorded interview data is converted into transcripts, qualitative data coding is performed using Nvivo10 software. This research adopts the coding scheme proposed by Auerbach & Silverstein (2003). In their method, the data is divided into three levels, the bottom level is Text-Based Categories, which can be considered as repeated ideas, the middle level is sensitizing concepts, which can be seen as Themes, and the highest level is theoretical constructs. First, the interview recording materials are edited to transcripts which can be analyzed and encoded; then, read and interpret the contents of the texts to identify repeated ideas and make them text-based categories. Then, sensitizing concept coding sorts and classifies these text-based categories (repeated ideas) into several higher level themes as sensitizing concepts. Lastly, extract the highest level theoretical concepts and framework from the themes to obtain theoretical constructs through repeatedly reading and analysing the relevance of the texts.

The reliability of this qualitative research is ensured by adopting multiple measurements of data sources and analysis, as based on the spirit of Triangulation. In order to improve the accuracy of the multiple measurements of data sources, the truth of the interview process is recorded in the process of data collection, which is converted into text data, and used for data analysis. In the multiple measurements of the analysers, this research invites another researcher for data analysis and coding. Finally, the research results are determined through discussions and verification of interviewed enterprise executives in order to consolidate the reliability of this research. The analysis results of the qualitative research interview data in this phase are as shown in Table 1, which divides information into three levels; the bottom level is to identify the conceptual nodes representing repeated ideas after transcript coding and analysis (listed in digits), the middle level is to classify and conclude the conceptual nodes of these repeated ideas into themes (listed in the English alphabet), and the highest level is the theoretical constructs revealing the theoretical framework of this research (I~IV). Lastly, Literature comparison shows that the Technology Organization Environment (TOE) theoretical framework can be applied to the explanatory framework of the qualitative research findings. For example, in studying EDI adoption, (Kuan & Chau, 2001) used perceived benefits in the technology context, perceived technical competence, and financial cost in the organizational context, and perceived industry and governmental pressure in the environmental context. (Hsu et al., 2014) used perceived benefits and business concerns in the technology context, IT capability in the organizational context, and external pressure in the environmental context in order to investigate the intention to adopt cloud computing. Thus, the Technology Benefits in Table 1 fall into TOE's technology context; Cost Concerns and Uncertainties about Technology correspond to TOE's organizational context, the connotation of Uncertainties about Technology is similar to the connotation of technical competence or IT capability dimension; External Motivating Force can be seen as TOE's environmental context, and its connotation is similar to the dimension of external pressure.

I. Technology Benefits	III. Uncertainties about Technology
A. Visibility of supply chain	G. Reliability of IoT system
1. Reduce the complexity of the information integrity of supply chain	14. The operation interface user friendly
2. Rapidly obtain exact experience information	15. Stability of IoT system
3. Provide detailed production pedigree	16. Reading rate of RFID
4. RFID memory storage is large enough to store lots of information	H. Concerns for system integration
5. Improving tracking and tracing ability	17. Compatibility with company's existing process
6. The upstream suppliers provide complete product pedigree information	18. Integration with company's current information system
7. The upstream suppliers can attach RFID tags on the parts	I. Concerns for integration of supply chain information
B. Supply chain efficiency	19. Concerns for information security
8. Automatic identification and no-line-of-sight operation save manpower	20. Whether the format of product pedigree data is consistent with the standard
9. The efficiency of automatically reading multiple tags at a time	
10. Simplify RMA * operation	
11. Process automation	
C. The consideration on selecting electronic tagging technology	
12. The integration of RFID with products	
13. An electronic tag can be read and written repeatedly.	
II. Cost Concerns	**IV. External Motivating Force**
D. Organization Adjustment	J. Customer Expectations
21. Process reengineering	28. Not take the initiative to adopt IoT system (unless required to)
22. Increase IT staff	29. Requirements by clients
E. Cost of Equipment	30. Afraid to lose customer order
23. Cost of RFID Tag	K. Social Expectations
24. Cost for IoT related hardware equipment	31. Willing to adopt IoT system in accordance with the governmental rules
F. IoT system development model	
25. Lease of IoT system	
26. Buyout of IoT system	
27. Self development IoT system	

* RMA: return material authorization

Table 1: Repeating ideas, Themes, and Theoretical Constructs for the IoT adoption study

QUANTITATIVE DESIGN AND DATA ANALYSIS (Phase II)

Hypotheses Development

The model framework of this research is established by comparisons between the qualitative research results in Phase I and the relevant theories adopted by information technology in the literature reviews mentioned above. This study finds that the intention to adopt IoT is affected by perceived benefits and costs, trust in technology, and external motivations in the process of qualitative research. In the above literature reviews, we find that TOE framework can fully support the spindle concept, as established by qualitative research.

Tornatzky and Fleischer (1990) developed the TOE research model as a theoretical framework to explore whether or not an information system is adopted, including the three dimensions of technological context, organizational context, and environmental background. Research modes adopted by many technologies use the TOE framework to

develop unique research dimensions for specific patterns of innovation environments (Baker, 2011). Thus, this paper constructs a quantitative research framework on the basis of TOE framework, as shown in Figure 1, and the related research hypothesis are discussed below.

Based on the qualitative research results we found that the reliability of IoT technology will affect the organization's trust in new technology. The reduction of the uncertainty factors outlined in table 1 can significantly increase the reliability of IoT technology, and further increase a firm's trust in IoT system and its intention to adopt IoT. Many researches also suggest that trust has significant impact on the acceptance of science and technology, and if users increase their trust of technological products, it will have positive influence on user's acceptance intention (M. S. Lee, 2009; Tung, Chang, & Chou, 2008). Therefore, we hypothesize:

Hypothesis 1. Perceived Trustworthiness of Technology will have a positive effect on a firm's intention to adopt IoT technology

Based on the discussions with enterprise executives regarding the relationships and implications among the four identified theoretical constructs, we found that the perceived benefit of IoT will be affected by the reliability of IoT technology, for example, a poor RFID reading rate or concerns for network safety will reduce the perceived benefits of IoT; on the contrary, it will strengthen the perceived benefits of IoT; therefore, the following hypothesis is proposed:

Hypothesis 2. Perceived Trustworthiness of Technology will have positive effect on the perceived benefits IoT technology

Benefit is the key factor all organizations consider in evaluating the adoption of new technology. Research has found that perceived benefits has significant impact on the acceptance of new technology; if the user of an organization has higher perceived benefit towards a technology, the organization will have higher intention to adopt the technology (Chang, & Chou, 2008; M. S. Lee, 2009; Tung, Kuan & Chau, 2001; Hsu et al., 2014). Therefore, we hypothesize:

Hypothesis 3. Perceived benefits will have positive effect on a firm's intention to adopt IoT technology

Perceived cost refers to all types of costs incurred by firms for the adoption of new technologies, such as hardware, software equipment, and system integration (G. Premkumar & Crum, 1997). The perceived cost elements in the technology dimension will have negative influence on the adoption of new technology for a firm (Tung et al., 2008). Therefore, the arguments above leads to the following hypothesis:

Hypothesis 4. Perceived cost will have negative effect on a firm's intention to adopt IoT technology

External pressure refers to the degree of pressure from the same industry or business partners affecting the new technology adoption of a firm (G. Premkumar et al., 1997). In addition to partners, external social competition, government regulations, and other social environments are also the sources of external pressure (Hsu et al., 2014), which have positive significant influence on a firm's adoption of new technology. Therefore, this research hypothesize:

Hypothesis 5. External Pressure will have positive effect on a firm's intention to adopt IoT technology

Quantitative Data Analysis

The survey subjects of this research questionnaire are top level managers from manufacturers of electronic industry, transportation and logistics industry, and retail industry All the questions in this research adopt a 5-Point Likert scale. There are 130 valid samples used in this research.

Partial Least Squares (PLS) is used in the statistical analysis of this research to conduct hypothesis verification. PLS is the analysis technology of the structural equation model (SEM), and is based on regression analysis, which is an important technology for research into the causal relation model, including multiple constructs, and is especially related to research regarding the adoption of new technology. As the application of PLS analysis is neither limited by the number of samples nor affected by variable distribution patterns. In general, PLS analysis and estimation can be divided into two stages, in the first stage, reliability analysis and validity analysis are conducted on the measurement model; in the second stage, path coefficient testing and model prediction capacity estimation are conducted on the model. This research adopts PLS for analysis, as samples are difficult to obtain and the number of samples is small, with only 130 valid samples due to the limitations of time and cost; if CV based SEM is adopted for analysis, insufficient samples is likely to cause a failure to converge and errors will incur in measurement results; however, PLS is a competent analysis mode for small samples.

The analytical results of the PLS research model are illustrated in Figure 1. H2 ~ H5 are all supported, with the exception of H1. The R^2 value refers to the percentage of dependent variables explained by the variables corresponding to independent variables, and represents the predictive capacity of the research model; its value is between 0 and 1, where the greater the value, the better the explanatory power of the model. The R^2 value in this research ranges from 0.28 to 0.32, indicating a moderate predicting power of our research model.

CONCLUSION AND IMPLICATIONS

Through the combination of qualitative analysis and quantitative analysis, this exploratory research aims to understand the intention of enterprises to adopt IoT technology in their logistics and supply chain management. Research results found that the four key factors affecting enterprises decision to adopt IoT for managing their logistics and supply chain includes perceived benefits, perceived cost, trust of science and technology, and external pressure. The trust of science and technology indirectly affects the intention to adopt IoT technology through perceived benefits. The preliminary results of data analysis suggests that, it is not urgent to import an IoT system when there is no external pressure, such as regulations or strong requirements of customers; However, if governments, society, or the cooperative enterprises upstream and downstream in a supply chain strongly support an organizational import system, it will have great benefits (perceived benefits), which can increase the enterprise's acceptance of IoT system.

The empirical research results can also explain the external pressure of government regulations or requirements, as supply chains are key factors for enterprises to import IoT in globally successful cases. The IoT system can improve the efficiency of logistics and supply chains, reduce the human cost, and trace the flow of products. During the research process, we found that enterprises have great expectations of IoT, and if the import costs of the IoT system can be further reduced, and external forces push it, it is believed that the intention of enterprises to adopt the IoT system to manage their logistics and supply chain will be further promoted. This research shows that mixed qualitative and quantitative research methods can provide in-depth explanations of the complex research theme of enterprises adoption of technology.
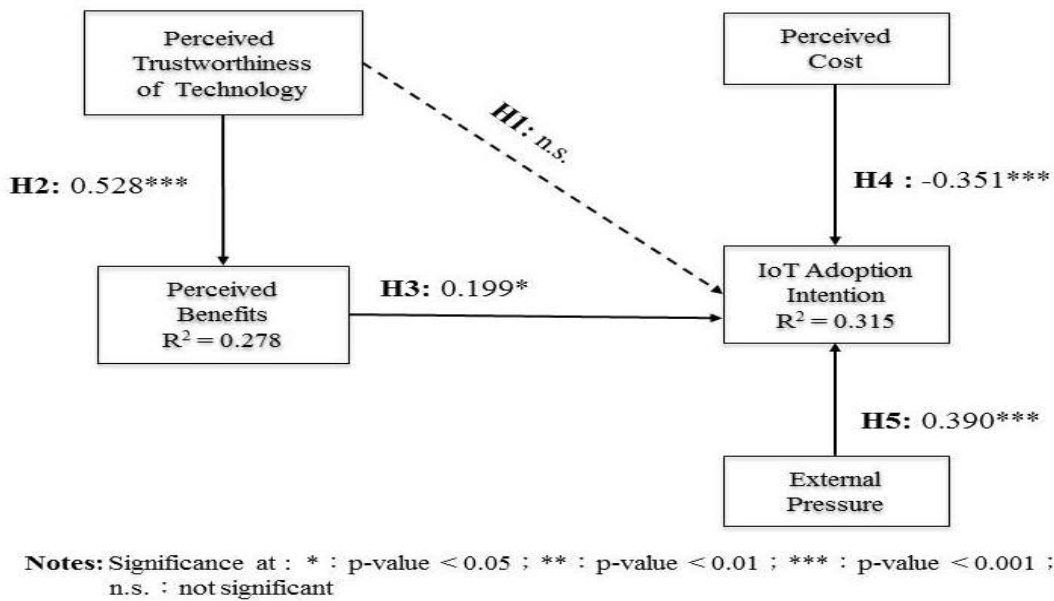
Notes: Significance at : * : p-value < 0.05 ; ** : p-value < 0.01 ; *** : p-value < 0.001 ; n.s. : not significant

Figure 1: The structural model and the PLS estimation

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Section 10: Logistics modelling and simulation

LOSS-DETECTION MODEL WITH KANBAN CARD AND DETECTION ACCURACY IN LARGER LOT-SIZE

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Abstract
According to increase of Mass Customization, it is commonly observed that a worker chooses some adequate part from several parts racks and assembles a product in assembly line. To enhance performance and quality of such processes, it is important to confirm that an adequate part is selected. To address that problem, we proposed a loss-detection model using Kanban cards. However, the model presents some problem such as types of loss occurrences. As described herein, we present a new discrete-time Markov Chain model to describe the loss types where loss-detection interval is infinite. The model performance is presented using numerical experiments. Furthermore, results show that undetected-loss risk becomes the maximum when the transition probabilities are identical.

INTRODUCTION

Consider a production process in which a worker chooses a piece of part according to the order displayed on the order sheet or display monitor. That process is apparent in many assembly lines, especially those associated with automobile production. Several variations of final products are produced depending on the combination of assembled parts in the production process. In that process, if a worker makes a mistake in the part selection, then the inferior product is delivered to the next process, where it is finally detected at the inspection segment. In general, correction of such a mistake demands a longer time if it is an earlier process among the whole production process because the part is located in the interior part of the product. We designate such inferior products as loss.

A Digital Picking System (DPS), which guides the worker to an adequate part with signal light, has been widely introduced into such assembly lines avoiding the loss. However, confirmation of the worker's choice of an adequate part or not depends on the worker. A confirmation method that is independent from the worker is necessary. In the literature, Takeno, Horikawa and Sugawara (2009, 2011) present a loss-detection model of this problem for automobile assembly-line production. In the model, they use E-kanban cards to count the consumed parts. By counting number of products passing through the process, the loss possibility can be detected by the difference between numbers of consumed parts and passing products. However, some problems remain: types of losses and their effects are not explained. For example, the loss probability for assembling part A instead of part B was assumed to be identical to the loss probability for assembling part B instead of part A. All loss probabilities were assumed as identical because of use of binomial distribution in their model. Furthermore, the undetected risk of a mixed loss also remains, where the mixed loss corresponds to a combination of losses among two or more parts.

As a first step to overcome the problem described above, we present a discrete-time Markov chain (Wolff 1989). For a model corresponding to a special case, the loss-detection interval is infinite, of the problem above, which includes consideration of the type of loss. Through analysis of the model, we demonstrate that the undetected risk caused by mixed loss and effects of parameters. Some numerical experiments elucidate the model behavior.
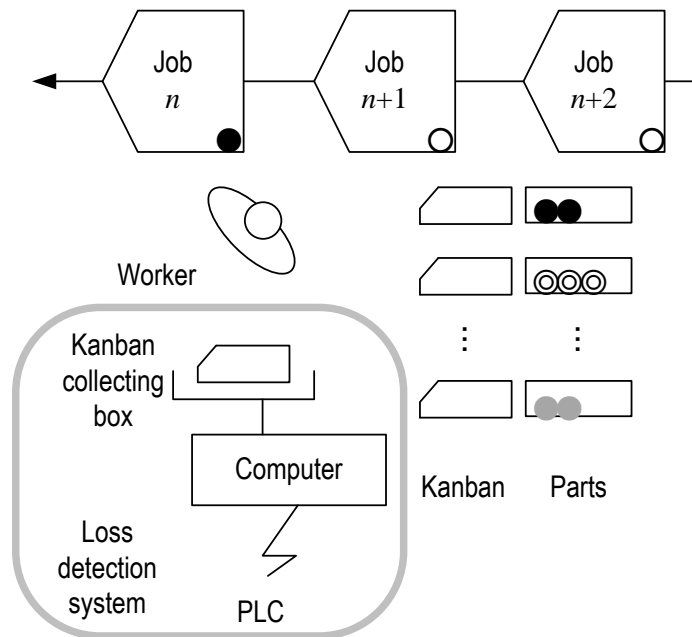
Figure 1. Fig. 1. Workstation and loss-detection system.

LOSS-DETECTION MODEL

Controlling parts supply with kanban cards (Liker 2004) is an important methodology in the Toyota Production System. It is popularly used in automobile assembly lines recently, especially in Japan. E-kanban cards are used mostly for parts supplied to assembly lines. An E-kanban card facilitates electronic order placement. The supplier sets the parts into a shipping container and puts the card on it. Then parts are sent to the corresponding assembly line. A kanban card is also regarded as beneficial for controlling the amount of work in process (WIP), using parts without consideration of lot-sizing problems. Therefore, the part lot size is not been determined theoretically but by material handling considerations such as container size or space remaining at the work station.

For a work station of an assembly line, K kinds of parts should be installed. At the station, a worker selects a part from a shelf and installs it into product transferred by conveyer. We designate a product in the parts to be installed as a "job." The order of production is printed on a sheet and is pasted on each job. The model consists of workers, jobs equipped with order sheets, a computer called a loss detection system, parts set in containers on the shelf, kanban cards for containers, and a kanban collection box equipped with a QR-code reader and connected to the computer. See Figure 1.

A worker reads orders of production for job n, where each job has its number to identify itself, and takes a part from the corresponding container. Then the worker installs the part to job n and repeats this process. When the container becomes empty, he prepares a new container for the parts and puts the card into the collection box. When the collection box senses a new kanban card, current job number, indicating that the number of jobs conveyed is scanned from a Programmable Logic controller (PLC), with which PLC controls electrical devices located along with the assembly line, using a computer. The difference between the current number and that of the last time during which parts are supplied with the same kanban card is checked. We can detect losses from the number and lot size of the container.

Takeno, Horikawa and Sugawara (2011) pointed out the possibility of undetected case in the model. The case is mainly caused by situation in which the number of occurrence of mixed among two parts becomes even number. For example, a worker sets part A instead of part B. Then the worker sets part B instead of part A. Under these circumstances, the final number of consumed parts is correct, but there are two inferior products. To estimate the effects of the case, additional analysis of a precise model is necessary. Models shown in following sections include mixed situations.
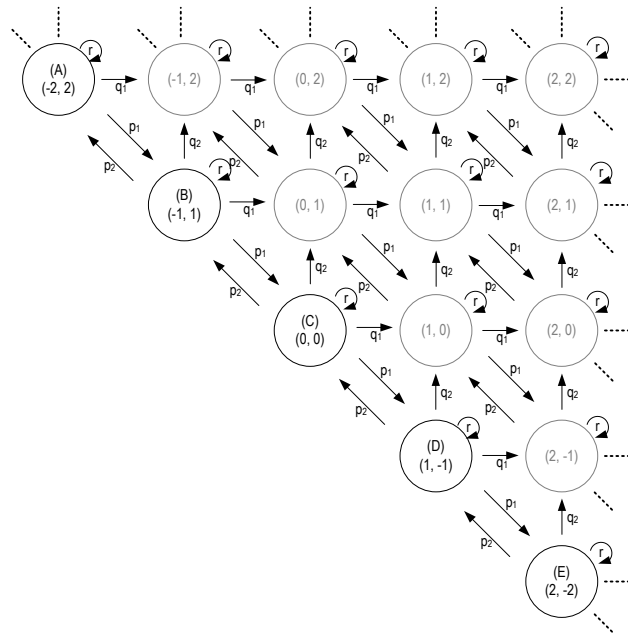
Figure 2. State diagram of Discrete-Time Markov Chain (K=2).

TWO PARTS MODEL

We build a Discrete Markov Chain model with two part types (K=2). The parts are denoted respectively as A and B. All jobs are assumed to be ordered and assembled with part A or B. We define probabilities p_1, p_2, q_1, q_2, and r as follows. Probability p_1 denotes the probability that the worker sets part A instead of B. Probability p_2 denotes the opposite side of p_1. Probability q_1 and q_2 denotes the probability that the worker forgets to sets part A and B respectively. Probability r denotes a complementary event probability, i.e. the worker sets the correct part for the job. Therefore,

$$r = 1 - p_1 - p_2 - q_1 - q_2. \qquad (1)$$

Presuming a situation in which whole parts are assembled correctly, we define the base state as this situation. Let n_{AP} and n_{AA} respectively represent the theoretical and actual numbers of remaining part A in the workstation. Let n_A be the number of differences between n_{AP} and n_{AA}. Then we have

$$n_A = n_{AP} - n_{AA}. \qquad (2)$$

If the theoretical number of remaining parts is equal to the actual number, then $n_A = 0$. Similarly, let n_B be the number of differences of part B. We define (n_A, n_B) as a Markov Chain state. Letting the initial state be (0, 0), assume that the loss probability does not affect the current state. This stochastic process becomes a discrete-time Markov Chain. Figure 2 shows a state diagram. Each circle corresponds to a state described as (n_A, n_B). States are classifiable into two groups: states shown in black colour and in grey. Grey shows states in which a transition corresponds to probability q_1 or q_2 used to reach the state. However, black corresponds to remaining states. Once entering a grey state, the transition will never revert to the black state. Therefore, a loss related to transition q_1 or q_2 can be identified at a steady state. Furthermore, we can detect loss by forgetting. There is no need to consider forgetting probabilities and their transitions for loss detection.

To calculate steady-state probabilities, we redefine the model as finite discrete-time Markov Chain with number of states N. In the model, p_1 and p_2 are considered for transitions. Calculations are made using an x86 workstation equipped with Intel Core i7-3930K CPU (3.20 GHz), 16.0 GByte memory and a 64-bit operating system (Windows 7;
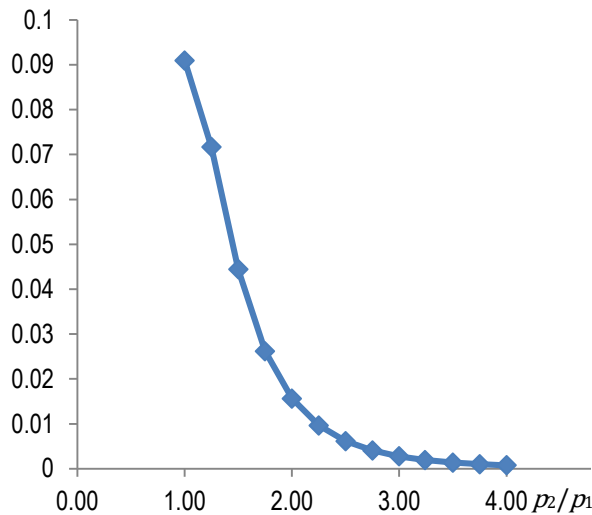
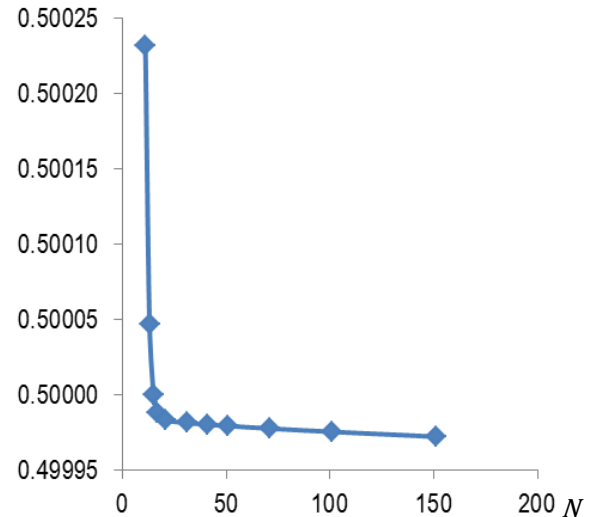Figure 3. Effect on steady state probability π_0 by the ratio of transition probabilities (p_2/p_1).

Figure 4. Effect on steady state probability π_N by the number of states N (p_2/p_1=2.0).

Microsoft Corp.). The Jacobi method is used to solve the system of the linear equations, which is coded in Visual Basic (ver. 2012; Microsoft Corp.).

Figure 3 shows the relation between steady state probability π_0 of state (0, 0), shown in (C) in the Figure 2, and transition probability ratio (p_2/p_1) where N=11. Horizontal and vertical axes respectively correspond to the transition probability ratio and the steady state probability π_0. The calculation time for a run is 1 sec at most. When the ratio is equal to 1.00, π_0 takes the largest value of 0.0909 (=1/11) and the value is identical to the other steady state probabilities. π_0 decreases monotonically as the ratio increases. Furthermore, π_0 shows the undetected probability of the Takeno, Horikawa, and Sugawara model (2011).

Figure 4 shows a relation between the steady state probability π_N of (N, $\boxtimes N$) and the number of states N. Horizontal and vertical axes respectively correspond to the number of states and the steady state probability π_N. As N increases from 11 to 151, π_N decreases monotonically, but the difference is not great. The calculation time for a run is no more than 3 sec for N=151.

From numerical analysis, the undetected probability caused by mixed situation becomes the largest value when the transition probability ratio (p_2/p_1) is equal to 1.00. The probability is $1/N$ where N is the number of states. As N gets larger, the undetected risk becomes smaller. Loss detection systems should be used carefully if N is not large.

THREE PARTS MODEL

Here we build a Discrete Markov Chain model with three part types denoted respectively as A, B and C. According to the outcome of the two parts model, we assume that probabilities related to forgetting, q_1 and q_2, can be omitted. We define probabilities p_1, p_2, p_3, p_4, p_5, and p_6 as shown in Table 1. Here, probability r denotes complementary event probability. We have

$$r = 1 - p_1 - p_2 - p_3 - p_4 - p_5 - p_6. \qquad (3)$$

Consider circumstances under which whole parts are assembled correctly and the base state in the same way with the two parts model. We also define n_A, n_B and n_C as numbers of differences of parts A, B, and C respectively. We define (n_A, n_B, n_C) as a state of Markov Chain. Letting the initial state be (0, 0, 0), we assume that the loss probability does not affect the current state. This stochastic process becomes a discrete-time Markov Chain. Figure 5 shows a state diagram where number of states is 19. Each circle corresponds to

Symbol	Ordered Part Type	Assembly Part Type
p_1	A	B
p_2	A	C
p_3	B	A
p_4	B	C
p_5	C	A
p_6	C	B

Table 1. Definition of transition probabilities (K=3)
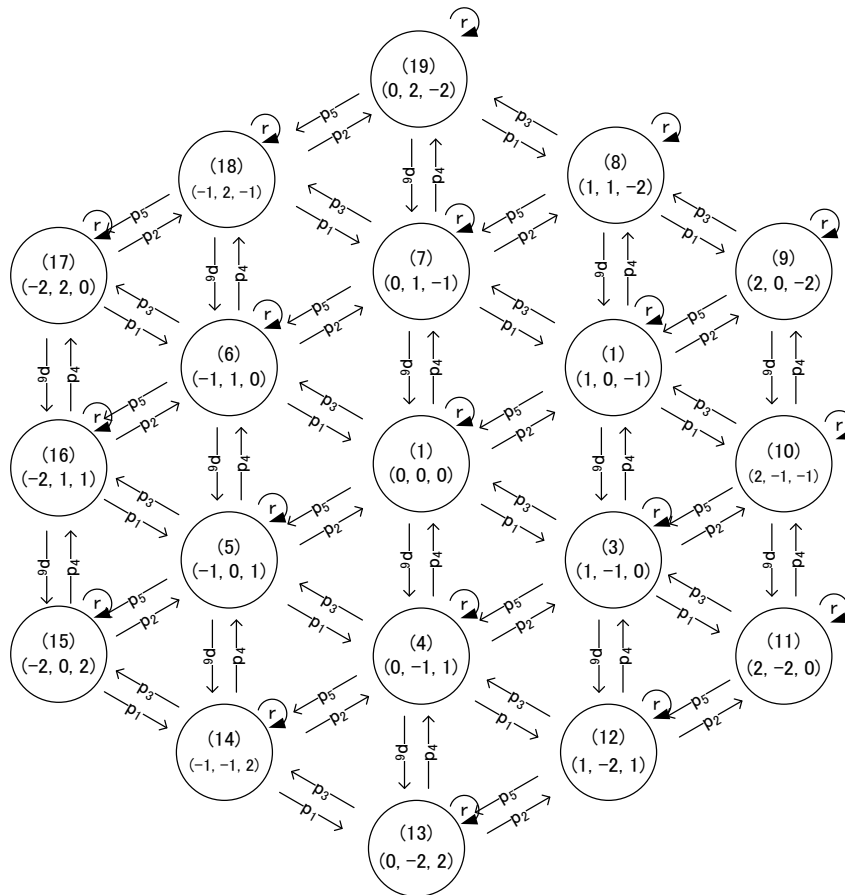
Figure 5. State diagram of discrete-time Markov Chain (K=3)

a state described as (n_A, n_B, n_C). To calculate steady-state probabilities, we redefine the model as a finite discrete-time Markov Chain with number of states N. Let N=7 and consider a stochastic process among states. Each state are identified with assigned letters (1)–(19) for convenience of explanation. The base state, corresponding to (1), is located at the centre of states and the other states are distributed on six axes. To see effect of transition probability value, we focused on ratio of the transition probabilities that leaving from and arriving at a certain states.

Let p_{OUT} be a transition probability leaving from state (0, 0, 0), (1) in Figure 5. We have

$$p_{OUT} = p_1 = p_2 = p_4. \qquad (4)$$

Let p_{IN} be a transition probability arriving at state (0, 0, 0). Then we have

Figure 6. Effect on steady state probability π_0 and π_5 by the ratio of transition probabilities (p_2/p_1) where $N=7$, $K=3$.

Figure 7. Effect on steady state probability π_0 and π_{15} by the ratio of transition probabilities (p_2/p_1) where $N=19$, $K=3$.

$$p_{IN} = p_3 = p_5 = p_6. \tag{5}$$

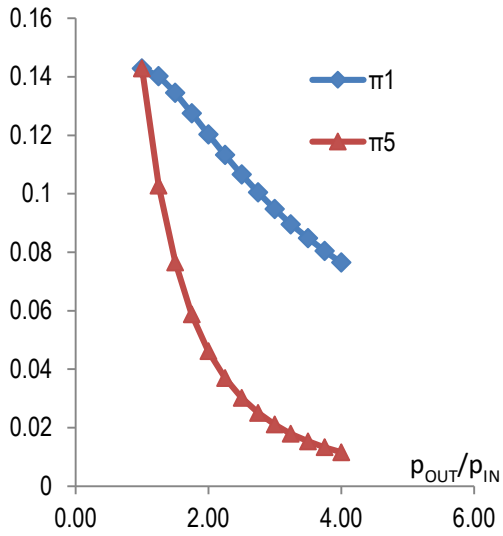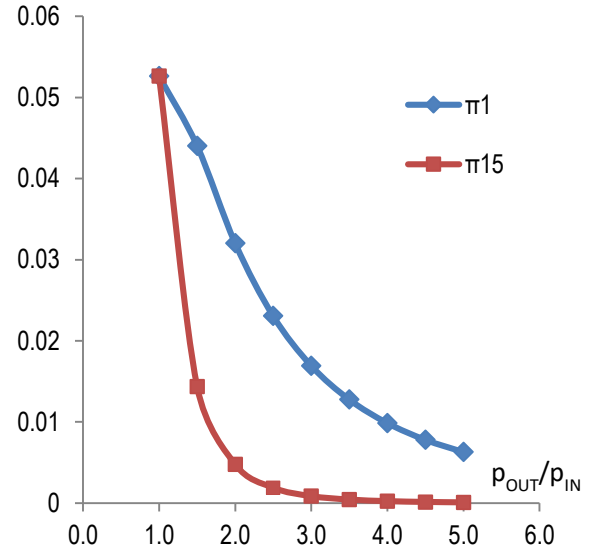We use p_{OUT}/p_{IN} as a parameter to view the effect of imbalance caused by transition probabilities.

Let π_0, π_5 and π_{15} respectively represent steady-state probabilities of state $(0, 0, 0)$, $(-1, 0, 1)$ and $(-2, 0, 2)$, where corresponding states are (1), (5) and (15) in Figure 5. Figure 6 and 7 show the relation between p_{OUT}/p_{IN} and the steady-state probabilities. Horizontal and vertical axes correspond respectively to ratios of p_{OUT}/p_{IN} and steady-state probabilities π_k. The calculation time for a run is no more than 1 sec. Figure 6 and 7 correspond to case of $N=7$ and $N=19$ respectively. When $p_{OUT}/p_{IN} = 1$, then all steady-state probabilities π_k become the same value. For case of $N=7$, $\pi_0 = 1 / 7 = 0.1429$. For it of $N=19$, $\pi_0 = 1 / 19 = 0.05263 = \pi_k$, $k=1, 2,…, 19$. As p_{OUT}/p_{IN} increase, steady-state probabilities π_0, π_5 and π_{15} decrease monotonically. State (15) can be regarded as a state of vacancy because $p_{OUT}/p_{IN} > 1.0$. Compared with π_0, π_5 and π_{15} converges earlier.

Similarly to the case of the two parts model, the undetected probability caused by mixed situation becomes the largest value when the transition probability ratio (p_{OUT}/p_{IN}) is equal to 1.00. Loss-detection systems should be used carefully if N is not large.

FOUR PARTS MODEL

We build four parts Discrete-time Markov Chain model in a similar way with the three parts model. We define probabilities $p_1, p_2,… p_{12}$ as shown in Table 2. Here, probability r denotes complementary event probability. We have

$$r = 1 - p_1 - p_2 - p_3 - p_4 - p_5 - p_6 - p_7 - p_8 - p_9 - p_{10} - p_{11} - p_{12}. \tag{6}$$

We also define n_A, n_B, n_C, and n_D as numbers of differences of parts A, B, C, and D respectively. We define (n_A, n_B, n_C, n_D) as a state of Markov Chain. Letting the initial state be $(0, 0, 0, 0)$, we assume that the loss probability does not affect the current state. This stochastic process becomes a discrete-time Markov Chain. Figure 8 shows a state diagram where number of states is 13. We use p_{OUT}/p_{IN} as a parameter to view the effect of imbalance caused by transition probabilities defined as ratio of probabilities that leave from and arrive at state (1) as Equation (7).

Symbol	Ordered Parts Type	Assembled Parts Type	Symbpl	Ordered Parts Type	Assembled Parts Type
p_1	A	B	p_7	C	A
p_2	A	C	p_8	C	B
p_3	A	D	p_9	C	D
p_4	B	A	p_{10}	D	A
p_5	B	C	p_{11}	D	B
p_6	B	D	p_{12}	D	C

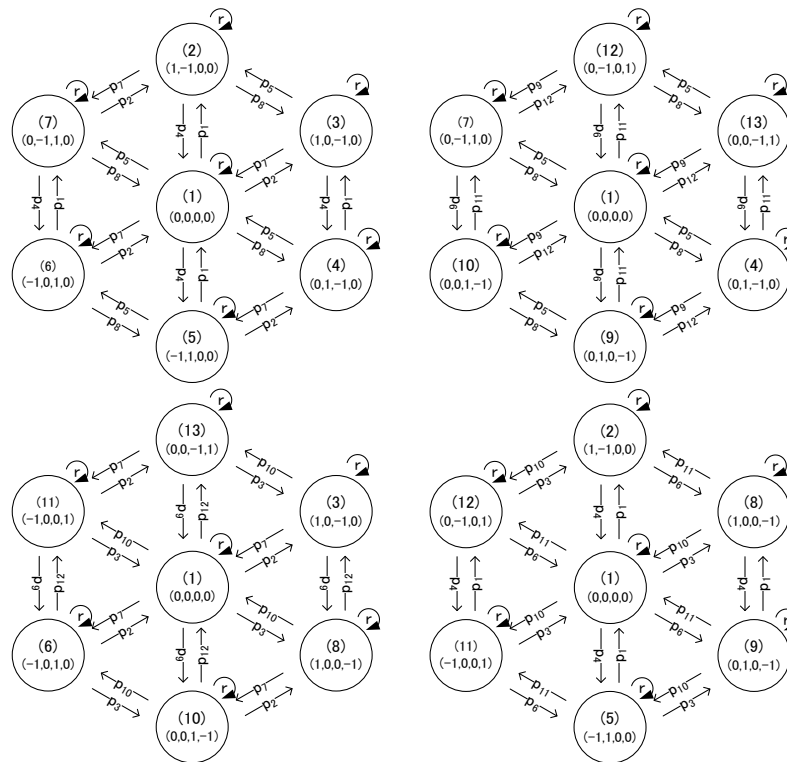Table 2 Definition of transition probabilities (K=4)

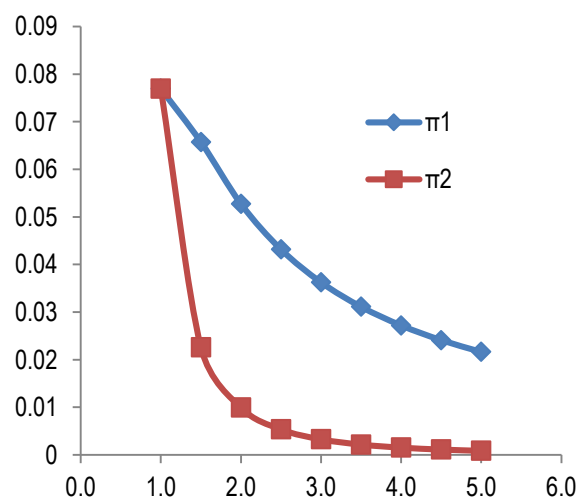Figure 8. State diagram of discrete-time Markov Chain (K=4)

Figure 9. Effect on steady state probability π_1 and π_2 by the ratio of transition probabilities (p_2/p_1) where N=13, K=4.

$$p_{\text{OUT}}/p_{\text{IN}} = \frac{p_4+p_6+p_7+p_8+p_{10}}{p_1+p_2+p_3+p_5+p_{11}} \qquad (7)$$

Let π_1 and π_2 respectively represent steady-state probabilities of state (0, 0, 0, 0) and (1,-1, 0, 0), where corresponding states are (1) and (2) in Figure 8. Figure 9 shows the relation between $p_{\text{OUT}}/p_{\text{IN}}$ and the steady-state probabilities. Horizontal and vertical axes are same with the three parts model. We have the largest steady state probability $\pi_k = 1 / 13 = 0.07692$ when $p_{\text{OUT}}/p_{\text{IN}} = 1$. π_2 becomes smaller if $p_{\text{OUT}}/p_{\text{IN}} > 1$.

DISCUSSIONS
According to the analyses with Discrete Markov Chain models, we have shown following characteristics of Loss-detection model where loss-detection interval is infinite.

- Once worker forget to set a part, current state never come back to the base state, e.g. (0, 0). Therefore loss-detection system can detect any this type loss.
- Steady state probability of the basic state π_1 is not affected number of parts type K and becomes the largest for all $p_{\text{OUT}}/p_{\text{IN}}$. Furthermore, π_1 gets the largest if $p_{\text{OUT}}/p_{\text{IN}} = 1$.
- Steady state probability of the basic state π_1 gets smaller if number of states N becomes larger. According to outcome of the three parts type model, π_1 is assumed to converge to 0 if $N \to \infty$.

CONCLUSION
Using a loss-detection model proposed by Takeno, Horikawa, and Sugawara (2009, 2011), we have presented effects of transition probabilities and a risk of a mixed situation. A discrete-time Markov Chain model is introduced to analyze the effect. According to the numerical experiment, we have demonstrated that undetected risk reaches the maximum if transition probabilities are identical, i.e. symmetric. It is difficult to estimate such transition probabilities in a practical assembly line. However, some efforts to escape from symmetric circumstances will support the loss-detection performance.
We are planning to extend our discrete-time Markov Chain model general N. Through the analyses, we confirm the property that undetected risk becomes greatest at a symmetric situation. For longer loss-detection interval, the model is expected to have same characteristics. We also plan to develop models for smaller lot-size K.

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CONCURRENT SCHEDULER APPROACH WITH GENETIC ALGORITHM FOR ITEM DELIVERY BY USING SWARM OF UAVS

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ABSTRACT

This paper provides an effective solution to accomplish the delivery of light weight items with a swarm of UAVs (Unmanned Aerial Vehicle). This solution is tailored to the transportation sector of logistics industry. The main concept is based on the concurrent scheduler approach which is applied to the fitness function of genetic algorithm. It achieves the shortest time for the whole delivery accomplishment with consideration given to UAV cruising speeds and various limitations of payload weights.

KEYWORDS

Gene/chromosome representation, Building GA with multiple constraints, Concurrent scheduler approach, Capacitated UAV routing problem

INTRODUCTION

Two limitations must be considered with respect to using UAVs in the logistics industry. First, items allocated to each UAV must not exceed its own sustainable weight payload and second is flight time limitation. UAV coverage areas are defined according to its sustainable flight time. This means that all of the incoming orders to the warehouse should be from the locations within round-trip UAV range (i.e., from the warehouse to the destination and back to the warehouse). Each item has its weight (g/kg) cannot be divided into smaller pieces for delivery.

When a lot of orders with varying item weights are received from the different locations, the following factors need to be addressed.

(1) Items must be assigned to each UAV without exceeding each UAV's respective maximum payload.
(2) The coverage area must be within the flight range of at least one UAV of warehouse.
(3) Due to the complexities of autonomous maneuvers, when choosing items to drop for each location, UAV should be restricted to carry only the order of the single destination location for each round trip.
(4) In some case, UAV needs to fly more than one times to the same location to accomplish the order while that order contains items which collectively exceed the UAV maximum payload.

In this paper, Genetic Algorithm (GA) approach is applied to maximize the efficiency. The better results with the smaller execution time of GA are given with the combining usage of Heuristics than applying the simple GA alone. Accordingly, the two limitations (weight capacity and flight time) are defined as multi-objective constraints to assist the GA in removing unqualified genes before the fitness stage. This enables better GA performance. GA fitness values are calculated according to the concurrent scheduler approach in which each gene is holding the mission allocation to the specified

location/target. Concurrent scheduling considers not only the simultaneous missions purposes of multiple UAVs but also a single UAV running in multiple missions. By choosing the best optimized flying time, finally, NP-Hard Problem of UAV routing problem can be solved.

BACKGROUND

The vehicle routing problem (VRP) serves as the research background for this paper. The simplest case is referred to Travelling Sales Man Problem (TSP) in which the route is defined by minimizing the total distance or cost of the route to travel for one vehicle/salesman. In the more complicated multiple TSP (MTSP), the problem is extended to include more than one depot and more than one vehicle. VRP comes into play when various vehicle fleet capacities restrict the travel routes, as well as, vehicles need to schedule when Time Window of depots is put to the problem. TSP, MTSP and VRP has been provided in numerous research papers. These solutions have integrated many different optimization problem solving approaches including Heuristic approaches, such as Nearest Neighborhood, Clark and Wright saving Heuristic, Cluster First Route second approach, Ant Colony optimization and Greedy algorithm approach.

GA was able to provide a better performance than Greedy algorithm when solving MTSP (Sadiq, 2012). In another study, a solution to single depot problem with multiple tours was derived using 2OP local search algorithm with GA; this yielded a better solution than Modified Ant Colony Algorithm (MACO) (Sedighpour, Yousefikhoshbakht and Darani, 2011). In 2009, M. S. Sanders tackled VRP for multiple capacity vehicles; the option for a solution that used GA with fitness heuristics. In his solution, the sum of the distance traveled for each route considered the total product delivered via the route (Sanders, 2009). Finally, a subsequent study dealt with multiple constraints for multiple depots with capacitated vehicles assignment problem using GA to reach the solution (Surekha and Sumathi, 2011).

UAV assignment problem is one of the VRP which is likely easier to solve with stochastic optimization methods rather than the deterministic methods. Tabu search method, one of the stochastic methods, can be used to solve the coordination and control assignment of multiple UAVs with timing constraints by considering loitering time between waypoints. The overall assignment problem is formulated as Mixed-integer Linear Programming (MILP) which minimizes the whole mission accomplish time by accounting UAV capabilities of cursing speed, no-fly zones and way points trajectory for each UAV (Alighanbari, Kuwata and How ,2003).

Different from the previous researches, the approach used in this paper determines the optimal scheduling assignment to reduce flight times for UAV. It does so with the concurrent scheduling approach which is modified to the fitness function of the GA.

CHROMOSOME REPRESENTATION/ GENE REPRESENTATION

Chromosome representation can be divided into two types of representations. The first type is the order/target location chromosome. This chromosome is statics; its permutations do not change throughout the entire execution. The second type is for UAV chromosome. This chromosome is dynamic; it enables UAV allocation to follow GA crossover and mutation methods to determine generation by generation changes so as to derive the best solution.

Order/Target Chromosome Representation

The Order/target chromosome represents order/target locations. Due to the complexity of choosing the correct items to be dropped at the correct locations, UAV is only permitted to carry order items for a single target location for each flight. When orders are received from the different locations, the furthest location from the warehouse is assigned to the first gene of the chromosome. Accordingly, the chromosome representation for the target locations assumes a descending order so that the longest

flight time receives as the first priority. This in turn reduces the total flying time when each UAV can be assigned multiple flights to finish all of the orders. Each target is associated with longitude and latitude coordinates as well as at least one item and the accumulative weight. The weight of the entire order must be managed so that the maximum UAV payload is not exceeded.
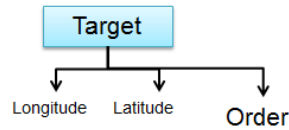

Figure 1: Parameters for each target location with respect to the genes in the order/target chromosome

If the weight of the target order exceeds the maximum UAV payload, the order must be divided into sub-orders. The weight of each sub-order must be less than the maximum payload. Let J_{wi} be the weight of item i for Target J. Then i=1,2,…,n. X=(x_{jk}) will be the decision variable matrix if the distance to Target J is covered by vehicle k. If so, then x_{jk}=1. If not, then x_{jk}=0. C_k is the maximum payload of UAV , k=1,2,…n. Equation (1) enables sharing weight from the total order weight to sub-orders and assigning genes to the chromosome, as follows:

$$\sum_{i=1}^{n} (J_{wi})\ x_{jk} \leq Max\ (C_{k\in\{1,2,…,n\}}) \qquad \text{Equation (1)}$$

Where x_{jk}=1

Figure 2: Order/target chromosome representation without sub-orders (left) and with sub-orders in T3 (right)

In Figure 2 (left), T1 is the furthest location from the warehouse, and T8 is the nearest location from the warehouse. All of the orders satisfy the maximum UAV payload restriction. In Figure 2 (right), the total order weight of T3 is greater than the maximum UAV payload, so a sub-order assignment is necessary.

UAV Chromosome Representation
During initialization, UAVs are randomly assigned to the genes of chromosomes. The length of UAV chromosomes has to be exactly the same length as the genes of the target chromosomes. The same UAV can be assigned to the chromosome more than once in order to achieve the same length as the order/target chromosome when the number of orders from the target is greater than the total number of UAVs in the warehouse.

In Figure 3 (left), each UAV is associated with its different sustainable payload weight, cruising speed and flight time. The right shows that the order/target chromosome is assigned to each gene of UAV chromosome which has total three UAVs (U1, U2 and U3) are assigned to the total eight targets (T1, T2, T3, T4, T5, T6, T7 and T8).
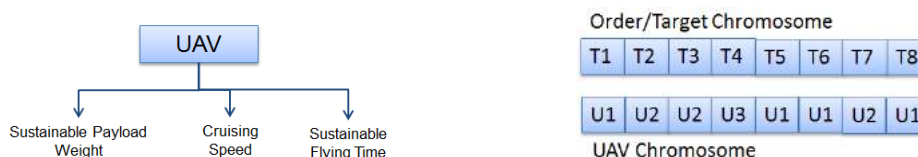

Figure 3: Parameters for each UAV with respect to the genes in the UAV chromosome (left) and chromosome representation of Order/target chromosome and UAV chromosome (right)

It can be called as the two chromosome representation of order/target chromosome and

UAV chromosome, however, only the UAV chromosome follows GA rules for mutation and crossover methods, meanwhile, order/target chromosome keeps its static representation which already ensures the best flight time by giving priority to the most furthest destinations. This reduces the iteration complexity of inefficient chromosome permutation results are eliminated. The execution performance is accordingly enhanced.

DEALING WITH MULTI OBJECTIVE CONSTRAINTS

At each stage of chromosome representation, multi-objective constraints are checked to determine whether the two chromosomes can satisfy one another. For the constraints, first, the order weight of gene form the order/target chromosome must not be exceeded the maximum UAV payload of the gene from the UAV chromosome. If this condition is not satisfied, the chromosome must be discarded, and a new chromosome must be build. Second, the order locations distance of gene from the order chromosome should be in the coverage zone of the gene of UAV chromosome. If this condition is not satisfied, the same consequence applies.

Normally, the fitness function is responsible to build the result by accounting for the problem constraints. However, the presence of more than one constraint can lead to the complexity with respect to the building fitness and consuming the time used for overall execution. Defining multi-objective constraints before the fitness state can reduce such complexity and allow for several constraints according to the nature of the problem without affecting the execution time. Figure 4 shows a condition in which the third gene of the UAV chromosome cannot satisfy a constraint. The rest of the genes are neglected, and the whole chromosome is removed to reduce the overall execution time.
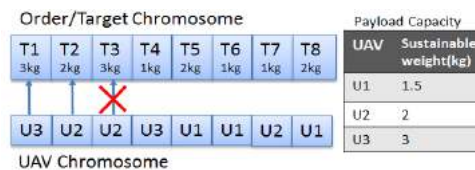
Figure 4: UAV chromosome allocation to the order/target chromosome while checking constraints

CONCURRENT SCHEDULER APPROACH

This approach is designed to save time and money when solving the network scheduling problem by ensuring that the transmission of protocols occurs in parallel way to the receivers. In terms of heuristics, this allows for a relatively easy acquisition of optimal scheduling for the UAV assignment problem.

Basic Concept of Scheduling Approach

The basic concept for concurrent scheduler approach can easily be understood with 2 Scenarios shown as follow:
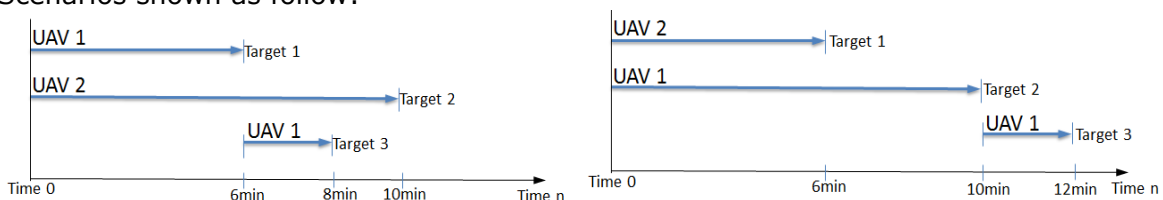
Figure 5: Scenario 1 (left) and scenario 2 (right)

In Figure 5 scenario 1, UAV 1 and UAV 2 fly at the same time to Targets 1 and 2, respectively, UAV 1 finished the delivery to the Target 1 with the flying time of six minutes. Subsequently, UAV 1 finishes the delivery to Target 3, which required another two minutes more. Finally, the total order completion time for scenario 1 takes 10mins

only meanwhile scenario 2 takes 12 mins. Figure 5 demonstrates that the scheduling is important to achieve optimal order completion time.

Concurrent Scheduler Approach applying to the Fitness of GA

The approach proposed in this paper modifies the fitness function of the GA based on the flight time scheduling algorithm. In the scheduling algorithm, the total flight time of each UAV to accomplish its all assigned places should be maximized f(x) in Equation (2). For example, if three UAVs are assigned to one specified mission, f(x) chooses the longest flight time of one UAV. After that, f(x) minimizes to achieve the shorter flight times for the rest of mission assignments until the last generation in Equation (3). This fitness function ensures the shortest overall delivery accomplish time with swarms of UAVs.

$$f(x) = \text{Max}(\sum_{i=1}^{n}(Flight\ Time_i)\ ) \qquad\qquad \text{Equation (2)}$$

Where $\forall$ i$\in$ {UAV$_1$, UAV$_2$, UAV$_3$, UAV$_4$, …, UAV$_n$}, i=1,2,3,4,…,n

$$Min\ [\ f(x) = \text{Max}(\sum_{i=1}^{n}(Flight\ Time_i)\ ] \qquad\qquad \text{Equation (3)}$$

Where $\forall$ f(x)$\in$ {Chromosome$_1$, Chromosmome$_2$, .., Chromosome$_n$}

Here, the above two formula for concurrent scheduler approach are going to prove with the following two chromosome representations.

I	H	J	J	G	G	E	F	D	C	B	A
1	2	1	2	1	4	3	3	3	3	4	4
UAV 1 [**57.65**],			UAV 2[42.75],			UAV 3[43.18],			UAV 4[24.27]		

I	H	J	J	G	G	E	F	D	C	B	A
1	2	1	1	3	4	4	3	3	3	4	4
UAV 1[**64.87**],			UAV 2[23.59],			UAV 3[46.31],			UAV 4[41.04]		

Figure 6: First chromosome representation (left) and second chromosome representation (right) for UAV and order assignments

In the first chromosome representation (left) in Figure 6, the total flight time for UAV1 (57.65) is selected as the best fitness value. In the second chromosome representation (right), the total flight time for UAV1 (64.87) is selected as the best fitness value for that chromosome. As a result, the first chromosome representation is chosen as the best elitism for the next generation according to the Equation (2) and (3).

SYSTEM STRUCTURE WITH GA

Initialization

UAV chromosomes are initialized randomly to achieve the exactly length of the order/target chromosome.

Mutation and Crossover

Some genes in the first chromosome are randomly selected to mutate with the second chromosome. After that, the two child chromosomes are born. This mutation is simple and easy, according to the UAV chromosome nature, the proposed system accepts gene repetition. In the crossover, some genes in the first chromosome are randomly selected and take on a reverse order to build a new chromosome. Detail Formula can be seen in (Bhage and Rastogi, 2011). For the n initialization, the input can produce 3(n) times of chromosome. For two parents, six chromosomes can be produced.

Multi-objective Constraints

The results of 3(n), each of chromosomes are checked whether each genes of chromosome can satisfy the constraints or not.

Fitness Function

Fitness is only accepted for the chromosomes that pass the checking stage of multi-objective constraints. After that, the fitness of each chromosome is calculated and the best fitness is determined according to the scheduling algorithm.

Elitism

Starting from the initialization stage, the best chromosomes with fitness values are selected as elitisms for the next generation. The system can sometimes omit the same structure of best chromosomes. In that case, random initialization is required to create a new chromosome to compensate that omitted chromosome's place.

Generation

The best chromosomes (Elitisms) are added to the system as the next generation parents. The system is terminated when the predefined number of generations is reached. In some case, the system can be terminated by itself before the predefined number of generation when there are no elitisms which are forwarded to the next generation. This issue can encounter while all chromosomes of the generation cannot satisfy the multi-objective constraints. The system is needed to initialize again.

Results

The best chromosome representation is selected from the generation-by-generation chromosome fitness selection.

Flow Chart for the System

The flow chart for the system can be seen as follow:
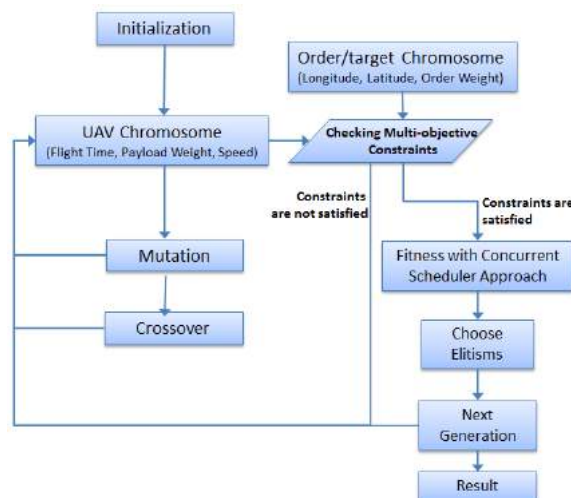
Figure 7: Flow chart for the system

EXPERIMENT

The experiment is implemented using PHP coding language. We defined 4 types of item with related weight in gram. They are Item1 (100g), Item2 (200g), Item3 (300g) and Item4 (400g) respectively. 4 UAVs with 2 types of specification are also defined. UAV1 and UAV2 with 5 m/s (meter/second) of speed, 30 minutes of flight time, 1000g of sustainable payload and 4km with coverage distance. UAV3 and UAV4 with 3 m/s (meter/second) of speed, 20 minutes of flight time, 1500g of sustainable payload and 1.8km with coverage distance. The UAV payload capacity lower bound is 1,000g with the upper coverage bound of 4km.The UAV payload capacity upper bound is 1500g with lower bound 1.8km. Order Detail Data for the experiment is shown in Table 1. Targets H, I and J cannot exceed 1,000g within the 4km coverage area. Target G has sub orders because the total order is over the 1500g of upper bound payload capacity; Equation [1] is applied. After configuring the order chromosome according to its upper and lower

bounds, the static representation for the order/target chromosome genes is IHJJGGEFDCBA.

TABLE 1: Order Detail Data for the Experiment

Order/Target		Latitude	Longitude	Order Items * Quantity	Total Weight(g)	Distance from Warehouse
1	A	37.60104873	126.86691642	Item 4 *1	400	0.1877 km
2	B	37.601954	126.86657488	Item 4 * 3	1200	0.2050 km
3	C	37.60349251	126.86847925	Item 1 * 1	100	0.4443 km
4	D	37.60425325	126.87175512	Item 1 *3, Item 3 *3	1200	0.7250 km
5	E	37.59015915	126.8755424	Item 4 * 3, Item 3 * 1	1500	1.509 km
6	F	37.60904702	126.85599088	Item 1 * 4	400	1.207 km
7	G	37.60829908	126.84687137	Item 4*2, Item 3*3	1700	1.791 km
8	H	37.58077293	126.89609528	Item 1 * 1	100	3.539 km
9	I	37.57470187	126.89585924	Item 1 * 1, Item 4 * 2	900	3.983 km
10	J	37.5998842	126.83221578	Item 1 * 3 , Item 4 * 3	1500	2.874 km

Units: g = gram, km = kilometre, Warehouse location: 37.60074273, 126.86482072, using Haversine formula to calculate the distance between two latitude/longitude points.

TABLE 2: Generation-by-generation results of the concurrent scheduler approach

1st Generation	[121214333344] => 57.65 [121134433344] => 64.87
2nd Generation	**[121234433344] => 46.31** [121233443344] => 52.8 [121133334144] => 69.98 [121114333344] => 76.81
3rd Generation	[121234433344] => 46.31 [121114333344] => 76.81
4th Generation	[121214333344] => 57.65 [121134433344] => 64.87

The majority of genes are discarded due to the checking during the multi-objective stage. Thus, only the genes that satisfy the constraints are carried forward to the fitness function of the concurrent scheduling procedure. Only two genes from the 3(n) pool of 60 are sent to the fitness function from the first generation to the second generation as shown in Table 2. The remaining 58 are discarded. The best fitness value of 46.31 minutes is selected with the UAV allocation of 121234433344. The worst chromosome representation is 109.7 minutes with 111114414341 which are never resulted as the solution. The reason the worst outcome does not give is that the system always try to mutate according to the number of generation loop after initialization stage. The most optimized solution is 45.71 minutes with 212134433134. The results depend on the randomly structures of chromosome in initialization stage and the number of the generation. The system with 10 generations results the acceptable solution mostly from 50 to 60 which is approximately 7.6% deviation to get the optimized one. Meanwhile, the system with 20 generations results from 50 to 45 with the least 2.8% deviation point.

TABLE 3: UAV assignment' results comparison with the delivery

No	UAV Assignment	Delivery accomplish time with Concurrent scheduler Approach(min)	Total Flight Time Approach(min)
1	**121234433344**	**46.31**	175.81
2	221134434431	50.14	174.97
3	112244323234	50.14	168.47
4	212143334141	50.08	172.99
5	212134414431	52.05	169.61
6	211241333443	54.69	167.85
7	121242414241	57.65	159.67

Table 3 indicates that the UAV Assignment with 121234433344 is the best optimal solution as given by the concurrent scheduler approach. However, this assignment is not the best solution only in terms of total flight times. The comparison shows that when the concurrent approach is used to establish to the UAV flight mission effectively, almost a third of the total flight time can be taken to accomplish the entire mission.

CONCLUSION

The drawback of GA is its complexity in terms of building fitness. In this paper, multi-constraints are checked with their feasibilities before fitness. As a result, the complexity is reduced and assistance is provided for the construction of the fitness function more easily. Even though, GA is not able to give the globally optimal solution. However, it is able to produce a reasonable solution when a massive amount of data must be calculated to solve NP-Hard problem, while dynamic program takes a lot of memory and significant running time to reach the globally optimal solution. Moreover, the concurrent scheduler approach ensures to attain the best delivery accomplish time. This novel approach forces to schedule the concurrent style of different fleets/members together at the same time which can save the operation time than the normal scheduling. Additionally, this can be applied not only for the UAVs routing but also other types of scheduling perspectives.

ACKNOWLEDGMENT

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A NOVEL APPROACH TO THE STORAGE ASSIGNMENT IN AN ORDER PICKING SYSTEM

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Abstract

Purpose – In an order picking system, storage assignment deals with the determination of the best location of stock keeping units (SKU) and is one of the most effective strategy to control the efficiency and minimize costs. The aim of this work is to develop of an adaptive approach addressing storage assignment in order to minimize the total cost of travelling with a particular focus on picking activities. The proposed approach aims to efficiently handle seasonality in the products mix avoiding expensive periodic re-arrangements of the warehouse.

Methodology – We implement a greedy-heuristics based on SKU popularity, dynamically calculated, able to handle seasonality and frequent inventory–mix changes as in the case of 3PL provider warehouses. The proposed adaptive approach is embedded within a properly designed decision support tool which uses a numerical simulation to perform multi-scenario analyses and to validate the approach with real warehousing instances.

Findings – We apply the proposed approach with a 5,000 storage locations 3P warehouse dedicated to perishable biomedical products. The obtained results quantify consistent reduction of the travel time for the outbound activities. In particular, the expected travel time for the picking tours decreases of about 10% over the observed horizon.

Value – The proposed adaptive assignment policy does not require a labor-intensive re-arrangement of the storage layout, but exploit the daily incoming SKUs and the empty storage locations to reduce day-by-day the distance between the *as-is* and the *desirable* storage configuration.

Practical implication – The proposed approach is particularly suitable for those warehouses where the rapid response to the changing inventory mix is a strategic lever for market positioning (e.g. 3P warehouses). Furthermore, the proposed approach might be quickly enriched by constraints (e.g., conservation temperature) regarding the quality and safety of the inventory along the storage cycle.

Keywords: Storage assignment, Adaptive policy, Warehouse, Picking, 3PL, Perishable products

1. Introduction

Despite the recent trends in operations management supporting the implementation of JIT or lean approaches to minimize inventory (Green et al., 2014), the lack of accurate demand forecasting results in inevitable physical decoupling points throughout the supply chain. These are warehouses and distribution centers. Therefore, the design (Gu et al. 2010) and management (Gu et al. 2007) of the warehousing systems find still room in the current research debate (Manzini et al. 2015).

In warehousing systems, specifically in order picking system (OPS), picking is renowned as the most labor-intensive activity. Practical evidences demonstrate that the cost accounted by the picking operations is more than 55% of the total warehouse costs (Bartholdi and Hackman, 2011), whereas most are due to travelling. Two main levers address the design and management of OPS: the storage allocation (1), which aims to determine the proper configuration of the fast-pick area (i.e., in terms of shelf volume and sizes) and related planogram issues, and the storage assignment (2), which deals with the identification of the best location for each stock-keeping unit (SKU) over the storage layout, in order to minimize the travelling distance and time for the retrieving tours (Accorsi et al., 2012).

A third levers, particularly diffused for slow-moving item and holding warehouses, is the storage re-location. It deals with the development of unit-load re-locating strategy to maintain the overall stock in space-effective and time-effective conditions. Storage re-location strategies play a crucial role in stock-keeping as well as in the accurate management of the inventory, but require time and labor and frequently result in evitable unit-load double or triple handling.

On the other side, the increasing trend in outsource storage and logistics is pushing the development of third-part logistic (3PL) providers which manage multiple-company inventories, merging different items in size and turn over, with the mutual objective of saving profitable storage space and increasing the efficiency of handling operations (Shi et al., 2016). As a consequence, most 3P warehousing systems are not so confident in implementing re-location strategies, but prefer developing effective storage assignment rules during put-away operations.

Another issue to be handled in 3PL warehouses, is the strong presence of seasonal demand and turn over of the whole inventory–mix, as well as the changing storage mix over and observed horizon. A slow-moving SKU in a selected period may rapidly changes its turn-over, or new SKUs can enter the system pushed by increasing demand curve while deserving less-convenient storage locations after the marketing campaign overs (Manzini et al. 2015).

This paper aims to present a greedy adaptive-storage assignment policy to handle seasonality in 3PL warehouses. A validation analysis is conducted by the design and development of a supporting decision tool embedding numerical simulation and its application to a real case study. The insight aim of the adaptive-storage assignment policy is supporting decision-making for put-away operations in order to minimize the overall travelling for retrieving both unit-load inbound and less-than-unit-load orders.

The proposed policy does not lead to the *static* re-warehousing of an existing system, but exploit the daily incoming SKUs and the empty storage locations to reduce day-by-day the distance between the *as-is* and the *desirable* storage configuration. This policy is in contrast with the traditional approach to re-warehousing, which periodically shifts the *as-is* to the *optimal* storage configuration, but needs the contemporary re-arrangement of the whole storage mix and breaks down the daily logistics services. Therefore, in presence of strong seasonality and high turn-over logistics services, the implementation of an *optimal* re-warehousing policy is not practicable, particularly in 3PL storage systems.

In order to maintain the storage configuration as *desirable* over the time, the proposed methodology is inspired to the healing approach (Kofler et al., 2011), but exploits put-away activities instead of cleanup and re-locating tasks. The proposed adaptive approach also meets 3PLs requirements by avoiding breaking down of daily operations, ensuring level of service, reducing double handling and managing several different items in size and demand pattern.

Empirical evidences on the impact of this policy are measured over a case study of an Italian logistic provider. The storage system is made of more than 5,000 locations dedicated to storage perishable biomedical products.

The remainder of this paper is organized as follows. The review of the literature on this topic is presented in Section 2. Section 3 illustrates the methodology, while Section 4 reports the results from the case study. The results as well as weakness of the methodology are discussed in section 5, and Section 6 concludes the paper with announcements for further developments.

2. Literature Review

The state-of-art concerning the re-warehousing process is limited to few recent works (Housseman et al., 2009, Kofler, 2010) that cover the re-arrangement of the storage configuration to increase operations performances. In presence of slow moving items and stable turn-over, the need for re-warehousing is less evident. Furthermore, this practice can affect the workers capacity to memorize the storage configurations losing the acquired knowledge and experience (Grosse et al., 2013). For these reasons, Tsamis et al. (2015) propose an alternative and less labor-intensive way to conduct re-warehousing based on warehouse adaptation to frequent changes in customer demand. They suggest applying the so-

called product intelligence paradigm in the warehouse management systems (WMSs) in order to calculate the optimized storage location for the incoming item. This is calculated on the current status of the inventory at the time of the item arrival. The benefits of the application of this approach to logistic providers warehouses are in accordance with the structure of Warehouse Management Information System design for 3PLs previously proposed by Tan et al. (2009). Recently, a dynamic storage policy based on SKU affinity is illustrated by Li et al. (2015).

3. Methodology

In OPS the daily retrieving operations empty a set of storage locations that become available to be refilled with the incoming SKUs. The proposed assignment policy exploits the daily put-away activity to assign each incoming unit load to the proper empty location. This allows to progressively minimize the distance from the *desirable* configuration.

The proposed adaptive approach bases upon the definition of a rolling metrics of SKU popularity (Manzini et al., 2015) to progressively move the incoming SKUs to the most convenient location among the set of empty ones. The rolling popularity metric quantifies the number of pick lines per each SKU collected in a selected and observed rolling period named Δt^{roll}.

The resulting storage configuration is to minimize the travelling costs for picking and is day-by-day closer to the optimal storage configuration. According to such a dynamic perspective, a *static* definition of the *convenient* location is upgraded. For each SKU incoming in *t* the convenient location is the one that meets the rolling popularity value calculated over the interval [t-Δt^{rol}, t]. As a consequence, the storage desirable configuration varies daily on the bases of the dynamics of the SKU mix and seasonal demand.

The adaptive storage assignment policy is embedded within a comprehensive procedure (see Figure 1) starting from the collection of the input dataset toward the assessment of the obtained results provided for a comparative what-if analysis.
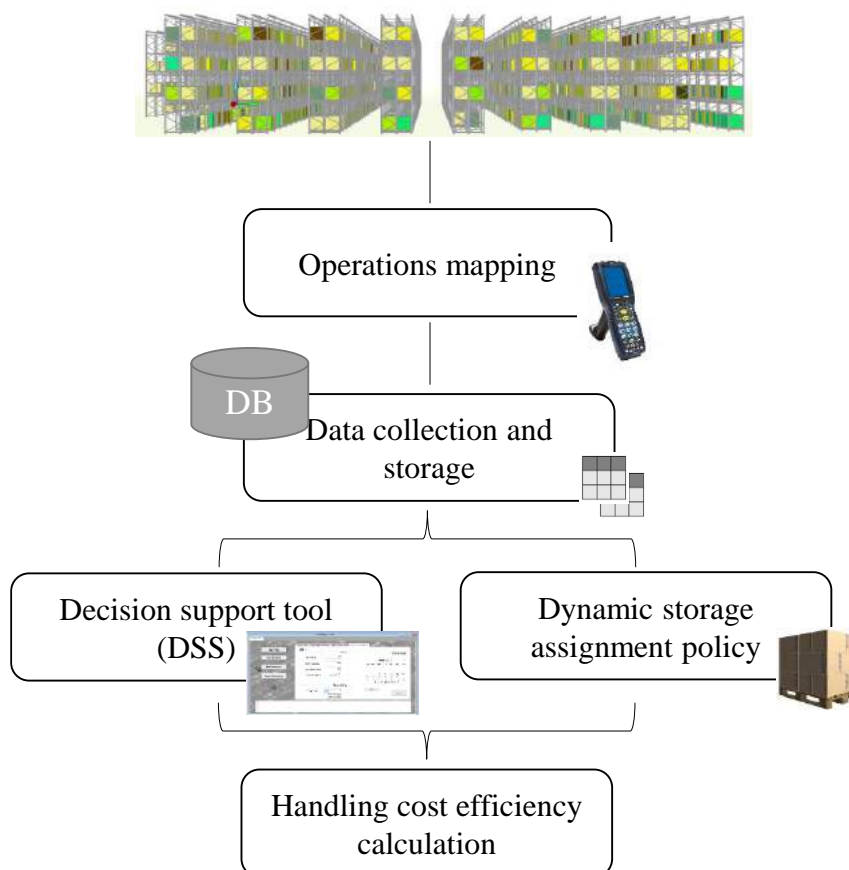
Figure 1. Undertaken methodology to implement the proposed adaptive policy.

A comprehensive dataset is collected from the company WMS, including the order list for the selected temporal horizon, the SKU master file, the list of the available storage locations, the layout pattern (e.g., input/output docks, storage levels, aisles and bays), the characteristics of the handling equipment (i.e., forklift) necessary to quantify the single-command time to achieve each location. Given a specific rolling interval Δt^{roll} (e.g., 1 month), the order list enables quantifying for each SKU and day t the rolling popularity metric POP^{roll}. The set of the incoming SKUs in day t is than ranked per decreasing value of POP^{roll}.

On the other side, the set of empty storage locations is ranked per increasing value of single-command travelling time, determining a ranked list of locations according to their *convenience*. Afterward, these two lists are calculated and matched day by day and the storage assignment pursued accordingly.

Figure 2. Graphic user interface of the simulation tool implementing the adaptive policy

A properly designed tool, developed in C# .NET is connected to the dataset and runs the adaptive assignment-policy over an observed horizon of time (e.g. 1 month) . Figure 2 shows the main Graphic User Interface (GUI) of the tool, where the parameters of the analysis can be properly set. The implemented storage assignment policy brings the *as-is* configuration of the inventory (i.e., at day $t=1$) toward a desirable configuration after T days. The number of empty locations in the generic unit time t significantly constraints this policy and the resulting performances, as well as the heterogeneous set of the daily incoming SKUs. The day-by-day storage configuration, resulting by put-away activities combined with picking activities, is used to perform the picking tours and to fulfill the daily demand.

The proposed tool performs a numerical simulation of the daily warehouse inbound and outbound operations. With respect to the inbound process, the put-away activity is decoupled into a number of time-windows, which are defined by the user. After their arrival, SKUs are assigned to a location during the first time-window or wait in a buffer. The simulation of the daily picking tours allows the assessment of the benefits provided in terms of travelling time (or distance) reduction. Starting from the list of orders provided by the company, the designed tool is able to create an original order list that reflects the inventory changes caused by the aforementioned adaptive policy.

Furthermore, two main policies for retrieving activities are introduced and applied via simulation: the so-called *less-distance* and *less-quantity* rules. Both rules are for choosing one

storage location for retrieval given a list of multiple locations where a given SKU is stored. The travelling time to achieve each location is calculated assuming a uniform input/output dock.

The former policy is to retrieve from the closest one to the input/output dock, the latter to retrieve from the less full, thereby enforcing the location emptying.

The following section presents the case study and the results obtained from different simulations.

4. Case Study

The observed case study deals with a 3PL storage system for biomedical products and equipment. The whole storage capacity is around 5,000 pallets, and the storage system is 4 storage levels high, 11 aisles wide with on average 24 bays per aisle. The observed horizon is about 1 month and half, from September, 28th to November, 11th, 2015. Table 1 summarizes the main characteristics of the observed inbound and outbound operations, while Figure 3 graphs the distribution of the popularity value over the set of SKUs, as well the number of incoming pallets per SKU. It turns out that the 20% of SKUs accounts the 80% of picks, and that 20% of SKUs is responsible of the 80% of the incoming pallets over the observed horizon of time. The reported storage layout (see Table 1) gives a 3D representation of the observed warehouse, where the value of popularity of each SKU is expressed with a green colored pallet filling its storage location. The darker the shade the higher the popularity is.

3PL Warehouse (from 28/09/2015 to 13/11/2015)	
Incoming pallets	6,618
Incoming SKUs	337
Occupied storage location at $t = 1$	3855 (76%)
SKUs in the storage mix at $t = 1$	483
Pick lines	9,938
Orders	1,673
Visited Storage Locations	2,596
Retrieved SKUs	405
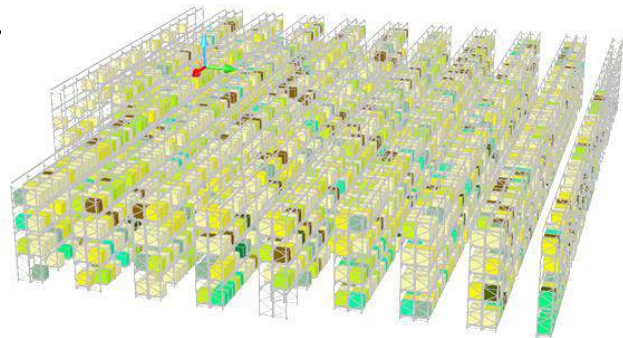
Table 1. Characteristics of the observed 3P warehouse and 3D illustration of the storage layout.
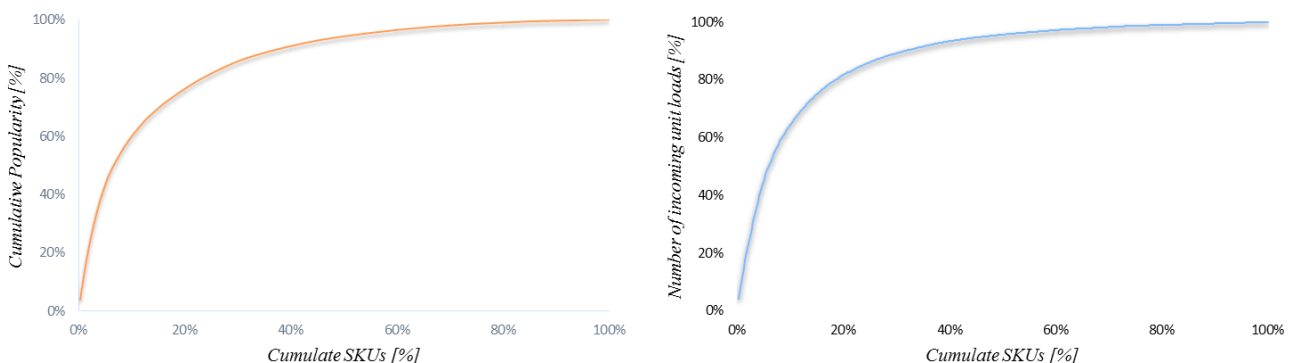
Figure 3. Distribution of the popularity and of the incoming pallets over the set of SKUs.

The illustrated warehouse is analyzed by applying the aforementioned tool to simulate how the proposed adaptive storage assignment policy performs in comparison with the *as-is* benchmark. A set of key performance indicators (KPIs) is measured and hereby reported to compare three scenarios. The *as-is* scenario implements the actual random assignment policy pursued by the 3PL company, the *to-be less-distance* couples the proposed adaptive policy

with the less-distance retrieving rule, while the *to-be less-quantity* scenario implements the adaptive policy in presence of the emptying-oriented rule.

Figure 4 shows the performance, in terms of daily travelling time, for the three scenarios highlighting the benefit provided by both the *to-be* scenarios, with a preference for the *less-distance* one. The *to-be less distance* scenario cumulates an overall saving of 8,3% in comparison with the as-is policy.
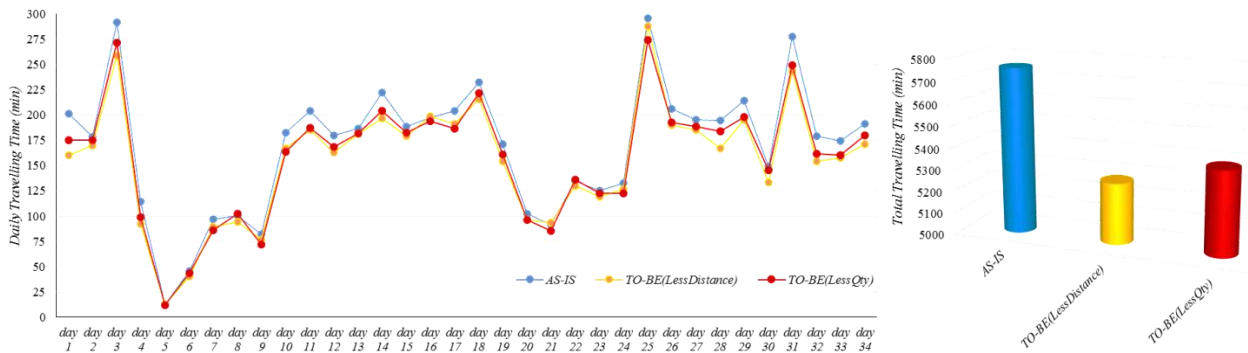
Figure 4. Simulated scenarios comparison (daily travelling minutes for picking).

Figure 4 also highlights as the savings obtained by the proposed policy increases with time and with the number of processed pick lines. On the left side the three scenario are comparable. Then, the differences among them become more and more relevant day-by-day, leaving room for further potential improvements measurable over an extended horizon.

Figure 5 overviews the benefits obtained by the application of the proposed adaptive storage-assignment policy in accordance with the alternative retrieving rules. The histogram represents the percentage of benefit, in terms of travelling time, performed by each policy compared with the *as-is* benchmark. Different behaviors are assessed observing the daily operations of the observed horizon of time, leaving room for debating the influence of the adopted retrieving rule. While evidences seem to favor the *less-distance* rule to decrease the travelling time, the *less-quantity* rule is useful to favor location emptying and to give a wide set of choice to the incoming SKUs, each of them seeking for its most desirable location.
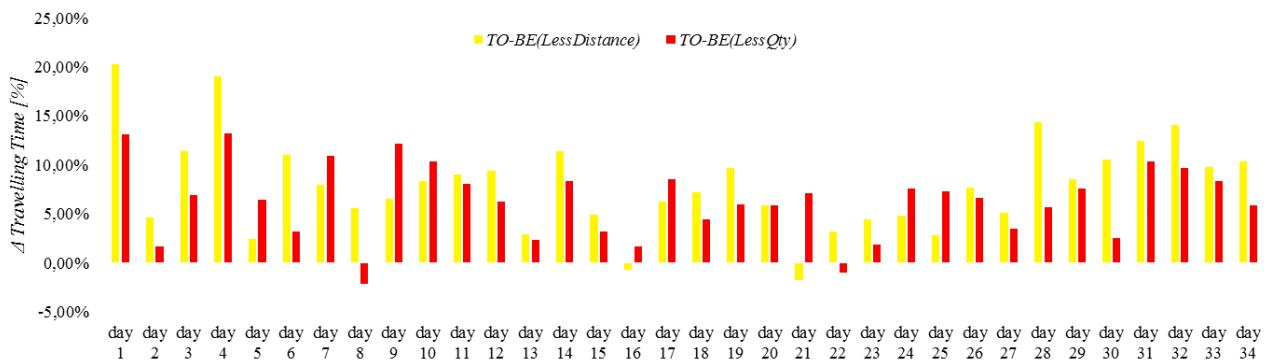
Figure 5. Comparison between the percentual benefits from the adaptive storage assignment with the two alternative picking rules.

Another metric is collected upon the observed case study highlighting the role of the proposed adaptive assignment policy picking policy in improving the picking performance. Specifically, comparing the *as-is* vs the *to-be* scenario over a 3D layout view, Figure 6 demonstrates as the proposed policy tends to move the fast-moving SKU toward the I/O docks (i.e., observe the dark green stain closer to the receiving/shipping docks). As a consequence, the overall density of the fast-pick zones (i.e., storage locations belonging to the distance class 1, 2 and 3) increases from 35% to 60% for zone 1, from 37% to 48% for zone 2, and from 44% up to 49% for zone 3.

While the obtained savings in terms of travelling reduction are illustrated in Figure 4, the layout views, as well as the reported density histograms of Figure 6, show as the storage system is still far from the *desirable* configuration, and there is still room for further improvements achievable within an extended horizon of observation.
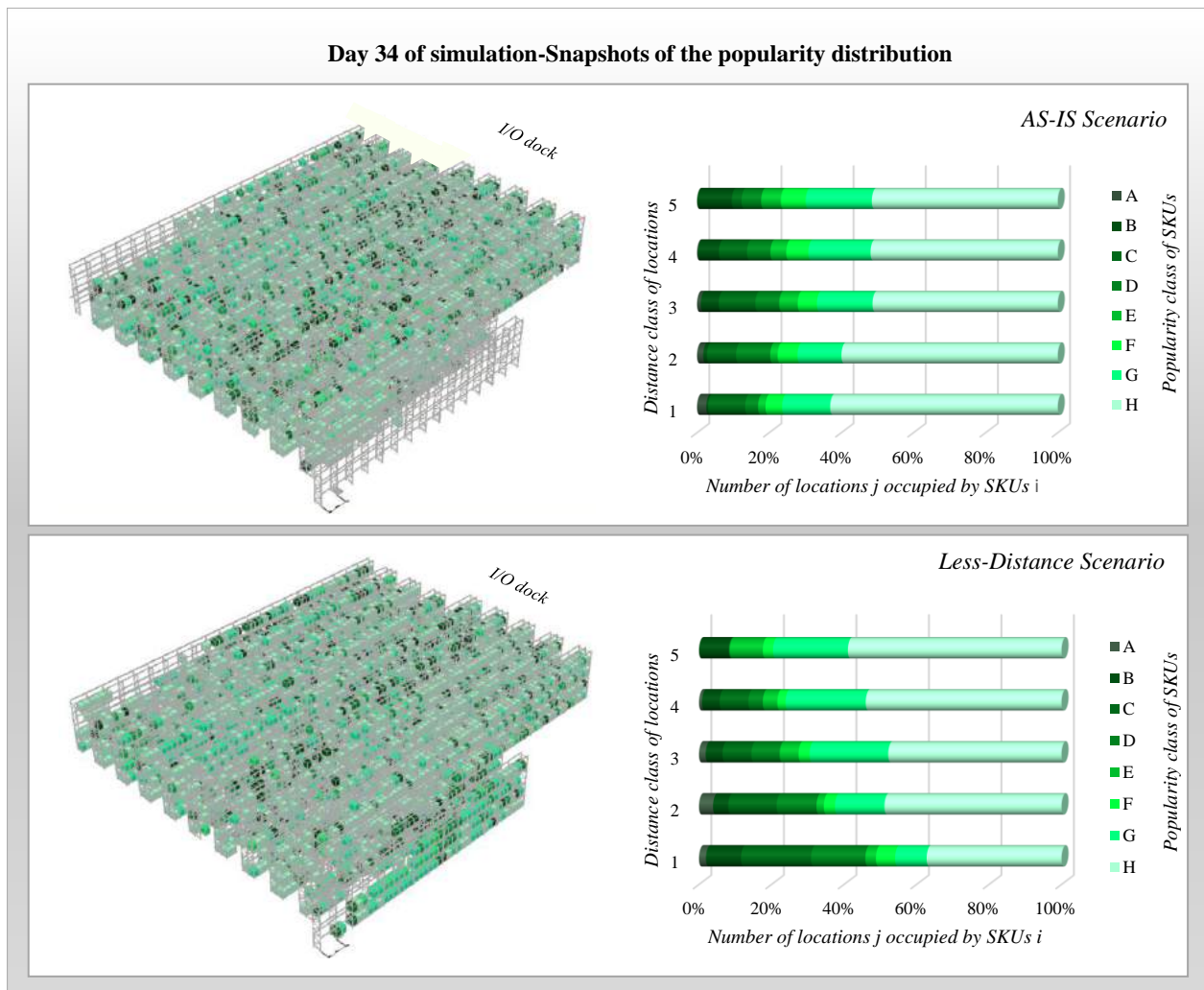
Figure 6. Comparison over the 3D layout view between the *as-is* vs *to-be* storage configuration.

5. Discussion

Despite of the need of further analysis and simulations to validate the proposed approach and policies with other case study and over extended horizon of time, the obtained results arise three fundamental considerations. The first consideration deals with the lack or the *availability* of the *information* related to the incoming SKUs (Giannikas et al., 2013). The operational environment of 3PL companies is often lacking of integrated ICT systems and architectures able to link and connect the client manufacturing data or the physical client distribution activities with the 3PL operator. Since the logistics operations are frequently completely outsourced by the client, information are neither stored and nor sent to the logistic operator, which is left with the eyes closed over the process he is called to manage.

Since the illustrated adaptive storage assignment policy requires the knowledge of the mix of the incoming SKUs to quantify the metric of the rolling popularity, this paper also provides a tool to quantify the cost of information lacking throughout a client-3PL supply chain, by determining the savings compared to the as-is, sometimes random, adopted policy.

The second consideration deals with the set of constraints not currently involved in the proposed policy. Particularly, concerning with the observed warehousing system for perishable biomedical products, the temperature stresses experienced by the stock during the product turn over should be considered when defining the assignment policy.

Figure 7 indeed showcases the temperature measured location by location resulting by the raise of the external temperature during summer months. Furthermore, locations are assigned to twelve classes with respect to their temperature value. The comparison of the two snapshots shows how, with an enhancement of 3 °C of the external temperature, the number of locations contained in high temperature classes raises significantly.

Since the warehouse is not temperature controlled, the distribution of the temperature is according to the air stratification phenomenon (Porras-Amore et al., 2014), and the higher storage level are less convenient for temperature-sensitive products. Therefore, to address this issue widely diffused in 3PL warehouses handling perishable products, multi-purpose assignment policies should be provided and will be object of future research developments.

Finally, the illustrated assignment policy and tool can be quickly implemented as a functionality of existing WMS for the management of the travelling time efficiency in high-turn over and multi-business 3P storage systems.

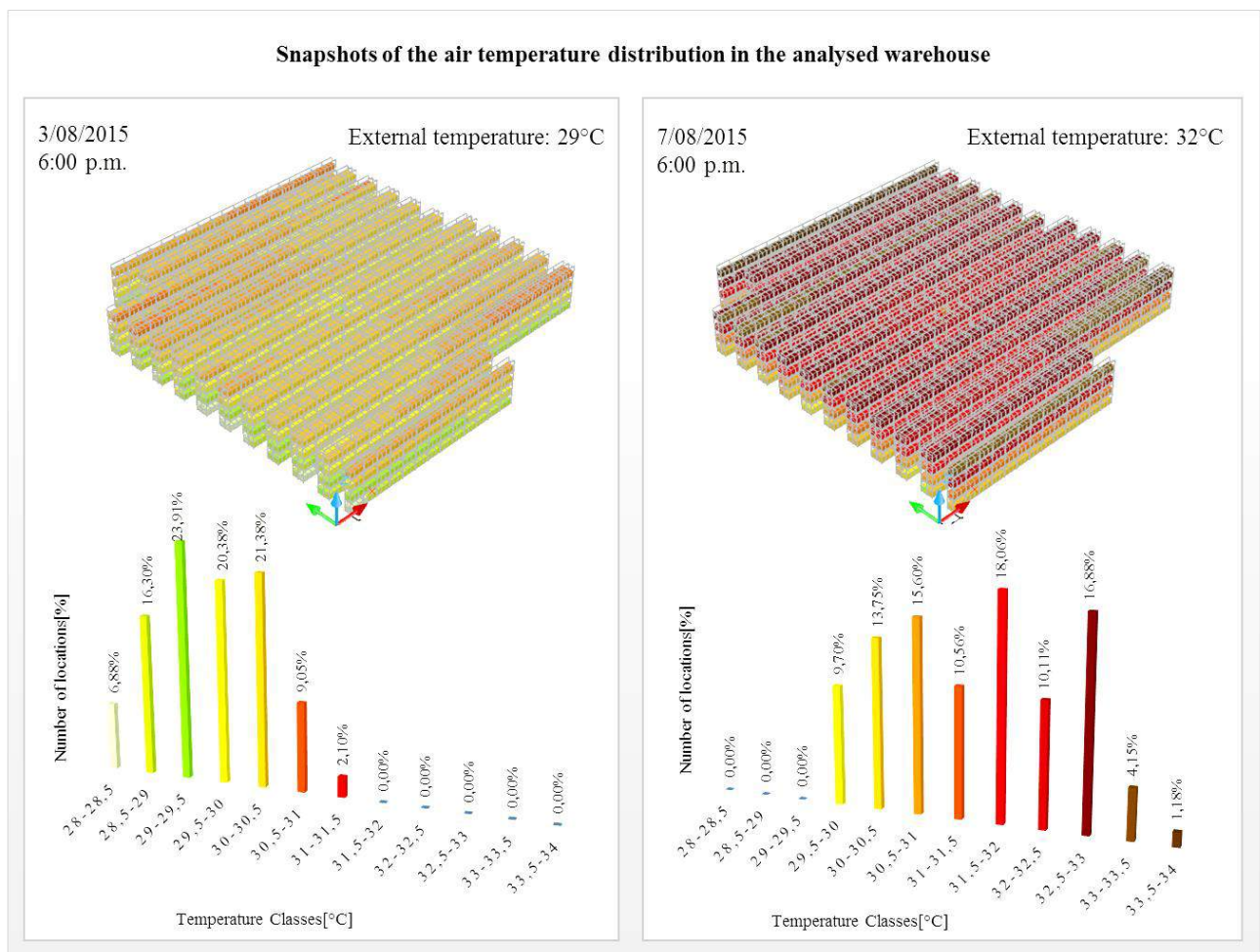**Figure 7**. Temperature measured over the storage locations during summertime.

6. Conclusions

This paper illustrates an effective adaptive storage assignment policy, particularly useful to address daily put-away operations in 3PL provider warehouses. Instead of completely re-configuring the storage layout, this policy exploits the empty locations and the incoming SKUs

ranked according to the value of their *rolling popularity* in order to move toward the most desirable configuration.

A tool developed in C# .NET language embeds the proposed policy and allows to validate its effectiveness with real world data by simulating the resulting picking operations.

Results, obtained via simulation by a multi-scenario analysis, show how the company can obtain a consistent reduction of the travelling time in the outbound activities. In particular, the expected travel time for the picking operations decreases overall of about 8% with daily picks of 20%.

Further developments will test the adoption of optimization instead of greedy-heuristics to define an improved adaptive assignment policy, and will enquire the impact of SKUs constraints (e.g., storage temperature) over the assignment problem and the resulting picking performances.

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IMPLEMENTING META-HEURISTICS FOR AS/RS PICKING SCHEDULING IN SUPPORT OF PRODUCTION LINES

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ABSTRACT

Most research in the past mainly considers AS/RS in distribution environment. In this study, we consider AS/RS in the support of an assembly line having multiple cells. For the coordination between the assembly line and the AS/RS, we implemented metaheuristics with Tabu algorithm to solve the sequencing of tasks having picking and put-away operations in support of a Toyota manufacturing system where production lines are composed of cells to assemble simultaneously a variety of products such as auto parts, electronic devices, etc. In this paper, three Tabu heuristic algorithms were devised with variations in search and exchange. The first algorithm (TI) is a regular Tabu search with special initial solution strategy; the second algorithm (TID) combines TI with divide and conquer search strategy; the third algorithm (TIE) is TI with special exchange strategy. We experimented on an AS/RS – production system having 40 assembly cells and an AS/RS with capacity of 1600 baskets for holding materials for assembly. By making 30 runs for each of the above three algorithms, we found that that TIE performs the best, followed by TID and then TI. It also demonstrates that Tabu search can help the operation of AS/RS by reducing 5-30% of shop floor assembly time while TIE can obtain a sequence solution in the best possible time by saving 54.9% of the computation time over TI.

Keywords: AS/RS, Tabu search, Production support, Divide and conquer

INTRODUCTION

Automated storage and retrieval systems (AS/RS) have widely been implemented at production sites for material storage to support shop floor. In distribution, it is also broadly used for its high storage capacity and computerized management system. Most research in the past mainly considers AS/RS in distribution environment and includes transportation and customers' due time requisite in the model (Chang and Lee, 2004; Roodergen and Vis, 2009). In this study, we consider AS/RS in the support of assembly operations; specifically,

there are many single cell stations, wherein, one or multiple operators work alone or in a coordinated manner to complete product assembly. For auto parts production that follows Toyota production principle, it may be organized in cells to produce a large variety of parts such as mirrors, head lamps, tail lamps, auto electronics devices, etc. To design an AS/RS system capable of supporting materials required in the shop floor, the fundamental principle is in-time supply of multiple parts simultaneously to avoid production stoppage.

For manufacturers, there could be many different kinds of demand at the production site. For example, for auto parts suppliers, there are OEM orders, AM (after market) orders, etc. For OEM orders, smooth supply of parts to auto assembly plants is compulsory; thus they feature low volume and high variety of products to be supplied many times a day. For AM products, orders are mostly medium to large in volume and low to medium in variety. Because OEM products are required every day, higher priority is usually given to this kind of products and the rest of the production volume is assigned to AM orders.

Despite there were some studies on AS/RS sequencing problems, none of them look into the problem in support of shop floor demand (Oliveira, 2007; Roodbergen and Vis, 2009). The main difference is that in pure AS/RS sequencing problems, we look into the optimal sequencing of AS/RS itself; while in the support of shop floor manufacturing, the sequencing is under the constraint of shop floor scheduling. In this paper, we study the sequencing problem, both put-away and picking sequences, of an AS/RS, capability of dual command cycles, in support of a Toyota manufacturing system where production lines are composed of cells to assemble simultaneously a variety of products such as auto parts, electronic devices, etc.

The sequencing of commands (jobs) changes the sequence of jobs in the list to meet the requirement of shop floor and is significant for the performances of AS/RS. There was some research (e.g., Lee and Schaefer, 1997) studying different sequencing methods with diverse types of operations (single or dual command) and sequencing constraints such as due date, critical ratios, etc. Past research on production support of AS/RS design and operations is quite rare (Chang and Lee, 2004; Roodbergen and Vis, 2009). Motivated by some auto parts manufacturers investing in AS/RS for their production plants, this research considers the operations of AS/RS differently from past research in finding a coordinated way to support the assembly lines. \Past research mainly studied AS/RS in the environment of manufacturing or distribution individually (Chang and Lee, 2004; Roodbergen and Vis, 2009) and was quite different from what we plan to address in this study.

Method

Tabu search was proposed by Glover (1986) as a metaheuristic algorithm employing local search methods for optimization. It embeds with a memory list to avoid searching into wrong directions or previous unfavored solutions to dodge being stuck in local optimum for better searching efficiency. It has widely been used in solving large-scale problems (Sung et al., 2007). Meeting with diverse problems, different strategies in Tabu search are schemed and they comprise: 1. Initial solution strategy, 2. Candidate list and selection mechanism, 3. Search strategy, 4. Move and exchange strategy, 5. Tabu list and aspiration criteria and 6. Stopping criteria. In this paper, three Tabu heuristic algorithms were devised with variations in search and exchange. The first algorithm (TI) is a regular Tabu search with special initial solution strategy; the second algorithm (TID) combines TI and divide and conquer search strategy; the third algorithm (TIE) is TI with special exchange strategy.

AR/RS performs picking for shop floor material requirement and when there is a put-away process after receiving materials, it interleaves the picking and put-away processes for efficient operations. The interleaved tasks in a day are divided into chunks, say 2 hours of tasks and Tabu algorithm is to find the best job sequence to support shop floor assembly.

Step 1. Initial solution strategy

Because AS/RS supports shop floor assembly, different materials are usually required simultaneously. In the initial solution strategy, we implemented the scattered strategy where the same materials are picked non-continuously but evenly in the picking sequence to avoid supplying too much of the same materials while leaving others in shortage.

Step 2. Candidate list and selection mechanism

The candidates here are jobs of mixed picking and put-away. The candidate list includes a central point and other candidate points and the size of the list, denoted as N, depends on the size of the wait list, which determines the size of the searching space. The central point exchanges with a candidate point based on the selection mechanism and if the exchange results in better improvement in performance, the move of the exchange takes place. The search and move mechanism in this study is divided into two stages. The first searches in a larger space to avoid being caught in local optimization and the second opts for an optimal solution locally. By searching for a better move between the central point and all the candidates, the algorithm finds a better solution. However, if there is no improvement in performance after searching through all the candidates, the central point is put into the Tabu list having length denoted as T.

The candidate list is void and replaced by a new one after a thorough search of all the candidates. The stopping criterion for the search algorithm is when the Tabu list is full.

Because we implemented a two stages search algorithm, the global search stops when the first Tabu list is full and then we move to the local search which stops searching when the second Tabu list is full.

In determining the central point in a candidate list, we devise a probability selection rule based on the emergence level of each task, Z, and it includes the time required for the crane to perform a job, denoted as T_{move}, and the utilization of assembly cells, U_{cell}. We constructed Z as a liner combination of T_{move} and U_{cell} and that when Z of a job is evaluated as low it means this job has a more urgent need to be carried out than others that have higher values and the probability of being selected is devised as higher and vice versa.

Step 3. Search strategy

In searching through the candidates, we consider that all jobs are aligned in a sequence and to avoid dealing with boundary conditions, we enclose the two ends to form a circle for the sequence. Thus in a search, there is no head or tail. In the candidate list, we first choose the central point with probability derived from Z value. We then select $N/2$ candidates respectively at the two sides of the central point.

Step 4. Move and exchange strategy

The move in this study is swapping, i.e., the central point will exchange with the candidate with the most performance improvement. If there is no improvement, the central point will be put into the Tabu list. We use two exchange strategies – (1) block to block exchange and (2) one to one exchange. The former can have a larger scale of improvement and is used at the initial searching process; the latter can have a more delicate improvement and is used when the solution improvement rate slows down.

Step 5. Tabu list and aspiration criteria

Tabu list is to avoid selecting a point that cannot improve performance in all the moves with the candidates to be selected again. Say the central points - R1 and R2 - cannot improve in performance in the move with candidates, they would be put into the Tabu list as $\{R_1, R_2\}$. When R3 is selected as the central point and find a move that can improve performance, both R1 and R2 would be aspired leaving only R3 in the list.

Step 6 Stopping criteria

The stopping criteria for the searching is when the Tabu list is full, i.e., when the Tabu list has length of T, it will keep searching until T+1 points continuously cannot improve

performance. Besides, the algorithm also stops searching after searching for 300 central points even though the Tabu list is still not full.

We perform Tabu algorithm for the tasks of every two hours. In the experiment below, we re-sequence the jobs in the morning, i.e., two two-hour sections of jobs in the morning. In the first two-hour of section, there are 3 OEM orders and 2 AM orders with total items of 1888 units, which amounts to 81.46% of the assembly capacity; the second section has 5 OEM orders and 1 AM order with the total amount of 1000 units, which occupies 94.69% of the assembly capacity. By calculating from the material requirement of the assembly shop floor of the two two-hour sections, we obtain a sequence list of 271 AS/RS picking and put-away jobs. Thus the solution length we used to experiment on different Tabu algorithm models is 271. The first stage of the candidate list is 10 units and the second is 6 units. Based on the recommendation of Glover & Laguna (1997), we set the length of Tabu list as 7. The maximum iteration constraint is 300. To experiment on the performance of the Tabu algorithms proposed, we experimented on an AS/RS – production system having 40 assembly cells and an AS/RS with capacity of 1600 baskets for holding materials for the assembly with three Tabu algorithm variations: (1) TI: Tabu algorithm with initial solution uniformity; (2) TID: TI algorithm with divide and conquer; (3) TIE: TI algorithm with special exchange algorithm. Figure 1 & 2 show the performance of the three Tabu algorithms after making 30 runs for each. In the figures, the objective value is the time constraints for the jobs to be performed in a two-hour section, i.e., 120 minutes and the lower bound is computing the time required without waiting and delay. As can be seen from the two figures, the three Tabu algorithms not only can achieve the objective bound but makes the assembly line complete the jobs earlier. The maximal improvement is mostly comes from the TIE model with 20-30% of improvement and it can also obtain the best possible sequence solution by saving 54.9% of the computation time over TI
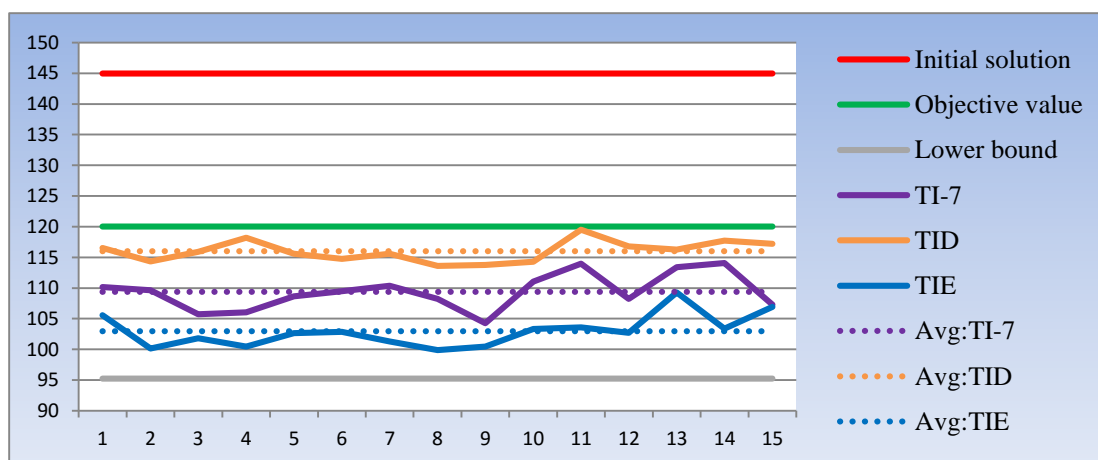
Figure 1 First 2-hour section results
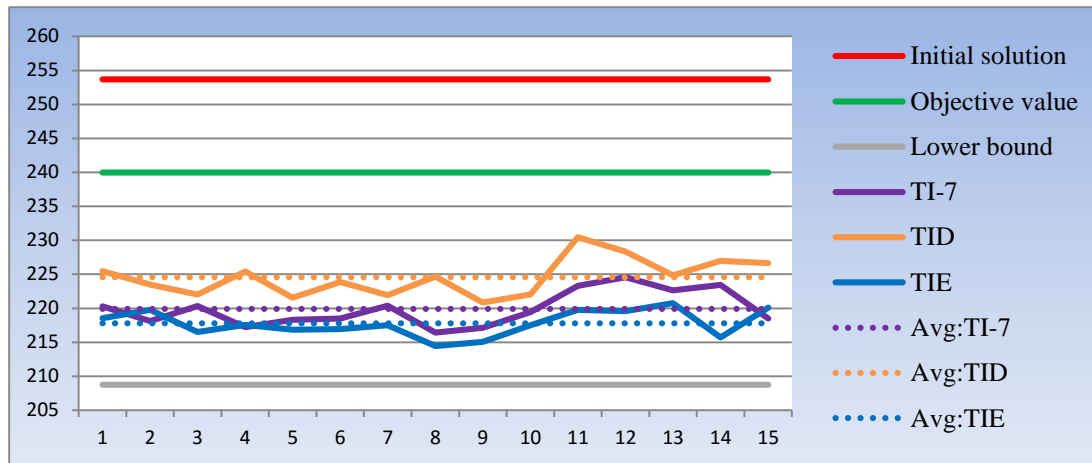
Figure 2 Second 2-hour section results

Findings and Originality

This study explores the sequencing problem of AS/RS in support of production line, which is quite rare in literature. Without considering shop floor material requirement, finding the best sequencing of jobs of an AR/RS is invalid and cannot improve the overall production efficiency. The main challenge for an AS/RS to support assembly cells in making multiple products at the same time is that many necessary parts are required to have in-time supply. The Tabu algorithms devised in this study show much improvement over the initial solution and this demonstrates the effectiveness of our Tabu algorithm. Future research can be toward implementing other metaheuristics such as SA or GA or a combination of some of them to have a more efficient and effective algorithm in order to be embedded in the controller box for real-time dispatching of jobs of AS/RS.

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ON RECONCILING MICRO AND MACRO ENERGY TRANSPORT FORECASTS

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ABSTRACT

Purpose of this paper: Shipping freight prices are characterised by volatility, seasonality and sensitivity to energy prices and market sentiment. Earning levels are considered to be mean-reverting in the long-run and subject to demand and supply imbalance in the short-run. On one hand, demand for shipping transport is a derived demand that depends on the state of the international seaborne trade. On the other hand, supply for energy transport is subject to availability and productivity of the fleet. This work investigates ways to bridge the differences and improve forecasting macro and micro levels in the energy transport sector.

Design/methodology/approach: Established approaches in the energy literature are employed for forecasting the demand and supply for energy transport. Consequently, hierarchical time series approaches (bottom-up and optimal combination) are applied and contrasted in order to identify the most suitable hierarchical approach in the case of energy transport.

Findings: We provide suggestions for optimal hierarchical reconciliation in the energy transport sector. Also, we show that combining forecasts from macro and micro levels lead to improved forecasting performance.

Value: This research study explores for the first time how reconciliation of forecasts produced at macro and micro levels can bring benefits in the energy transport sector.

Research limitations: This work focuses on the application of hierarchical approaches to energy transport on a monthly data frequency. Extensions could focus on alternative data frequencies, or even producing combinations of forecasts across multiple levels of temporal aggregation.

Practical implications: Shipping practitioners (shipowners, charters, brokers, investors) will benefit from more informed decisions. This comes as the direct result of reconciled forecasts on macro and micro levels that take into account information at various level of the hierarchy.

Keywords: forecasting, freight revenues, shipping energy, freight earnings.

1. INTRODUCTION

Shipping practitioners are faced with challenging strategic decisions that require valuing shipping revenues at both microeconomic and macroeconomic levels. On the one hand, micro operational strategies are the choice of trading routes and steaming speeds, on the other hand, macro investment decisions are type of trades, ordering a new-build or buying a secondhand and the optimal vessel size. This research study explores for the first time how reconciliation of shipping revenues forecasts produced at macro and micro levels can improve decision making in the energy transport sector. This should benefit Shipping practitioners (shipowners, charters, brokers, investors) in making more informed decisions, which is a direct result of reconciled forecasts that take into account information at various level of the hierarchy.

The maritime economic literature that investigates freight dynamics has mainly focused on improving forecasting methodologies for freight revenues and not on improving forecasting strategies, as if, the general consent is that generated forecasts for freight revenues at any hierarchy level are appropriate for making investment and operational decisions alike. Thus, the focus in literature is the accuracy of freight revenues forecasts across different methodologies and not at different aggregated level. This paper proposes a forecasting strategy to improve operational and investment decisions instead of the literature focus on forecasting methods. The reminder of the paper is organized as follows. Section 2 is a background review of shipping energy dynamics. Section 3 is the design and data description. Section 4 is results. Section 5 is the conclusion.

2. BACKGROUND REVIEW OF SHIPPING ENERGY DYNAMICS

In this section, we discuss the relevant literature related to modelling and forecasting freight revenues in the short-term and long term, and across different hierarchy levels, in an attempt to answer the following question: What is the link between forecasts for freight revenues generated at different hierarchy levels and shipping strategic decisions?

Freight revenues are characterised to be highly volatile, seasonal (Kavussanos and Alizadeh (2002)), sensitive to energy prices and market sentiments and are considered to be mean-reverting in the long-run and subject to demand and supply imbalances in the short-run (Adland and Cullinane (2006); Alizadeh and Nomikos (2009); Stopford (2009); Abouarghoub (2013)). On the one hand, demand for shipping transport is a derived demand that depends on the state of the global economy and international seaborne trade. On the other hand, supply of shipping transport is subject to availability and productivity of the fleet. Therefore, shipping freight revenues are highly correlated and co-move together in the long-run, but behave differently in the short-run, (Kavussanos and Alizadeh, 2002). The co-movement in the long-run is due to the nature of the demand function for sea transport that is derived by macroeconomic factors such as global demand for seaborne trade, average haul, global shocks and transport costs. In the short-run the dynamics of freight revenues are shaped by microeconomic factors such as the vessel segment (size), steaming speed and the specific trading route.

Shipping transport is a nonstorable service where short and long-term revenues are not linked through an arbitrage relationship (Batcherlor et al., 2007). This is due to the perfect competitive nature of the shipping market in adjusting supply and demand in the short-run, which is mainly influenced by feet capacity, feet productivity, shipbuilding, scrapping, losses and freight revenues. For details of key macro and micro factors that affect the demand and supply of shipping services, see Stopford (2009). The dynamics of freight revenues in the long-run and short-run are dissimilar due to the impact of supply and demand factors, thus, it is reasonable to suggest that forecasting freight revenues in the short-term and the long-term are two independent activities that require different forecasting strategies. However, the literature does not suggest different forecasting strategies for freight revenues in the short- and long-term or at different hierarch levels

to account for these dissimilarities; instead the focus is on the methodological approach that provides the best forecasting results. This study aims to address this shortcoming.

The shipping markets are considered to be one entity with a common market sentiment (Randers and Gluke, 2007), which is reflected in a highly correlated freight market and thus. A natural hierarchical structure is aggregated through a middle vessel size level to better reflect the strong degree of substitutability of cargoes across different routes. Therefore, in this study, shipping freight revenues and their forecasts are aggregated at three levels, consequently improving forecasts of freight revenues at the top level. First, the lower-level of the hierarchy represents tanker routes and forecasts generated at this level is more relevant for short-term operational decisions. Second, the middle-level hierarchy represents tanker segment (size of vessel) and forecasts generated at this level is more relevant for long- to medium-term investment decisions. Finally, the top hierarchy represents the tanker trade (type of trade) and forecasts generated at this level is more relevant for macro-level planning.

Most papers (see Table 1) that investigate freight dynamics using spot, forward freight agreements (FFAs) and Time-Charter contracts are actually attempts to model freight rates at different levels of the hierarchy, but not been recognized as such. For example studies by Kavussanos and Alizadeh (2001), Kavussanos and Alizadeh (2002), Batcherlor et al. (2007), Adland and Cullinane (2006) and Zhang et al. (2014) focus on one particular level of the hierarchy, while studies by Kavussanos and Dimitrakopoulos (2011) and Abouarghoub et al. (2014) focus on more than one level of the hierarchy. Although modelling and forecasting freight revenues has been investigated in the literature at all three proposed hierarchy levels, none discusses the strategic implication, suggesting that forecasts for freight revenues generated at any hierarchy level is suitable for both making micro operational decisions and macro investment decisions. Consequently, the maritime literature does not discuss the importance of generating freight revenues forecasts at different hierarchy levels to improve shipping strategic decisions, instead it is focused on investigating the most appropriate and best forecasting model for freight revenues. In other words, the literature does not offer different forecasting strategies for different state-levels. We find ourselves asking the question 'Are forecasts generated at different hierarchy levels suitable for making micro and macro decisions?'

Table 1: Key references to hierarchical mapping in maritime literature.

Focus of the Study	Shipping Sector		Freight Market			Hierarchy-Level		
	Bulk	Tanker	Spot	Forward	TCE	Trade	Size	Route
Kavussanos and Alizadeh (2001)	✓		✓	✓			✓	
Kavussanos and Alizadeh (2002)			✓				✓	
Batcherlor et al. (2007)	✓		✓	✓				✓
Adland and Cullinane (2006)			✓		✓		✓	
Kavussanos and Dimitrakopoulos (2011)			✓			✓		✓
Zhang et al. (2014)			✓	✓				✓
Abouarghoub (2013)		✓	✓		✓	✓	✓	✓

3. DESIGN AND DATA DESCRIPTION

In this section, we describe the shipping energy[1] data under investigation, mainly focusing on crude and product trades categorized by shipping capacity; type and size of the tanker.

3.1. Data

The shipping energy market consists of specialised large tanker vessels that transport crude oil on long haul distances and medium/small product tankers that transport oil products on medium and short haul distances. The tanker trade is mainly categorized by cargo capacity into four sizes; very large crude carriers (VLCC,200,000 mt and over), Suezmax (130,000 mt - 200,000 mt), Aframax (80,000 mt - 130,000 mt) and Product (less than 80,000 mt). In Table 2 we present the most disaggregated level of tankers' earnings for crude oil and product trades in two sections, categorized by tanker size, also loading and discharging ports are described. For a complete list of shipping routes and historical developments of tanker trades see Alizadeh and Nomikos (2009). Oil shipments are mainly crude and are shipped for long hauls by large tankers loading from the Arabian Gulf. In Table 2 we describe the tanker routes under investigation in this study, the most disaggregated level of the hierarchy that is the base for tankers' earnings depicted in Figure 1. Tanker trade is presented in two sections, crude oil trade in the top part and oil product trade in the bottom part, details of loading ports and discharging ports and sailing distance in nautical miles are described for each tanker size.

3.2. Experimental framework

Monthly averages of daily freight earnings are the base for our forecasts at the hierarchy lower level. The sums of these earnings for each tanker size are the base for our forecasts at the middle level and the total sums of freight earnings are the base for our forecasts at the top level. In other words, our forecasts at lower, middle and top levels are average daily tanker earnings for specific routes, average daily tanker aggregated earnings for each size category and average daily aggregated earnings for all tankers, respectively.

Statistical forecasts based on historical data can be produced at every of the three levels of the hierarchy considered in Figure 1. However, forecasts created at the bottom level do not exactly sum up to the forecasts calculated directly at upper levels. Equally, forecasts produced at the top-level can disaggregated to lower level forecasts, however there will be some deviations from the estimates directly produced at the lower levels.

To tackle this problem, several hierarchical reconciliation approaches have been considered in the literature. Bottom-up and top-down are the two most widely used hierarchical approaches. In the bottom-up approach, forecasts are calculated only at the lowest hierarchical level; these forecasts are subsequently summed up to create forecasts of higher levels. Top-down approach produces forecasts only at the highest hierarchical level; these forecasts are then splitted down to other levels using appropriate proportions (usually calculated based on historical data). More recently, combination approaches have been considered in the literature. More specifically, Hyndman et al. (2011) and Athanasopoulos et al. (2009) proposed the "optimal reconciliation" approach. This approach statistically and optimally combines the forecasts produced at all levels. The calculation of the optimal weights is given by $w = S(S'S)^{-1}S'$, where S is a Boolean matrix that directly corresponds to the hierarchical structure of the data. For the hierarchy used in this paper,

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[1] The term shipping energy in this study refers to crude oil and products, excluding gas

Table 2: Hierarchical at the bottom level and shipping energy routes.

No	Node	Crude Oil Trade	Dist(NM)	Tanker Size
1	AAA	Ras Tanura (SA) - Rotterdam (NL)	6544	VLCC
2	AAB	Ras Tanura (SA) - Singapore (SG)	3754	VLCC
3	AAC	Ras Tanura (SA) - Ulsan (KR)	6280	VLCC
4	AAD	Ras Tanura (SA) - Ain Sukhna (EG)	3404	VLCC
5	AAE	Sidi Keri (EG) - Rotterdam (NL)	3186	VLCC
6	AAF	Ras Tanura (SA) - Chiba (JP)	6673	VLCC
7	AAG	Ras Tanura (SA) - LOOP (US)	9645	VLCC
8	AAH	Bonny Off (NG) - LOOP (US)	6244	VLCC
9	BAA	Sidi Kerir (EG) - Fos (FR)	1446	Suezmax
10	BAB	Bonny Off (NG) - Philadelphia (US)	7058	Suezmax
11	CAA	Ras Tanura (SA) - Singapore (SG)	3754	Aframax
12	CAB	Sidi Kerir (EG) - Trieste (IT)	1202	Aframax
13	CAC	Arzew (AG) - Philadelphia (US)	3712	Aframax
14	CAD	Sullom Voe (GB) - Wilhelmshaven (GER)	594	Aframax
15	CAE	Sullom Voe (GB) - Bayway (US)	4060	Aframax
16	CAF	Curacao (VN) - Texas City (US)	1800	Aframax
17	CAG	Curacao (VN) - Hamburg (GER)	4586	Aframax
18	CAH	Jakarta (ID) - Chiba (JP)	3190	Aframax
19	CAI	Ras Tanura (SA) - Chiba (JP)	6673	Aframax
		Oil Product Trade		
20	DAA	Ras Tanura (SA) - Chiba (JP) 35k	6673	Product
21	DAB	Singapore (SG) - Chiba (JP) 30k	2907	Product
22	DAC	Curacao (VN) - New York (US) 38k	1771	Product
23	DAD	Bahrain (BH) - Bombay (IN) 30k	1372	Product
24	DAE	Rotterdam (NL) - New York (US) 37k	3340	Product
25	DAF	Tees (UK) - Dunkirk (FR) 22k	289	Product
26	DAG	Augusta (IT) - Lavera (FR) 22k	655	Product
27	DAH	Ras Tanura (SA) - Chiba (JP) 55k	6673	Product

In Table 2 we describe energy shipping routes for the most disaggregated level, the columns from left to right are, route number, node code, loading and discharging ports (country),distance between ports in nautical miles and tanker size.
LOOP stands for The Louisiana Offshore Oil Port.
Fos stands for Fos-sur-Mer Port.
Countries codes are NL: Netherlands; SG:Singapore; KR: South Korea
US: United States; FR: France; IT: Italy; GER: Germany; SA: Saudi Arabia
EG: Egypt; NG: Nigeria; AG:Algeria; GB: Great Britain; VN: Venezuela;
ID: Indonesia; BH: Bahrain; JP: Japan

$$S = \begin{bmatrix} 1_{27} \\ 1_8 \ 0_{19} \\ 0_8 \ 1_2 \ 0_{17} \\ 0_{10} \ 1_9 \ 0_8 \\ 0_{19} \ 1_8 \\ diag(1_{27}) \end{bmatrix}, \qquad (1)$$

where x_y is a vector of values x and order y while $diag(.)$ refers to the diagonal matrix. The reconciled forecasts, $\tilde{y}$, can be calculated as $\tilde{y} = w\hat{y}$, where $\hat{y}$ are the original forecasts calculated directly at each level.

A disadvantage of the optimal combination approach is that it gives more emphasis to the higher level forecasts. Athanasopoulos et al. (2015), focusing on the temporal hierarchies, suggest the use of a scaling matrix W so that $w = S(S'W^{-1}S)^{-1}S'W^{-1}$. One-way to estimate W is directly from the structure of the hierarchy and the number of bottom level nodes contributing to each node. For the hierarchy of this report, W = diag(27; 8; 2; 8; 9; 1_{27}).

In this research, we focus on producing forecasts from all levels and subsequently reconciling them using the optimal combination approach. We benchmark this strategy

against the bottom-up approach, where forecasts are calculated only on the most granular level and forecasts of other levels are directly derived as appropriate sums of the bottom level forecasts. It is noted in the literature that autoregressive integrated moving average (ARIMA) models are considered to be the most suitable methods for forecasting shipping freight rates (Batcherlor et al. (2007) and Kavussanos and Alizadeh (2002)), thus, forecasts at all levels are produced considering the automatic ARIMA approach (Hyndman and Khandakar, 2008, auto.arima() function) implemented in the *forecast* package for the R statistical software. In more detail, this approach identifies and estimates the most appropriate ARIMA model for each time series individually.

Forecasting performance is evaluated over the last three years of the available data (from 01/2013 till 12/2015) in a rolling origin manner. First, the in-sample consists of data up to December 2012 and monthly forecasts for the next year (01/2013 till 12/2013) are produced. Then, the in-sample increases by one month and forecasts are produced for the period 02/2013 till 1/2014. The procedure is repeated till the point that the forecast origin is the end of 2014 (12/2014 is the last available observation in the in-sample) and monthly forecasts are produced for 2015. In all cases, the forecasting horizon equals to 12 months.
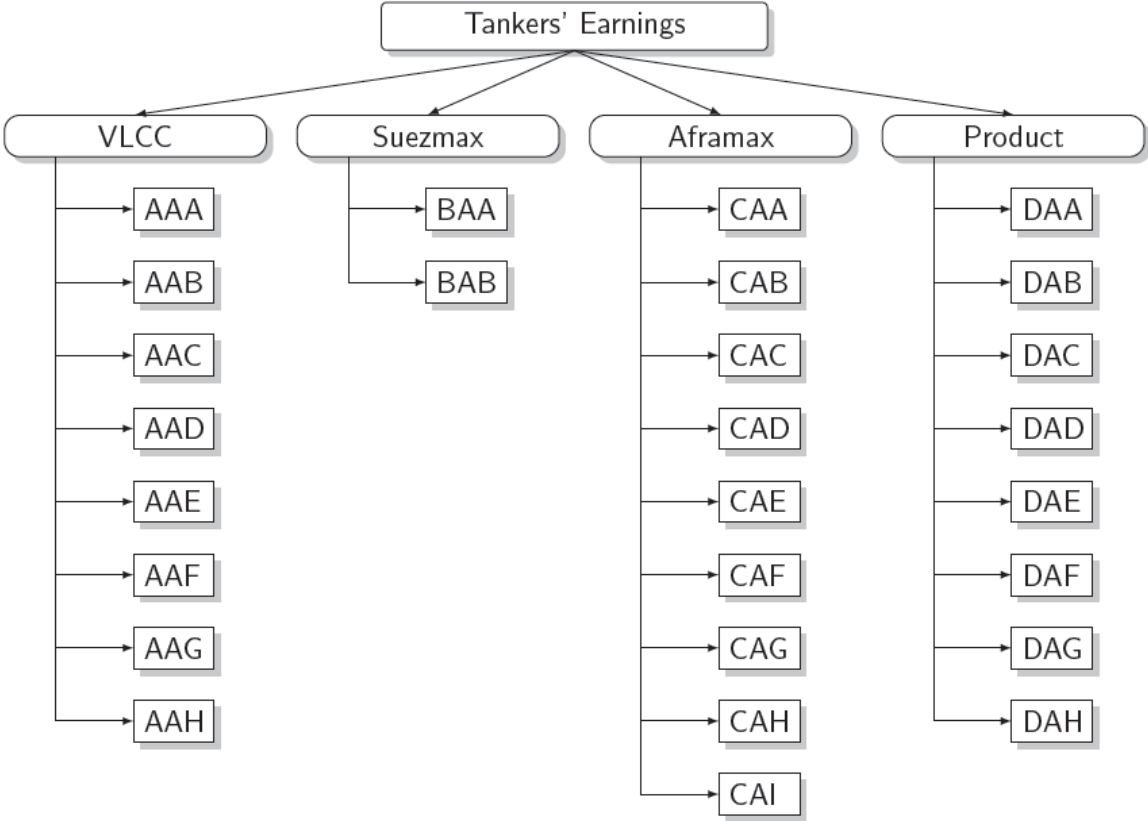

Figure 1: Hierarchy structure of tankers' earnings by size and route.

4. RESULTS

We measure the forecasting performance by the Mean Absolute Error (MAE), an error measure that is suitable for measuring forecast accuracy. MAE refers to the average (across origins and horizons) of the errors. The forecast error is defined as the actual minus the forecast, or $y - \tilde{y}$. The MAE is calculated for each node of the hierarchy and for each of the two approaches, bottom-up and optimal combination, denoted by MAE_{BU} and MAE_{OC}, respectively. The percentage differences in forecasting performance are captured by the percentage decrease in the value of MAE_{OC} relatively to the value of MAE_{OC}, or

$$\%Improvement = 100 \left(1 - \frac{MAE_{OC}}{MAE_{BU}}\right), \tag{2}$$

while these differences are subsequently averaged across all nodes of the same hierarchical level. A positive difference indicates increase (improvement) in the forecasting performance (accuracy).

Table 3 presents the empirical results of our study. The optimal combination approach is benchmarked against the bottom-up approach and the percentage improvements in performance are captured. We analyse the results in terms of forecasting horizons and hierarchical levels (top, middle and bottom level), which correspond to trade, size and route respectively. We observe that the values of MAE decrease by up to 5.26% for the top level and the shortest horizon. Lower improvements are recorded for the middle and bottom levels. At the same time, we observe decreases in performance for the latter horizons (1.46% for 12- steps-ahead and across all levels). Overall (all level and horizons), the forecast improvement is 0.53% and 1.34% for horizons up to six months. In balance, the optimal combination approach performs better than the bottom-up approach for horizons up to 9 months, while more significant improvements are recorded at the higher levels.

Table 3: Percentage improvements of the optimal combination over the bottom-up approach.

Level	Description	Forecasting Horizon								
		1	2	3	6	9	12	1-6	7-12	1-12
Top level	Trade	5.26	4.16	3.45	2.55	0.57	-2.74	3.59	-0.33	1.63
Middle level	Size	1.76	-0.27	1.08	1.61	-0.04	-1.43	1.21	-0.14	0.53
Bottom level	Route	1.56	0.74	0.90	1.29	0.23	-1.42	1.28	-0.31	0.49
Overall		1.70	0.72	1.00	1.37	0.21	-1.46	1.34	-0.29	0.53

5. CONCLUSION

The focus in the literature so far has been on finding the best model to forecast freight revenues and the directional forecast accuracy between different shipping freight contracts (spot, FFA and TC) rather than matching the appropriate forecasting level with their corresponding strategic decision. If the optimal combination approach was applied to reconcile forecasts up to six months ahead, then the total savings in trading decisions at the very top-level of the hierarchy over the three-year evaluation period (2013-2015) would be at the range of one million US$ a day. The respective total savings at the middle level would be around half million US$ a day. On top of the significant improvements in forecasting performance, the new approach provides reconciled forecasts and as a result reconciled strategic decision across all hierarchical levels.

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CASE STUDY: DYNAMIC DISCRETE MODEL OF FIXED ORDER POINT QUANTITY SYSTEM FOR INVENTORIES IN PHARMACEUTICAL DISTRIBUTION

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ABSTRACT

The reason for writing this paper is development of dynamic discrete model of fixed order point quantity system for solving problem of control and ordering inventories in pharmaceutical distribution. This paper analyzes inventory system of pharmaceutical company, with continuously changing state of sales. Changes of state of inventories are registered at the ends of the defined time period. Considered time period is one or two years. Dynamics of system are described by discrete equations and inequalities. Structure of inventory system is generally known (sales forcast per months), and has deterministic character, while the variables in the system may have deterministic and stochastic character. Inventory control problem set in this paper is modeled and presented in spreadsheets. Spreadsheets are used for building of decision model of a discrete controlled object. The results obtained from discrete dynamic spreadsheet model are used for procurement planning more than 50 products per country for five countries from East Central Europe for the year 2016. Simulation model should be able to give exact proposal for ordering of products in an acceptable time for discrete periods in one or two years. Also, model will eliminate shortages of theoreticaly based models by "book" and show what kind of limitations, in reality, can be appear in the proces of design of dynamic inventory model. The orginality of the paper will be shown in fact that the company will be able to use the model for all procurement operations. From theoretical aspect value of the paper is to show the critical atitude for limitations of theoretical inventories models. Discrete controlled object is represented by simulation model of inventory management problems, with clearly separated: the law of dynamics, control domain and performance criterion. The practical contribution of this paper by should be prove that the dynamic simulation spreadsheet inventory model can be used as reliable and easy way for control and ordering of inventories in pharmaceutical distribution. In reality, two models will be applied: Fixed Order Quantity model with cumulative sales forecast (for the few same brend products for different countries) with fixed minimal order quantity (MOQ) defined by supplier and the Lot-for-Lot model for each product with exactly needed order quantity for three months of sales that occurs after the expiry of defined lead time. Models will be applied over the real data collected in the company.

Keywords
Inventory control, FOQ, MOQ, Pharmaceutical distribution, Dynamic simulation spreadsheet inventory model, Spreadsheets

1. INTRODUCTION

Pharmaceutical industry is one of the most sensitive and major industry that deals with human life. A pharmaceutical companies handle 500-600 types of products that includes huge amount of raw materials movement, packaging, secondary packaging of the finished products and delivering to the customers. Planning and scheduling in the pharmaceutical companies is a critical activity. The Fixed order quantity (FOQ) system and Lot-for-Lot system belongs to a class of classical inventory static 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.

As we can see in Axsäter et al. (2006), Arnold et al. (2012), Russell et al. (2006), Chase et al. (2004), Barlow et al. (2003), Muller et al. (2003) and Wild et al. (2002), even new books dealing with inventory control describe the classical inventory models 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 Kostic (2009). 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 (1958) and Scarf (1959). In order to find an optimal inventory control for various variants of dynamic lot-sizing problems, dynamic programming algorithms are applied in Bertsekas (1987). Numerous special heuristics and metaheuristic-based algorithms are used to solve such problems in Zoller (1988) and Jans (2007).

The problem is modeled in Section 2 and 3. 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 Kostic (2001).

2. ASSUMPTIONS AND NOTATIONS

The mathematical model of the inventory replenishment problem here is based on the following assumptions:

a) Lead time (LT) is known. Lead time is time which is needed in distribution of goods from manufacturer to distributor (needed time for one delivery from moment of ordering to the moment of delivering the goods);
b) Shortages are allowed, but not backlogged.
c) The initial inventory level is known;
d) Order quantity is fixed, ie, manufacurer defined minimal order quantity per each product (MOQ), but periods between orders are not fixed.
e) Sales forecast is known and predicted for one year.

Note that the authors visited company in Belgrade and learned what are the specific assumptions of supply chain in pharmaceutical industry.

In addition, the following notation is used throughout this paper:

m - number of products are given and for each product i , $i=1,2,....,m$;

t - number of time periods, i.e number of months, $t=1,2,3...T$;

T - finite time horizon, $T=12$ months;

D_t^i - predicted deterministic demand per month per each product i, $T=12$ months;

X_t^i– the total amount of product i remaining on the stock at the end of period t. Also named as Stock level on hand for product i;

Y_t^i - the amount of product i ordered at the beginning of period t. Also described in model as Planned input of stock for product i;

Y_t^o - the amount of product i withdrawn from the stock continuously per month per sales plan per product i;

$\min Q_t^i$ - Fixed order quantity - FOQ defined by manufacturer for product i. This amount of order is also known as minimal order quantity MOQ;

LQ^i – Lot-for-lot order quantity for each product i with exactly needed order quantity for three months of sales that occurs after the expiry of defined lead time. This variable is automatically generated in model;

S_t^i- Stock level report of product i. On the begining of each month, the main distributor of goods report to the main supplier about amount of inventories per product i.

A_t^i - Stock level alarm (value 0 or 1) is additional variable which give us the signal is the current stock level on hand X_t^i greater than security stock for product i.

Q_t^i - Planned order quantity for $\min Q_t^i$ per periods t is automatically generated decision variable.

R_t^i - Realized input of stock in time, per planned order quantities Q_t^i. This variable confirm which order quantity is arrived on stock;

P_t^i- Position of reorder point is additional variable which allows that the planed input of stock Y_t^i shows up after lead time LT;

SS_t^i - Security stock, also known as average amount of sales quantity of products per month Y_t^o in time horizon T;

AS_t^i - Average stock on hand in time horizon T. This additonal variable is calculated as product of SS_t^i and LT/2. Assumption is that the amount of average stock should „cover" avrage sales at least half of LT.

u^i - number of orders in time horizon T. This variable is automatically generated in model.

Cf^i – correction factor in mathematical model in order to improve the accuracy of the model.

3. MATHEMATICAL MODEL AND SOLUTION

First, we will present the model of Fixed Order Quantity system with cumulative sales forecast and fixed minimal order quantity (MOQ) defined by supplier. We consider a time-continuous multiproduct inventory problem which has most of the characteristics of a well- known classical lot-size model.

A number of products m are given and for each product i , $i = 1,...,m$, the total deterministic demand per year 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 no constant time t_i between two orders;

- the whole ordered amount Q_i arrives on the stock simultaneously and immediately after *LT*, while it is withdrawn from the stock continuously by the rate in plan of sales.

Shortages of the product on the stock are permitted, but not backlogged.

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 $t = 1,...,n$. (For example, if T is a year then t is a month). 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 per sales plan Y_t^o.

Decision variable Q_t^i is automaticaly generated in model per time periods. We consider $i = 1,2,...,m$ as the number of products.

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– the total amount of product i remaining on the stock at the end of period t. Also named as Stock level on hand for product i;

Y_t^i - the amount of product i ordered at the beginning of period t. Also described in model as Planned input of stock for product i;

Y_t^o - the amount of product i withdrawn from the stock continuously per month per sales plan per product i;

If we consider X_t^i as the *state* of a process at the end of period t then the *state equations* which describe the behaviour of the process can be defined as,

$$X_0^i = 0 \tag{1}$$

$$X_t^i = \left\{ \begin{cases} 0 & , X_{t-1}^i + Y_t^i - Y_t^o < 0 \\ X_{t-1}^i + Y_t^i - Y_t^o, & otherwise \end{cases}, S_t^i = 0 \right\}, \ t = \overline{1,12} \tag{2}$$
$$\left. \begin{array}{l} \\ S_t^i \quad , otherwise \end{array} \right.$$

Obviously, ordering of amount Q_t^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 greater than Average stock on hand in time horizon T. Therefore, the value of Y_t^i depends on Q_t^i and can be formally expressed as,

$$Y_t^i = \left\{ \begin{array}{ll} R_t^i & , R_t^i > 0 \\ \begin{cases} Q_t^i & , P_t^i = Q_t^i \\ 0 & , otherwise \end{cases} & , otherwise \end{array} \right\}, \ t = \overline{1,12} \tag{3}$$

where the amount of product *i* withdrawn from the stock continuously per month is,
$$Y_t^o = D_t^i, \ t = \overline{1,12} \tag{4}$$

Let us mention that the process described by (1) - (4) 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 Q_t^i.

Additional variable S_t^i represent Stock level report of product *i* where amount of S_t^i is,
$$S_t^i = \left\{ \begin{array}{ll} S_t^i & , S_t^i \neq 0 \\ 0 & , otherwise \end{array} \right\} t = \overline{1,12} \tag{5}$$

Security stock, also known as average amount of sales quantity of products per month Y_t^o in time horizon T is,
$$SS_t^i = \frac{\sum_{t=1}^T D_t^i}{T} \tag{6}$$

where average stock on hand in time horizon T is,
$$AS_t^i = SS_t^i \cdot \frac{LT}{2} \tag{7}$$

Let us determine decision variable - Planned order quantity for $\min Q_t^i$ per periods *t*. More formally, it is equal,

$$Q_t^i = \left\{ \begin{array}{l} \left\{ \begin{cases} \min Q_t^i & , X_t^i < AS_t^i - SS_t^i \\ 0 & , otherwise \end{cases}, \prod_{t=1}^{t+LT-1} A_t^i = 1 \\ \min Q_t^i \hspace{3cm} , otherwise \end{array} \right\}, X_{t+LT-1}^i < 1 \right. \\ \left. 0, \hspace{6cm} , otherwise \right. \tag{8}$$

where the value of stock level alarm is presented as,
$$A_t^i = \left\{ \begin{array}{ll} 1 & , X_t^i > \frac{\sum_{t=1}^T D_t^i}{T} \\ 0 & , otherwise \end{array} \right\} t = \overline{1,12} \tag{9}$$

where the $\min Q_t^i$ is fixed order quantity (FOQ) defined by manufacturer for product *i*. This amount of order is also known as minimal order quantity MOQ.

Now, we will present the second type of model, named as Lot-for-Lot model with exactly needed order quantity of product *i* for three months of sales that occurs after the expiry

of defined lead time LT^i. Also, we consider a time-continuous multiproduct inventory problem which has most of the characteristics of a well-known classical lot-size model. Described discrete control+1ed object with clearly separated the law of dynamics, control domain, performance criterion and all discrete equations and inequalities stay the same as previous model, but the *min* Q^i (FOQ or MOQ) will be changed with lot-for-lot order quantity LQ^i.

Let us determine this new decision variable LQ^i for per periods t. More formally, it is equal,

$$LQ_t^i = \begin{cases} \left(Cf_t^i + 1\right) \cdot SS_t^i & , Y_{t+LT+Cf}^o = 0 \\ \displaystyle\sum_{t+LT}^{t+LT+Cf} Y_t^o & , otherwise \end{cases}, t = \overline{1,12}$$

(10)

3. INVENTORY CONTROL MODEL FOR PHARMACEUTICAL DISTRIBUTION

Pharma 4U gmbh is Swiss company, established in 2013. Main activity of this company is production and sale of innovative pharmaceutical products. 4U Pharma d.o.o. Company 4U Pharma (2016) is a branch in Serbia, aimed at pharmaceutical distribution for Balkan and neighbourhood countries. This company supplies wholesalers and pharmacies from Serbia, Macedonia, Montenegro, Bosnia and Herzegovina, Slovenia, Croatia, Albania, Rumania and Bulgaria. The company is constantly expanding, thanks to constant investment in development and monitoring of recent trends in the global pharmaceutical market. Inventory management is an especially important for 4U Pharma d.o.o., as it is core activity of the company.

At the end of every year company's logistics manager creates monthly sales forecast for next year. This forecast is based on historical data from previous years and manager's experience. At the beginning of every month customers from all countries deliver their stock reports. Ordering quantities and ordering periods are calculated in accordance with Fixed Order Quantity (FOQ), defined by supplier for each product (brand). There are more than one FOQ for each product and unit price depends on the ordered quantity. Order quantities are based on cumulative sales forecast for products of the same brand for different countries. Logistics manager orders articles of the same brand in total quantity for all countries, with remark about language for packaging and instruction. The company does not hold stocks and products are immediately transported to the clients, after customs and analysis. Production lead time is between 90 and 120 days, transportation lead time is up to 7 and custom and analysis 21 days. Total lead time, from order to delivery, is between 118 and 148 days, e.g. approximately about 5 months. Additionally, manager negotiates about shortening of deadlines and price.

Ordering problem can be defined as follows: it is necessary to determine order quantities and ordering periods for each product (brand) for all countries, in accordance with FOQ, in order to provide enough inventories to cover monthly sales forecast, and to minimize distribution costs. Inventory management system is modelled in order to solve this problem.

Model is implemented in spreadsheet and procedures are automated through Visual Basic for Application (VBA). Spreadsheets are inexpensive and run on machines of modest specification. Due to ease of learning, usage and a great possibility for complex analyzing, spreadsheets have been accepted by many users at all levels, from beginners to experts Lawson et al. (2009). Spreadsheets can be effectively used for analyzing logistics and supply chains issues. Usage of spreadsheets as logistics decision making software tool has exploded in the last two decades, driven by the need to optimize and integrate the supply chain. These tools are extremely effective in determining the optimum number of distribution locations, the appropriate mix of transportation modes,

production scheduling, inventory optimization, product rationalization and strategic planning exercises Smith (2003). Spreadsheet software, notably Microsoft Excel, allows analysis from many different perspectives and can be modified and enhanced to reflect new situations and options. Moulder develops a baseline model according to current operations, creates alternative scenarios and compares those scenarios to the baseline. Non-quantifiable factors and soft costs are also considered to develop a complete analysis. Using spreadsheet, moulder can analyze the impact of business decisions on any number of variables, such as: logistics strategies, flow planning, inventory control, allocation and aggregate planning and network design and planning. Also, spreadsheet charts and graphs are excellent tools to provide visual impact to the logistics problems analysis. The effective use of graphs can aid in understanding the models results. Contrary to the traditional logistics software, that may not always provide the flexibility required, spreadsheet allow analysis from many different perspectives and can be continually modified and enhanced, to reflect new situations and options. The user can add complexity to the model, in compliance with the increase of experience and knowledge about the process. Spreadsheet models can be used for strategic, operations or logistics planning and in many cases can be used simultaneously for all cases.

Input elements for model are sales forecast, FOQ and stock level report and realized input of stock (see Figure 1). Monthly sales forecast is created at the beginning of year for entire next year, based on historical data from previous years and manager's experience. FOQ is defined by supplier fo FOQ model, but in Lot-for-Lot model that variable is automatically generated by mathematical function. There are more than one FOQ for each product and unit price depends on the ordered quantity. At the beginning of every month, each wholesaler and pharmacy (customers from all countries) sends a report about stock level status to 4U Pharma's logistics manager. This report is prescribed form and format in Excel spreadsheet.

Brend	Article Code		Lead time LT^i	Average stock AS^i	Security Stock SS^i
BABYTOL_D3	BB01BLSRB01		5	39.250	15.700

Time periods t	Month	Sales forecast Y^o	Fixed order quantity (min Q^i)	Stock level report S^i	Stock level on hand X_t	Stock level alarm A^i (0 or 1)	Planned order quantity Q^i	Planned input of stock Y^i	Realized input of stock R^i	Position of reorder point P^i
0				60.000	60.000	1				
1	January	10.900	32.000	0	49.100	1	0	0		0
2	February	12.100	32.000	0	37.000	1	32.000	0		0
3	March	25.200	32.000	0	43.800	1	32.000	32.000	32000	0
4	April	13.000	32.000	0	30.800	1	32.000	0		0
5	May	13.800	32.000	0	17.000	1	0	0		0
6	June	14.500	32.000	0	2.500	0	32.000	0		0
7	July	14.700	32.000	0	19.800	1	0	32.000		32000
8	August	15.400	32.000	0	36.400	1	0	32.000		32000
9	September	16.100	32.000	0	52.300	1	0	32.000		32000
10	October	16.900	32.000	0	35.400	1	32.000	0		0
11	November	17.200	32.000	0	50.200	1	32.000	32.000		32000
12	December	18.600	32.000	0	31.600	1	32.000	0		0

Figure 1: Input elements of model and reorder point after LT =5 months

In addition, monthly stock level on hand has to be calculated. As stock level report is received at the beginning of month, it corresponds to the level at the end of previous month. Stock level for current month is calculated as sum of stock level quantity at the end of previous month and planned input of stock and reduced for forecasted sale. In that way model covers whole year, even future months, where stock level is calculated based on planned delivery (input) and forecasted sale (output). Column Stock level on hand (see Figure 1) represents stock levels for all months in observation period at one place, which are calculated in described way. In this way, we define the sensor function of model, which prepares data for comparison in the model comparator.

Unusually long lead time (LT) indicates that order quantity has to be calculated based on inventory levels and sales forecast for all months between current period (t) and delivery period (t+LT). Variable calculated in column Planned order quantity is used to determine the difference between necessary inventory levels for observed months and actual state of stock. Defined differences in the output of variable are used for making final decisions about quantities of items that will be ordered and delivered to each wholesaler and pharmacy and time periods when orderings have to be realized (reorder periods, see Figure 1). According to comparison algorithm (see Figure 2), stock levels are compared with necessary inventory levels. Necessary inventory levels consider that demand should always be satisfied. Based on these differences, order quantity and reorder periods are calculated and presented in column Planned order quantity (see Figure 1).
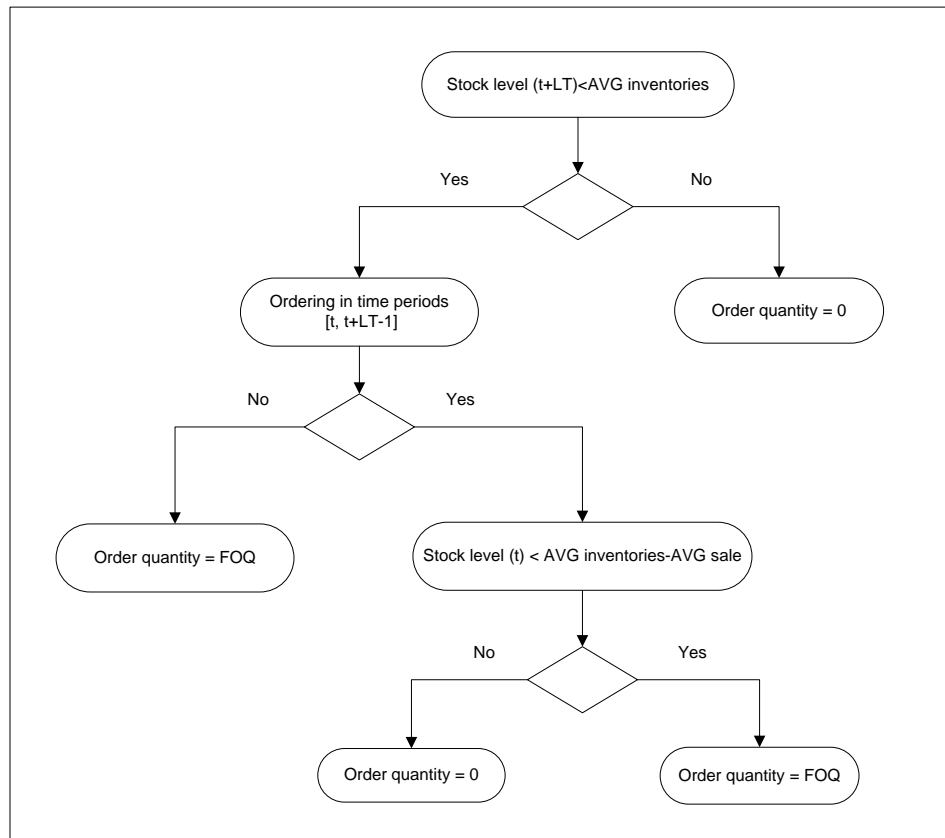
Figure 2: Comparison algorithm

Column Realized input of stock is used in cases when order arrives earlier or later than expected. In those cases, whole model is recalculated automatically. For example, if ordering is realized in January and LT=5 months, then ordered quantity is delivered after five months, in June (see Figure 1). However, if delivery of articles ordered in January is realized earlier, in May, then stock level is increased and ordering plan has to be changed in accordance with comparison algorithm (Figure 2).

When quantities are approved, order is realized and sent to production, to 4U pharma gmbh. These actions as an effect has inventories planned level filling for all clients, wholesalers and pharmacies from different countries. Additionally, when order quantity and delivery is confirmed from production plant, whole quantity (FOQ) is assigned to the countries and clients. In this manner, logistics manager controls distribution of ordered quantity, which provides articles necessary for customer requirements fulfilment.

4. CONCLUSION

In this paper a static time-continuous multiproduct inventory problem is modelled as a combinatorial optimization problem in the corresponding dynamic discrete time system control process for company Pharma4You. Management of pharmaceutical inventory and pharmaceutical distribution have become a major challenge for pharmaceutical companies, as they simultaneously try to reduce costs and improve customer service level in an increasingly competitive business environment. As is is presented, in order to solve this problem we have developed two type of models. Preliminary numerical results show that the algorithm could be efficiently applied to problems of smaller and higher dimensions. Focal point of this paper is inventory control in pharmaceutical distribution company, with an emphasis on order quantities and reorder periods, which have to satisfied specific constraints, described in the paper. As it is presented, this spreadsheet model allows analysis from many different perspectives and can be modified and enhanced to reflect new situations and options. We have developed baseline model that enables alternative scenarios creation and compares those scenarios to the baseline. The results obtained from the model are used for procurement planning for more than 50 products per country for several countries from East-Central Europe for the year 2016.
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.

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STACKELBERG GAME STUDY ON THE SCHEDULING PATTERN CHOICE OF MANUFACTURER AND DISTRIBUTOR

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Abstract: Manufacturer has the problem of production waiting while the distributor faces the distribution waiting, which make them waste of cost and time. They want to solve the problems above by optimizing their shceduling. But it exist conflict between the manufacturer and the distributor's scheduling. This paper analysis their scheduling objectives and cost firstly. Then, built up the Stackelberg game model. The game balances showed that the manufacture has the first-mover disadvantage, only the distributor coordinated the manufacture's scheduling can help the manufacturer. Then designed the reward mechanism for the manufacturer, the game model and the reward mechanism were validated by the numerical test.

Key Words: Supply chain management, Scheduling pattern, Stackelberg Game, Motivate mechanism

INTRODUCTION

Production waiting always happened on the manufacturer major's supply chain, which leads a lot of inventory, and the cost. The manufacturer needs to make the scheduling base on the benefit, and the distributor as the after action point, can obtain the information from the manufacturer, then revise the scheduling base on it's own benefit, therefore, it is Stackelberg Games between manufacturer and distributor. How to make the best scheduling for the manufacturer and distributor is significant to reduce the inventory cost, the supply chain cost, and to accelerate the supply chain's responsiveness.

The earliest research on the production- distribution scheduling conflicts is to study the problem for newspapers distribution issues. Hunter and Van Buer Studied the production and distribution of the newspapers company's coordination problems, the newspaper printing sector make the production scheduling based on minimizing production time，but the distribution departments consider farther distance newspapers should be produced first, the authors studied the contradictions cost. Dawande et al. Re-analysis of the newspaper distribution problem, Also confirmed the coordinated scheduling can solve the conflict. As it is a new area for research, there are relatively few papers dealing specifically with scheduling problems in supply chains.

Hall and Potts presented the first paper on this important topic. They study a variety of scheduling, batching and delivery problems in supply chains with the objective of minimizing the overall scheduling and delivery cost. Chen and Pundoor extend these to supply chains with assembly-type manufacturing systems. Some of the issues studied on these papers are related to previous work on coordinating production and distribution systems. Sawik 's research account to the coordination scheduling of different production and transportation capacity issues, and compared With the traditional scheduling model. Similar studies emerge in large numbers in china, such as Yao Jianming's paper.

These studies are from the perspective of reducing the cost of production and distribution scheduling, establish a coordinated scheduling model of production and distribution，the studies

provide a theoretical basis for this study, this paper focuses on the manufacturer major's supply chain，base on game theory, establish a scheduling game model for manufacturer and distribution. Standing on the manufacturer's position, design the incentives for the distribution, to ensure that manufacturers and distribution achieve their own interests, Finally, use the numerical experiments to verify the feasibility of the model and incentives.

STACKELBERG GAMES MODEL

PROBLEM DESCRIPTION

Assuming the companies involved in the supply chain scheduling are manufacturer and distribution, manufacturer's scheduling goal is to minimize the transform frequency Y_s, reduce the production cost C_M; distribution center's scheduling objective is to reduce the distribution costs C_D. If the manufacturer produce first, the distributor can observation the action σ_M, then determine their own scheduling mode σ_D. Manufacturer want distributor to be able to coordinate its production scheduling, which will increase the time compression costs C_T for distributor；If the distributor's selection is uncoordinated to manufacturer, the inventory costs H_M of manufacturer will increased, This allows the formation of stackelberg game between manufacturer and distributor. In the supply chain of manufacturer's major，manufacturer needs to design incentives to ensure distributor coordinate manufacturer's scheduling，then maximize it's own interests。

MODELING

In the course of the game, there are two strategies for manufacturer and distributor: coordinate the other's scheduling mode, or choose their own optimal scheduling model. Manufacturer selects the operation mode σ_M first, the distributor grasp the manufacturer's action, then make the scheduling model σ_D, the manufacturer don't know the action of the distributor, then in a passive position. Throughout the course of the game, there is asymmetric information between manufacturer and distributor, the distributor have the after mover advantage in the stacklberg game. This paper is a study of this issue that manufacturer and distributor's stacklberg game under asymmetric information problems

If the manufacturer select its optimal scheduling model σ^*_M first, the distributor grasp the manufacturer's action, then the distributor has two choice: the optimal scheduling model σ^*_D, or coordinate the manufacturer's scheduling model σ^T_D, the distributor need to measure the cost of the two scheduling. Under the situation [σ^*_M, σ^*_D], the distributor's payment function is the time compression cost C_T, at this point, manufacturer will produce the inventory costs H_M,

$H_{i,n}$ represents the inventory for any product P_i in one production cycle. Then,

$$H_{i,n} = H_{i,n-1} + Q_p - Q_{i,d(n)} \qquad (1)$$

Among them, $H_{i,n-1}$ is the Beginning inventory of P_i, Q_p is fixed value, on behalf of the manufacturer's yield in the production cycle, $Q_{i,d(n)}$ is the distribution amount for the distributor in this period. However,

$$H_{i,1} = H_{i,0} + Q_p - Q_{i,d(1)} \qquad (2)$$

$$\begin{aligned} H_{i,2} &= H_{i,1} + Q_p - Q_{i,d(2)} \\ &= H_{i,0} + Q_p - Q_{i,d(1)} + Q_p - Q_{i,d(2)} \\ &= H_{i,0} + 2Q_p - (Q_{i,d(1)} + Q_{i,d(2)}) \end{aligned} \qquad (3)$$

Then,

$$H_{i,n} = H_{i,0} + nQ_p - \sum_{k=1}^{n}(n-k+1)Q_{i,d(k)} \qquad (4)$$

In the entire production cycle n, the inventory levels for P_i is:

$$H_T = nH_{i,0} + \frac{(1+n)n}{2}Q_p - \sum_{k=1}^{n}(n-k+1)Q_{i,d(k)} \qquad (5)$$

The inventory cost of P_i is：

$$H_T = I_i[nH_{i,0} + \frac{(1+n)n}{2}Q_p - \sum_{k=1}^{n}(n-k+1)Q_{i,d(k)}] \qquad (6)$$

Thus, we can conclude, the factors that affect the size of the inventory cost for the manufacturer is ： the unit inventory cost of different specifications of the product I_i ; the amount of distribution product in one cycle $Q_{i,d(k)}$.

Under [σ^*_M , σ^T_D], the manufacturer's payoff function is 0, the increased cost of time compression for distributor is ΔC_T , and the compression time is proportional to the cost, then $C_T = C_i \times (T_i - T)$. Since the distributor choose σ^T_D , the scheduling cost increase ΔC_T , the distributor will choose their optimal scheduling mode σ^*_D in general, therefore, the equalizer will not exist.

However, if the manufacturer has learned the distributor's after action, in the subsequent scheduling mode selection, it can measure whether to coordinate the distributor or to choose its own optimal scheduling mode. If the distributor choose its own optimal scheduling mode, the coordinated to the distributor's scheduling, will lead the manufacturer's production conversion cost C_S , C_S is the function of Y_s :

$$C_S = \sum_{s=1}^{n}C_i T_S * Y_s \qquad (7)$$

when $Y_1 = Y_2 = L = Y_n = 1$, the manufacturer's production conversion cost is minimum. This means that manufacturer centralized production: after products the same category, and then start another class of products. If the manufacturer chooses its optimal scheduling mode, the inventory cost H_M will increased.

when C_S f H_M , the manufacturer will choose its optimal scheduling model, at this time, stacklberg balanced game of manufacturer and distributor is[σ^*_M , σ^*_D].

When C_S p H_M , then the manufacturer selects to coordinate distributor's scheduling, stacklberg balanced game of manufacturer and distributor is [σ^T_M , σ^*_D].

No matter which scheduling mode the manufacturer select, it will damage its own interests, so it presences first-mover disadvantage of stacklberg game, on the other side, the distributor has the after-mover advantage.

INCENTIVES

In the course of manufacturer and distributor's selection scheduling game, the manufacturer at a disadvantage, the manufacturer only by improving its scheduling mode and incentives designed, can ensure distributor choose the action of coordinated scheduling mode.

Make $M(\sigma)$ represent the manufacturer's cost under the strategy σ , $D(\sigma)$ represent the distributor's cost under the strategy σ . The manufacturer chooses its own optimal scheduling model, distributor coordinate the manufacturer's scheduling, then the total cost of manufacture and distribution is $M(\sigma^*) + D(\sigma^T)$; if the manufacturer chooses its optimal scheduling model, the distributor not to coordinate, and the total cost is $M(\sigma^*) + D(\sigma^*)$. The saving cost of manufacturer and distributor under the coordination is:

$$C^s = [M(\sigma^*) + D(\sigma^*)] - [M(\sigma^*) + D(\sigma^T)] \qquad (8)$$

The increased cost for the distributor because of the coordinated supply chain scheduling is C_T , the compensation value of the manufacturer needs to give to distributor is:

$$p = C_T + \alpha C^s \qquad (9)$$

Among it, the size of α is affected by the position of the distributor in the supply chain, also the strong degree of the coordination need in the scheduling. For the purpose of increasing profit, the manufacturer will improve its production mode and use its dominance position to affect the size of α .

Manufacturers can adjust the production order without change the number of production conversions, that is when you need to produce the kind of product family is n, which is the first production of the product family will not change the production conversions, then product the shorter lead time produce first, neither increase the cost, but also to reduce the time compression cost for the distributor, so it will increase the distributor's willingness to coordinate, thereby enabling α smaller.

The implementation of Manufacturer's major , distributor coordinating to manufacturer's scheduling mode requires the manufacturer integrated using of compensation strategies and improve its scheduling mode. And the compensation should be greater than the cost of time compression, which is caused by changing the scheduling mode for distributor. At the meantime, the compensation should be less than gains from the coordination scheduling for manufacturer. Thereby, this can reduce the risk of loss revenue resulting from the information asymmetry for manufacturer.

NUMERICAL EXPERIMENT

Assuming that one manufacturer sells two products P_1 and P_2 to 6 retailers 100 units respectively from one distributor, and the distributor's capacity is 200 units for a single-cycle. Manufacturer produces 200 units per production cycle, and produce six cycles totally, finally, the retailers receive a total of 200 units on a certain demand percentage of the two products. The number ratio of the two products All 6 retailers obtained is 100:100.

Assuming that for the former five retailers, the demanding for P_1 obey evenly distributed $U[1,199]$, then the sixth retailer demand for the product P_1 is $d_{16} = 600 - \sum_{i=1}^{5} d_{1i}$, and the retailer demands for the product P_2 is $d_{2i} = 200 - d_{1i}$, among it, $i = 1,2 \text{L } 6$.

Select 100 sets of data for testing, the unit inventory cost of the product P_1 is $h_1 \in [5,10,20,40]$, the unit inventory cost of the product P_2 is $h_2 \in [1,5,10,20,40]$. Make the increase rate of cost as a measure. Specific results are shown in Table 1, Table 2 and Table 3.

Table 1: The increased rate of time compression cost of distributor under manufacturer's Optimal scheduling

Manufacturer's conversion times		Production times		Order lead time requirements	
				I=800 U=1200	I=400 U=1600
I	U	I	U	The increase rate of time compression cost	
1	100	1	100	15.9%	19.7%
1	100	1	200	9.2%	21.3%
1	200	1	100	11.2%	19.6%
1	200	1	200	6.8%	20.9%
The average increased percentage				10.78%	20.38%

Table 2: The increased rate of inventory cost of manufacturer under distributors optimal scheduling

	$h_2=1$	$h_2=5$	$h_2=10$	$h_2=20$	$h_2=40$
$h_1=5$	88%	89.3%	88.3%	87.9%	88.1%
$h_1=10$	88.2%	88.3%	89.3%	88.3%	87.9%
$h_1=20$	88.5%	87.9%	88.3%	89.3%	88.3%
$h_1=40$	88.7%	88.1%	87.9%	88.3%	89.3%

Table 3: The increased rate of time compression cost of distributor under the former and after of manufacturer's improvement

Manufacturer's conversion times		Production times		Order lead time requirements			
				I=800, U=1200		I=400, U=1600	
I	U	I	U	The increase rate of time compression cost			
				Random	Adjustment	Random	Adjustment
1	100	1	100	15.9%	5.7%	21.3%	6.9%
1	100	1	200	9.2%	0.7%	23.4%	7%
1	200	1	100	11.2%	3.5%	19.6%	6.7%
1	200	1	200	6.8%	0.6%	22.3%	6.9%
The average increased percentage				10.8%	2.9%	20.8%	6.8%

The experimental results show that, if the distributor coordinates the manufacturer's optimal scheduling, it will lose 10%-20% cost, if the distributor choose its own optimal scheduling, the manufacturer will increase 88.41 percent of the average inventory cost. The result of table 3 shows that:

By reordering the manufacturer's production module can reduce two-thirds cost for the distributor.

Corollary: there is only a small part of the time compression costs of distributor is caused by the manufacturer's production methods, which can reduce production conversion costs, while the most part of cost is from the manufacturer's sort improper production.

From the analysis above, while improving its scheduling mode, the manufacturer should give appropriate compensation to the distributor, and the compensation value is $p = C_T + \alpha C^s$.

 In this numerical experiment, when I=800, U=1200, the Value interval of P is [2.9%$^{D(\sigma^*)}$, 88.41$^{M(\sigma^*)}$];when I=400, U=1600,the value interval of P is [6.8%$^{D(\sigma^*)}$, 88.41$^{M(\sigma^*)}$], then it can ensure the coordinated scheduling model realized..

CONCLUSION

This paper studies the stackelberg game between manufacturer and distributor during the scheduling mode selection process. Through comparing the scheduling cost of manufacturer and distributor, identified the manufacturer having first -mover disadvantage in the course of the game, and give the optimal scheduling model to the manufacturer, which is manufacturer choosing its optimal scheduling model, while the distributor coordinate the manufacturer's scheduling. The manufacturer only by adjusting its production sorting and giving the distributor compensate, can ensure its optimal scheduling model to achieve.

This paper solves the supply chain scheduling problem on operational level based on the game theory. The further research will focus on the supply chain scheduling problem form different supply chain structures and different modes of production in depth.

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MITIGATION OF SUPPLY CHAIN INTERRUPTIONS DUE TO DISASTER: A SIMULATION MODEL

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ABSTRACT

Enterprises with a global supply network are at risk of lost revenue as a result of disruptive disasters at supplier locations. Various strategies exist for addressing this risk, and a variety of types of research has been conducted regarding the identification, assessment and response to the risk of disruption in a supply chain network. This paper establishes a decision support model to assist Business Continuity Planning at the first-tier supplier level. It incorporates Monte Carlo simulation, risk index determination, and discrete-event simulation of supply chain networks (through Simio software). After modeling disruption vulnerability in a supply chain network, costs of implementing selected combinations of Business Continuity Plans (BCP) are ranked and then tested in discrete-event simulation for further insight into inventory level variations, unmet customer demand, production loss and related costs.

A case study demonstrates the implementation of the decision support process and tests a historical set of data from a large manufacturing company. Discrete-event simulation modeling of monetary loss is confirmed to be accurate. The relevance of the model concept is upheld and recommendations for future work are made.

Keywords: Business Continuity Plan (BCP), discrete-event simulation, Monte Carlo simulation, risk index, risk management

INTRODUCTION

In 2011, two major natural disasters occurred and shook the business world. Companies relying on materials from suppliers in east Asia were unable to continue production for stretches of time following the Fukushima earthquake and tsunami and as well as major floods in Thailand (Wai and Wongsurawat, 2013). The year 2011 was a wake-up call to the supply chain community where the topic of mitigating supply chain disruptions was already growing in importance.

The topic of supply chain disruption mitigation is of continued and increasing interest to corporations, as well as various professional societies including the International Symposium on Logistics, as demonstrated by their calls for more research regarding the topic. According to information gathered from two large, high-tech companies in the U.S., simulation is a particular tool of interest for Business Continuity Planning. Additionally, the question of how simulation might be integrated into BCP processes lingers. However, research about these two combined topics is still limited. This study sets the stage for such integration through a combination use of risk index analysis and discrete-event simulation.

LITERATURE

Previous work on the subject of BCP includes the use of discrete-event simulation. However, the existing literature lacks systematic work to offer a decision model that acts as a framework for discrete-event simulation for BCP. Work by Brian Tomlin (2006) presents an approach centered on the evaluation of responses to disruption risk. His and other studies of this type are valuable groundwork for those developing best responses, which act as the best combination of mitigation and contingency plans, for preventing and responding to disaster triggered disruptions. Describing risk planning, Tummala (2011) states that, "Since it is not feasible and practical to develop mitigation and prevention strategies for every risk identified, risk-planning begins with the examination of the costs required to implement each preventative action…" (p. 482). The SCRMP (Supply Chain Risk Management Process) suggested by Tummala provides a useful guide for evaluating and preventing disruption risk in supply chain. However, while various types of simulation

methods are mentioned, none are specifically demonstrated in the study, presenting a vacancy for further work. Our research project incorporates this suggestion in the form of a decision framework to support the discrete-event simulation model.

Breuer, et al. (2013) provide a framework which involves the use of both a discrete-event simulation model and decision trees for decision support to mitigate the supply flow interruptions. Breuer, et al. (2012) suggest another combined approach to decision support which involves agent-based modeling in combination with discrete-event simulation. While these papers portray the leading idea of combining both discrete-event simulation and decision-support methods, the models focus on disruption risks on a reactive case-by-case basis for support of small and midsized enterprises (SMEs) (2013, p. 218), whereas the model prepared in this paper will simultaneously and proactively establish multiple hazard risk response strategies.

The discrete-event simulation portion of this model was inspired by a 2009 paper by Amanda Schmitt and Mahender Singh, published at MIT, "Quantifying Supply Chain Disruption Risk Using Monte Carlo and Discrete-Event Simulation." Schmitt and Singh used Arena, for discrete-event simulations, and @Risk, for Monte Carlo simulation as a means to quantify risk, to model flexibility to random occurrences of disaster, and to test mitigation procedures (Schmitt and Singh, 2009, p. 1248). Simulation approaches motivated by Schmitt and Singh's model include the use of Monte Carlo simulation to generate 'multi hazard' risk disruption distributions, the use of 'demand' object entities, and the use of 'product' object entities. While the work by Schmitt and Singh provides influence as how to simulate a supply chain disrupted by random events, it does not provide a way to frame the discrete-event simulation with a decision support model. Further, as in other existing supply chain simulation research, Schmitt and Singh use Arena, a process-based simulation software. The model developed in this article, however, implements Simio software, an object-based simulation software that, as will be discussed, provides the advantages of being able to input the risk probability distributions in an intuitive manner and to have a logical, user-friendly interface.

METHODOLOGY

This article proposes a methodology to use the risk index (frequency x impact of risk) to determine an optimal set of responses that can then be tested in discrete-event simulation. Optimal responses to disruption risk include a combination of most relevant mitigation (action prior to the event of disruption) and contingency plans (action in response to the event of disruption). Each location in a supply chain contains a certain amount of risk to disruptive events. Monte Carlo simulation is used, as in Schmitt and Singh (2009), to generate a multi-hazard distribution for frequency and impact (days interruption), which includes the frequencies of multiple types of disasters that have the potential of occurring (i.e. tornado, volcano or earthquake), at each location. As applied in research by Schmitt and Singh (2009), the exponential distribution is used for the inter-arrival of disruptions and triangular distribution is used to express the number of days a supplier will be disrupted for.

In order to generate the disruption probability distributions, the Global Risk Data Platform, an application created by the UN Environmental Program found at PreventionWeb.com was used as the source of publically available global information on disaster probabilities. Data was gathered from this source in the form of the historical average number of occurrences per year (of a given disaster) and the average number of people affected per year. Historically available information on 'people affected per year', while the most unfortunate result of disasters, was the best publicly available information regarding the strength of a disaster disruption. In the absence of any publically available business interruption information, the choice of people affected per year per disaster was practical. A factor of 1/1000 was used to correlate the number of people affected by the disaster to one week of business disruption at the given location. This factor was chosen by comparing the available information regarding people affected to the number of known

weeks of supply interruption by the suppliers of Company XYZ in Fukushima (our model validation to be discussed later). Because there is no publically available database that provides more specific information about the number of days that a disaster will disrupt a factory, human impact was the best method of estimation we could find for business impact. Future recommended work is for a collaborative, publically available database with data including historical disaster impact on businesses in different parts of the world.

Our combinatorial assessment model is used to compare the response sets according to the decrease in the value of the risk index that they cause, along with the cost of implementation. Similarly, multi-hazard risk impact distributions are used to express the likely number of days a supplier will be out of service at a given supplier location, according to the impact that multiple types of disasters may cause. These distributions are subsequently useful for both the calculation of risk indices and for use in the discrete-event simulation portion of the model described in this article. Our system design process is summarized in Figure 1. Risk information is gathered and run in Monte Carlo simulation to develop multi-hazard distributions. These distributions are used, along with production rates and inventory policies, in a discrete-event simulation which is verified for accuracy in predicting production loss and unmet demand. Subsequently, the model is used in sequence with the combinatorial risk index assessment to evaluate the best combination of mitigation and contingency strategies for all supplier locations.
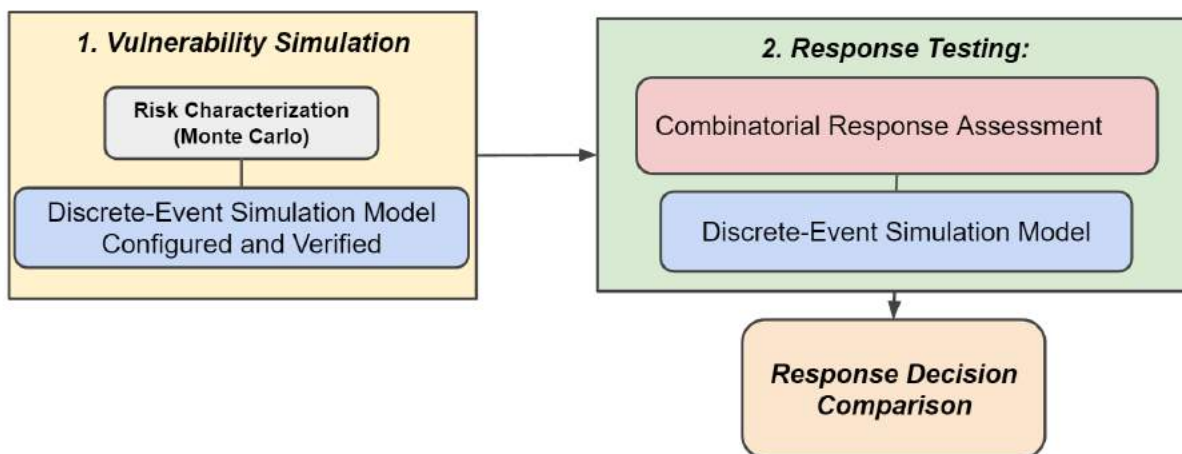
Figure 1: Model Design

Combinatorial Response Assessment

While the likelihood of a disaster cannot be changed, the chance that a business will be disrupted by that disaster may be controlled. In this model, we have used the likelihood and impact of disruptions to assess the values of response strategies. This is done using pre- and post-response risk distributions in the risk index spreadsheet (Table 1) to assess the monetary net gain of each combination of responses; thus, this portion of the model is referred to as the Combinatorial Response Assessment.

Supplier	Risk	Response	Initial Probability	Initial Days Down			Post-Response Probability		Post-Response Days Down			
				Median	Min	Max	Change	Probability'	Change	Median'	Min'	Max'
A	1	c										
	3											
	4											
	5											
	1	d										
	3											
	4											

Table 1: Response Change Sheet

A total of 2^ (n x m) response combinations, with n suppliers and m response types, are tested in the risk index comparison spreadsheet in order to determine the most cost-effective response combinations. The risk index equation (likelihood x impact) was chosen from project management practices (Gray & Larson, 2008, pg. 203), where planned response to risk is prioritized according to the given risk index values. In the Combinatorial Response Assessment (Figure 1), however, the risk index is used to compare the magnitude of risk reduction (risk index before minus risk index after) as a result of mitigation and contingency strategies. All combinations of response choices are assessed by comparing change in risk index that a response combination will cause. In order to do so, a model in Excel was developed to assess the, "Yes or No," choices associated with each location and response combination in the supply chain. The risk index calculation for each supplier location is expressed as follows (Equation 1).

$$Risk\ Index = probability\ of\ disruption \times revenue\ loss$$
$$= \frac{1}{average\ interarrival\ time\ of\ disruption} \times median\ days\ down\ (revenue\ loss\ per\ day\ down)$$

Equation 1: Risk Index

Lastly, the 2^ (n x m) response combinations are compared according to the quantity of risk reduction they create and the cost of implementing the responses. The risk index value is used as though it is a dollar amount (i.e., expected value of loss due to disruption), and the reduction in the risk index value is treated as dollars saved. Thus, net gain, or risk index reduction ($) from a given response combination minus the cost of implementing the responses, is the value by which each response combination is evaluated. After the combinatorial response assessment is performed, response combinations which resulted in the highest net gain are further evaluated in the discrete-event simulation model to determine the best response combination.

Testing in Discrete-Event Simulation

The evaluation of responses in our discrete-event simulation model consists of running experiments under the conditions of each of the respective responses (inventory and risk parameters). The results (in unmet demand, production loss and average inventory held) were compared to the same metrics for the non-response conditions (inventory and risk parameters), which were established in the first part of the design (Vulnerability Simulation, Figure 1). While this information can be compared in non-monetary units, a cost translation and analysis provides a final understanding of which response is the most cost-effective.

Simio software was chosen for the discrete-event simulation model to test the vulnerability and response to supply chain disruptions for a number of reasons. The object-based discrete-event simulation software includes the 'Reliability Logic' property of server objects, which is useful and intuitive for the input of probabilistic distributions for the inter-arrival time of randomly simulated shutdowns of the supplier (=server in Simio). This type of model in Arena software requires the building of a separate process that generates disruption 'entities', which is more time intensive and less intuitive. The Simio software

model can produce an intuitive layout of the real supply chain scenario (Figure 2). This graphic, which animates the flow of objects and status labels over time can be said to be more easy to use than the visuals available in Arena (Vieira, et al., 2014, p. 9). For example, as seen in Figure 2, production can be seen in a visual flow from the objects labeled "Raw1", "Raw2" and "Raw3" through the servers labeled by location and "Supply" and the "OEMFactory," after which the product is matched with demand at "Combiner1" to produce sales entities. If no inventory is available at "Combiner1," demand objects are sent to "UnmetDemand" and recorded. Further, any product objects that are not able to flow from "Raw" sources through the "Supply" servers due to disruption, are sent to respective "Sinks" and counted as lost production. Ultimately, the count of average inventory, unmet demand and production loss are used for the final comparison of scenarios, which are the results of various response combinations.
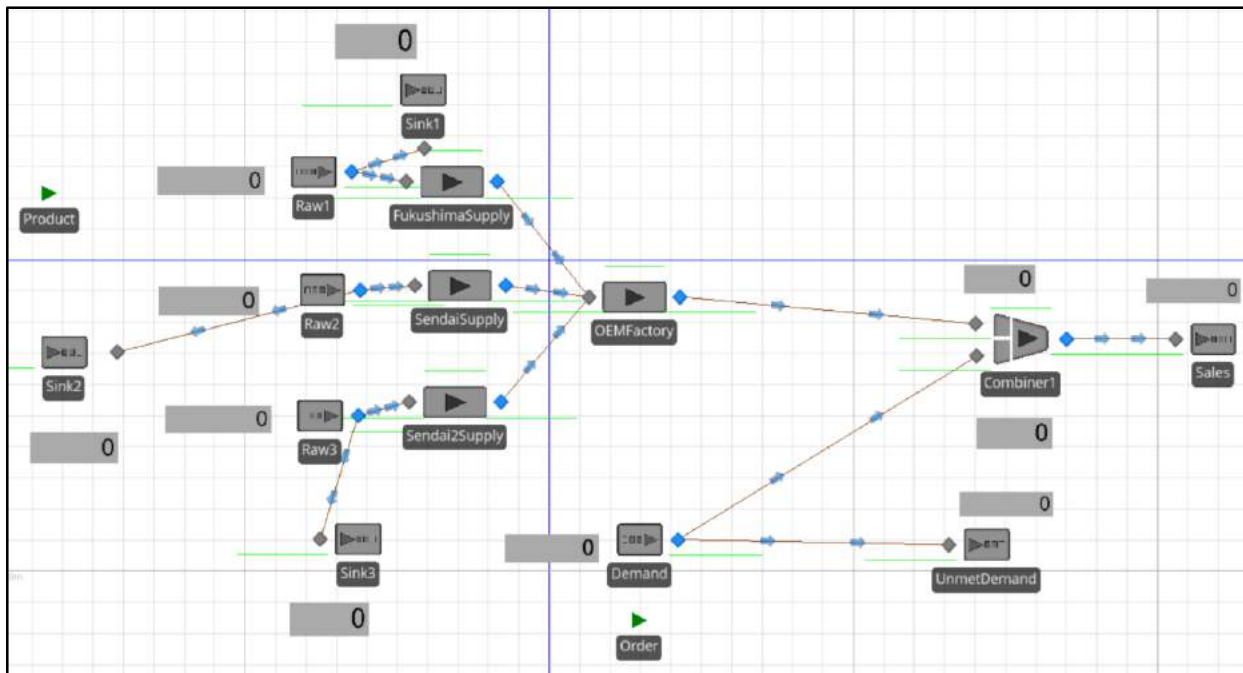
Figure 2: Case 1 Simulated Supply Chain, Simio

TESTING AND ANALYSIS

In order to validate the model described above, two scenarios (Cases 1 & 2) were tested.

Case1: The purpose of Case 1 was to prove that a) The discrete-event simulation model is accurate in its determination of production loss/unmet demand in a supply chain and that b) The concept of the combinatorial response assessment will perform the function of narrowing down response choices ahead of testing in the discrete-event simulation.

Testing revealed that the discrete-event simulation model was indeed accurate in showing the amount of production loss and unmet demand which occurred in a historical set of data. Namely, a large OEM company, Company XYZ, with three suppliers in three locations in Japan, reported a production loss of between 0% and 5% in the year 2011 as a result of the Fukushima earthquake and tsunami. The company reported having held inventory levels of 40 days of production quantity with average daily demand and

production of 580,000 units per day. Therefore, our model's production and demand were set according to the arrival rate of 580,000 units per day, and Monte Carlo simulation was used to establish the probabilistic disruptions (Table 2) from publically available information (Global Risk Data Platform) that were input to the 'Reliability Logic' of the Fukushima and two Sendai servers (supplier locations), as imbedded in Table 2. This table shows the generated Monte Carlo simulation results for the frequency (exponential distribution) and impact (triangular distribution) of any disruption (due to a multi-hazard assumption) of the three supplier locations. After running the simulation for multiple replications, Percent Production Loss was 1.13%, agreeing with, "between 0% and 5% production loss," that Company XYZ had specified. Further, the model indicated zero unmet demand. Hence, the vulnerability simulation model accuracy was validated.

Location	Fukushima	Sendai1 (City Proper)	Sendai2 (Tagajo)
Frequency (Days Between)	Exp(211.29)	Exp(244.05)	Exp(455.2)
Days Down	Tri(2.05,6.49,10.92)	Tri(2.36,7.81,13.27)	Triangular(1.64,21.26,40.88)

Table 2: Case 1 Reliability Distributions: Exp (mean), Tri (Min, Median, Max)

The Response Testing portion of the model was implemented using both the data given by Company XYZ and common response options, along with the estimated costs of implementing these responses. Response choices which were tested included a) Mitigation strategies: holding more inventory at the OEM, changing sourcing to a more reliable supplier or assisting the current supplier in becoming more resilient and b) Contingency strategies: second-sourcing to a backup supplier and assisting a supplier with recovery in the event of disruption. Results showed that the most cost-effective responses were those which only included a decrease in the amount of inventory held at the OEM. Because the results showed a strong recommendation for this particular choice, Case 1A (a variation of Case 1) was performed in order to show the model's capability to choose other types of responses. Case 1A involved a lower cost of holding a specified quantity of inventory per year ($66,240). Case 1A showed a wider variety in results, including choices to second-source. This confirmed that the response assessment did not show a recommendation towards a particular type of response unless cost parameters caused it to do so.

Because no unmet demand occurred in any of the Case 1 simulation experiments (pre or post response), Case 1B was created to exemplify discrete-event simulation results of Unmet Demand greater than zero. In particular, the inventory holding quantity at the OEM site was reduced to 14-days production quantity in the simulation model. Experiments were run accordingly, and unmet demand was shown, providing further validity of the model.

Case 2: To further test the discrete-event simulation model variability according to inventory holding quantities, a variety of inventory quantities were assessed. Results showed that inventory held did not have a linear relation to simulated unmet demand. In particular, under the Case 1 supply chain setup, zero unmet demand occurred under a 21-day production quantity of inventory, while less than a 21-day and between 22- and 26-day production quantities of inventory showed a positive amount of unmet demand. These results are not surprising due to the fact that discrete-event simulation, consisting of multiple stochastic factors, produces a volatile or fluctuating simulation. The results of Case 2 also show the value of using discrete-event simulation to plan the quantity of inventory held for mitigating the risk of disruption.

Accuracy of Risk Index Comparison
Finally, in order to assert the usefulness of the combinatorial response assessment, the uniquely defining portion of this research, a comparison of the results of the

combinatorial model and the results of the discrete-event simulation model was required. Both models were used to predict the monetary net gain of given responses under the same risk scenario. Results showed that the combinatorial response assessment predicted less extreme values for net gain than the discrete-event simulation did. At the same time, it reflected the same trends in net gain as the discrete-event simulation. Thus, the combinatorial response assessment was confirmed to be an effective method for choosing the most cost-effective responses to disruption risk in a supply chain. It acts as an accurate way to narrow down the response choices prior to testing in discrete-event simulation, as a part of an efficient business continuity planning process. Differences in combinatorial assessment versus discrete-event simulation results were traced to originate from inaccurate estimations in the combinatorial response assessment model of the impact of holding more inventory. Therefore, improvement of inventory impact information would make the combined model even more effective.

CONCLUSIONS AND RECOMMENDATIONS

The objective of this research was to develop a simulation model with a decision model framework to assist in the Business Continuity Planning process. A discrete-event simulation in Simio was created involving the use of Monte Carlo simulation for probabilistic distributions, and this information along with production rate was used to indicate lost sales, a direct monetary loss to the company. Model configuration was confirmed to accurately portray financial loss through the comparison of loss due to disruption in a historic business scenario. Usefulness of Simio, due to its benefits as an object-oriented, discrete-event simulation for this type of modeling is noteworthy.

The validation tests show that the incorporation of discrete-event simulation into BCP through risk index combinatorial response assessment is feasible and effective for testing both mitigation and contingency strategies. Future work to enhance the response assessment portion is needed, including the use of budget constraints, if applicable to the business scenario. Other advancements to the response assessment model may include the use of Analytical Hierarchy Process for the initial decision of which response choices to test. Bayesian Analysis could also be effective when using probabilistic risk information by incorporating the reliability of the risk information that is given. Finally, what would be most beneficial, as discussed earlier, is the future creation of an entire database of disruption risk information categorized by global locations.

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Section 11: Food and agriculture logistics

MANAGING A SUSTAINABLE AND RESILIENT CHEESE SUPPLY CHAIN FOR THE DYNAMIC MARKET

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Abstract
Purpose of this paper:
The cheese industry is special: production start-up is pull. Once started, however, the process becomes push. The entire process to make cheese 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. Any product shortage causes customers to seek alternative sources of supply (Gonçalves et al., 2005). To manage a sustainable (i.e. short throughput time) and resilient (i.e. few lost sales) cheese supply chain for the dynamic market (i.e. endogenous demand) is difficult, and thus becomes the focus of this paper.

Design/methodology/approach:
A system dynamics simulation is applied to study a supply chain with three tiers: a producer, a logistics service provider (LSP), and a retailer. Seven balanced feedback loops and two reinforced feedback loops are identified from the simulation model. They are: B1: Producer information delay; B2: Producer capacity availability; B3: LSP capacity availability; B4: LSP order fulfillment (push); B5: Lost sales; B6: Retailer information delay; B7: Retailer sales availability; and R1: Producer order fulfillment (pull); R2: Maintained sales. Two types of disruptions that cause product shortages are selected to simulate: a producer capacity disruption and an LSP capacity disruption. A behavioral approach to feedback loop dominance analysis (Ford, 1999) is applied to identify dominant feedback loops for each disruption recovery.

Findings:
For a producer capacity disruption recovery: B1, B2, B3, B4, B5, and R2 are identified as the dominant feedback loops to help maintain a sustainable cheese supply chain. Meanwhile, B4, B5, and B6 are helpful to build a resilient cheese supply chain. For an LSP capacity disruption recovery: B3, B4, B5, and R2 influence the sustainability of a cheese supply chain. Moreover, to keep the resilience of a cheese supply chain, B3, B4, B5, and B6 are worth paying attention to.

Value:
Through the feedback loop dominance analysis, this research has set the first step to manage a sustainable and resilient cheese supply chain for the dynamic market, when the supply chain faces a product shortage (either by a producer capacity disruption or an LSP capacity disruption). Further investments can thus be targeted at the identified dominant feedback loops to ensure cost efficient improvements.

INTRODUCTION

The cheese industry is special: production start-up is pull, i.e. demand driven. The main inbound resource is milk, of which supply is assumed abundant. Once started, however, the process becomes push, i.e. supply driven. The entire process to make cheese 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. The cheese supply chain needs coordination among production, distribution, and retailing stakeholders, so that the product can be available on the right time at the right place (Mentzer et al., 2001). Due to the multitude of participating stakeholders, the cheese supply chain is complex and thus particularly vulnerable to supply chain risks in purchasing and supply, storage, and retailing (Srivastava et al., 2015). If the product cannot be delivered to customers in time, it does not have value any more. Any product shortage causes customers to seek alternative sources of supply (Gonçalves et al., 2005). To manage a sustainable (i.e. short throughput time) and resilient (i.e. few lost sales) cheese supply chain for the dynamic market (i.e. endogenous demand) is difficult, and thus becomes the focus of this paper.

This paper models a cheese supply chain of three tiers (i.e. a producer, a logistics service provider (LSP), and a retailer). Two types of disruptions that cause product shortages are simulated: a producer capacity disruption and an LSP capacity disruption. We aim to identify dominant feedback loops for each disruption recovery to ensure cost efficient improvements. The rest of this paper is arranged as follows: a literature review of sustainable and resilient cheese supply chain and the dynamic cheese market is presented in the next section. Section three introduces the research methodology. The results are shown in section four. The paper ends with discussion and implications in section five.

LITERATURE REVIEW
To evaluate perishable food (like cheese) supply chain quality, Siddh et al. (2015) have identified 12 key constructs through a literature review: 1) product quality (including quality of raw material, biological quality, hygienic quality, carcass quality, printing quality, food additives, nutritional quality, quality of resources, appearance quality, labeling and food quality decay parameter); 2) product safety (including freshness/taste, status of quality of most critical products, etc.); 3) cost of quality (meaning that cost of product is directly related to quality of product); 4) quality in logistics (including distribution quality, roads quality, service quality, availability, etc.); 5) quality of human resources (including moral quality of workers, skill quality of labor, high-quality personnel, quality of education, etc.); 6) quality of information and information technology (including product information, communication, e-commerce and transparency, etc.); 7) quality of marketing (including brand awareness, quality regulation regarding the sale); 8) quality performance (including performance measurement, consumer's quality perception, innovation, customer satisfaction, robustness, efficiency, flexibility, responsiveness and process quality of supply chain); 9) relationship quality (including trust, consistent quality, reputation, etc.); 10) sustainability (including environmental quality, soil quality, water quality, etc.); 11) extrinsic quality (including the type of packaging material, amount of pesticides used, etc.); and 12) quality assurance (including quality standard, continual improvement, meeting specified quality, quality provision, lower quality barriers, quality consolidation, quality checks, auditing process, quality advancement, supporting quality claims, policy quality, quality of solution, etc.). Siddh et al.'s (2015) framework serves as a guide for our research. Below, we will show how issues of sustainable and resilient cheese supply chain and the dynamic cheese market fit into this framework. Moreover, we expect that our research findings will also relate to some of the key constructs in this framework.

Sustainable cheese supply chain
Sustainable production and distribution is a pertinent and timely issue for the food industry, which is still the largest manufacturing sector in many developed and developing countries (Li et al., 2014). Especially for perishable food (like cheese) supply chain management, sustainability concerns are becoming an essential part (Kaipia et al., 2013). Products reaching the retail store shelf too late (i.e. low quality in logistics) leads to a short remaining shelf life (i.e. product safety issues) (Mena et al., 2011). The further

disposal of expired food to landfill causes pollution (i.e. sustainability issues) (Griffin et al., 2009). Therefore, sustainability concerns include not only sustainability (i.e. the tenth construct of Siddh et al.'s (2015) framework), but also product safety (i.e. the second construct of Siddh et al.'s (2015) framework) and quality in logistics (i.e. the fourth construct of Siddh et al.'s (2015) framework). As the root cause of these problems is quality of logistics, *throughput time* will become one of the performance measurements in our simulation.

Resilient cheese supply chain
In recent years, there has been growing concern that the world's food systems for producing and distributing food should be more resilient to a variety of shocks, be they economic, of natural making, accidental, malicious or born out of ignorance (Leat & Revoredo-Giha, 2013). Christopher & Peck (2004) defined supply chain resilience as the ability of a supply chain to return to its original state or move to a new, more desirable state after being disturbed. Melnyk et al. (2014) added another aspect that it can be proactive efforts towards helping prepare for a disruption. They defined supply chain resilience as the ability of a supply chain to both resist disruptions and recover operational capability after disruptions occur. Hence, a resilient cheese supply chain should focus on both robustness and responsiveness (Chen et al., 2012), which cover two aspects of the eighth construct of Siddh et al.'s (2015) framework. Together with the consideration of the dynamic market, we will propose the other performance measurement in the next sub-section.

The dynamic cheese market
The dynamic market is formed by the heterogeneity and rapid changes in the composition of customers in the market and their preferences (Trkman & McCormack, 2009). The challenge of demand variability and instability in cheese industry is complicated by long production delays. When customer demand varies, production and logistics managers must adjust capacity utilization to maintain adequate product supply while avoiding excess inventory. However, the combination of variability in demand and long production delays often leads to alternating periods of scarce and excess supply. The resulting supply variability can feed back to customer demand, as a supply chain's inability to meet demand leads to lost sales, eroded reputation, and decreased goodwill. The interactions of supply chain instability and customer response generate a phenomenon of endogenous demand (Gonçalves et al., 2005). Thus, customer satisfaction, another aspect of the eighth construct of Siddh et al.'s (2015) framework, is the main issue for the dynamic cheese market. Along with resilience efforts to deal with supply chain instability, we propose that *lost sales* should be the other performance measurement to manage a resilient cheese supply chain for the dynamic market.

METHODOLOGY
A system dynamics simulation is applied to study a cheese supply chain. System dynamics is a methodology that is capable of studying and modeling complex systems (Özbayrak et al., 2007). The complexity of supply chains, especially those which encompass several partners, warrants a perspective that considers the supply chain structure and the feedback inherent in these structures, which is provided by system dynamics modeling (Wilson, 2007). Although discrete event simulation can deal successfully with disruption events, agent based simulation and system dynamics have the capability to reproduce the interaction of different system agents to improve the understanding of the real system. Compared to agent based simulation, system dynamics modeling takes less time to build and works better when the level of aggregation is high (Hilletofth & Lattila, 2012).

The cheese supply chain in our model consists of three individual firms: a producer, an LSP, and a retailer. Milk and other resources are assumed to be infinite for the producer. The producer produces the cheese with a six weeks' production time and the finished products are immediately delivered to the LSP. When ready, the cheese has a remaining

shelf life of six weeks. The LSP keeps inventory, but it is the ordering policy pulled by the retailer and the production volume pushed by the producer that determine the actual inventory level. This is beyond control of the LSP. The retailer sells the products to consumers. The sales time is one week. Table 1 shows the initial simulation inputs. Please note that, all the value in this paper is reported in E notation.

Simulation input	Value
Producer order backlog	7.68E6 kg
Production time	6 weeks
Producer base capacity, LSP base capacity, Real customer demand rate	1.28E6 kg/week
Order backlog, LSP inventory, Cumulative demand	1 kg
LSP target shipment time, Retailer sales time	1 week
Retailer inventory	2.56E6 kg
Producer perception delay, Retailer perception delay	2 weeks

Table 1. Simulation inputs with value

There are two types of disruptions that we will simulate: a producer capacity disruption and an LSP capacity disruption. For each type of disruption, we simulate a process in 48 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 drop of 6.40E5 kg/week; at the end of Week 12, the base capacity recovers 3.20E5 kg/week; at the end of Week 15, the base capacity recovers another 3.20E5 kg/week -- back to the starting level, until the end of simulation. The length of simulation is set to be 48 weeks, because all the performance measurements will stay stable at only one atomic behavior pattern (i.e. linear, exponential, or logarithmic) from Week 24 to Week 48, which serves as the reference time interval for the feedback loop dominance analysis (please refer to the following text of the feedback loop dominance analysis for more details).

The structure of our simulation model is illustrated in Figure 1. For the producer, there are one information delay (for "Shared customer demand rate") and one material delay (for "Producer order backlog"). "Shared customer demand rate" equals the product of "Real customer demand rate" and "Perceived delivery reliability". "Product shipment rate" is the minimum value between "Producer desired shipment rate" and "Producer base capacity". For the LSP, 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". "Fraction of orders fulfilled" equals "Order fulfillment rate" divided by "LSP desired shipment rate". "LSP shipment time" evaluates throughput time, so it is one of the performance measurements. "LSP shipment time" is equal to "LSP inventory" divided by "LSP shipment rate". For the retailer, there are one material delay (for "Retailer inventory") and one information delay (for "Perceived delivery reliability"). "Sales rate" is the minimum value of "Shared customer demand rate" and "Retailer inventory"/"Retailer sales time". "Lost sales rate" is the other performance measurement. It equals "Shared customer demand rate" divided by "Real customer demand rate".
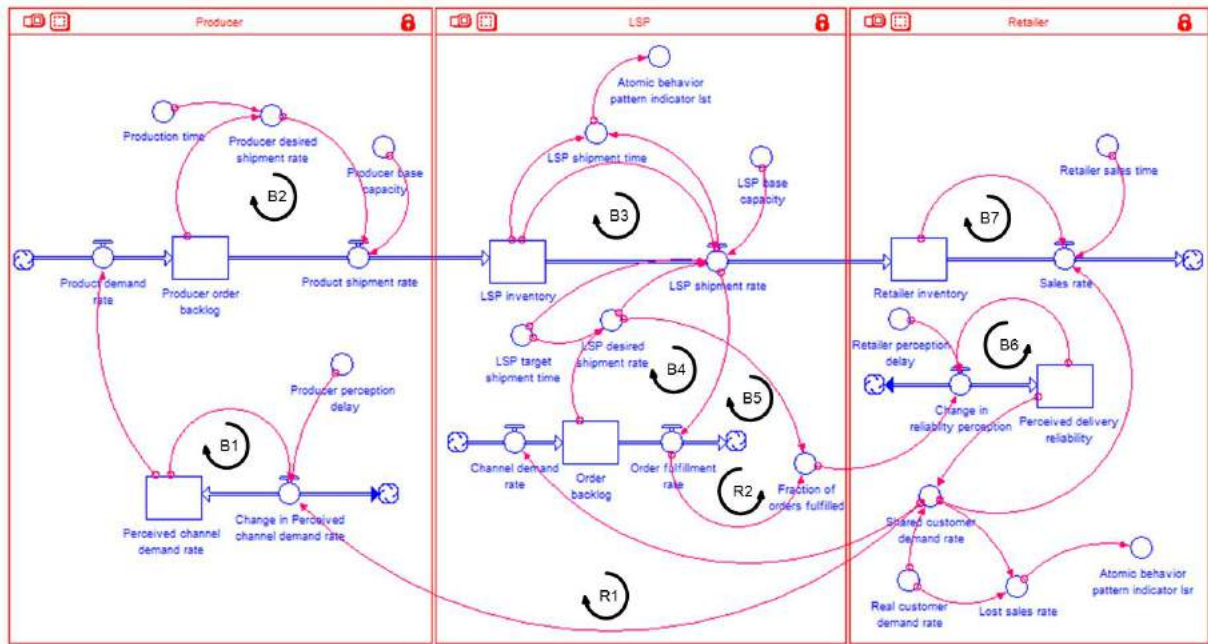
Figure 1 – The simulation model of a cheese supply chain

Seven balanced feedback loops and two reinforced feedback loops are identified from the simulation model (Figure 1). They are: B1: Producer information delay; B2: Producer capacity availability; B3: LSP capacity availability; B4: LSP order fulfillment (push); B5: Lost sales; B6: Retailer information delay; B7: Retailer sales availability; and R1: Producer order fulfillment (pull); R2: Maintained sales. A behavioral approach to feedback loop dominance analysis (Ford, 1999) is applied to identify dominant feedback loops for each disruption recovery: 1) Identify the variable of interest (i.e. "LSP shipment time" and "Lost sales rate" in this research) that will determine feedback loop dominance and simulate its behavior over time. 2) Identify a time interval (i.e. from Week 24 to Week 48 in this research) during which the variable of interest displays only one atomic behavior pattern. This is the reference atomic behavior pattern and time interval. The system structure and parameter values during this time interval define the conditions in which dominance is specified. The equation for each atomic behavior pattern indicator is: Atomic behavior pattern indicator = DERIVN(ABS(DERIVN(Variable of interest,1)),1). 3) Use the feedback structure of the model to identify the feedback loops that influence the variable of interest. Select one of those feedback loops as the candidate feedback loop. 4) Identify or create a control variable in the candidate feedback loop that is not a variable in other feedback loops and can vary the gain of the candidate loop. Use the control variable to deactivate the candidate loop. 5) Simulate the behavior of the variable of interest over the reference time interval with the candidate feedback loop deactivated and identify the atomic behavior pattern or patterns of the variable of interest during the time interval. 6) If the atomic behavior pattern generated in step 5) is different from that identified in step 2), the candidate feedback loop dominates the behavior of the variable of interest under the system conditions during that time interval. 7) Repeat steps 3) through 6) with the candidate loop active to test for multiple dominant feedback loops during the time interval.

RESULTS
The results of a feedback loop dominance analysis for a producer capacity disruption recovery are shown in Table 2. B1, B2, B3, B4, B5, and R2 are identified as the dominant feedback loops to help keep a reasonable "LSP shipment time" to maintain a sustainable cheese supply chain. Meanwhile, B4, B5, and B6 are helpful to control "Lost sales rate", hence building a resilient cheese supply chain in facing a producer capacity disruption.

	B1	B2	B3	B4	B5	B6	B7	R1	R2
LSP shipment time	✔	✔	✔	✔	✔	✘	✘	✘	✔
Lost sales rate	✘	✘	✘	✔	✔	✔	✘	✘	✘

Notes: B1: Producer information delay; B2: Producer capacity availability; B3: LSP capacity availability; B4: LSP order fulfillment (push); B5: Lost sales; B6: Retailer information delay; B7: Retailer sales availability; R1: Producer order fulfillment (pull); R2: Maintained sales.

Table 2 – A feedback loop dominance analysis for a producer capacity disruption recovery

The results of a feedback loop dominance analysis for an LSP capacity disruption recovery are presented in Table 3. B3, B4, B5, and R2 dominate the changes of "LSP shipment time", therefore influencing the sustainability of a cheese supply chain. Moreover, to lower "Lost sales rate" and thus keep the resilience of a cheese supply chain, B3, B4, B5, and B6 are worth paying attention to.

	B1	B2	B3	B4	B5	B6	B7	R1	R2
LSP shipment time	✘	✘	✔	✔	✔	✘	✘	✘	✔
Lost sales rate	✘	✘	✔	✔	✔	✔	✘	✘	✘

Notes: B1: Producer information delay; B2: Producer capacity availability; B3: LSP capacity availability; B4: LSP order fulfillment (push); B5: Lost sales; B6: Retailer information delay; B7: Retailer sales availability; R1: Producer order fulfillment (pull); R2: Maintained sales.

Table 3 – A feedback loop dominance analysis for an LSP capacity disruption recovery

DISCUSSION AND IMPLICATIONS
Discussion
Through the feedback loop dominance analysis, this research has set the first step to manage a sustainable and resilient cheese supply chain for the dynamic market, when the supply chain faces a product shortage (either by a producer capacity disruption or an LSP capacity disruption). Further investments can thus be targeted at the identified dominant feedback loops to ensure cost efficient improvements. In this sub-section, we will group the identified dominant feedback loops according to Siddh et al.'s (2015) framework and discuss their theoretical implications.

B1 (Producer information delay) and B6 (Retailer information delay) form the first group, i.e. information delay. It belongs to the sixth construct of Siddh et al.'s (2015) framework. Timely information is essential for good planning and forecasting. When information is limited, variations between forecast and orders will increase and this could lead to waste (Mena et al., 2011). It is proved by B1 as a dominant feedback loop for "LSP shipment time" after a producer capacity disruption. On the other hand, a resilient supply chain builds on timely information exchange (Christopher & Peck, 2004). In the light of cheese production, failure in upstream supply chain (i.e. the producer and the LSP in this research) will produce a chain of reaction on the downstream side (i.e. the retailer in this research) (Chen et al., 2012). Therefore, for both disruptions' recovery, B6 is found to be a dominant feedback loop for "Lost sales rate".

The second group is about capacity availability, which represents the fifth construct of Siddh et al.'s (2015) framework. The second group includes B2 (Producer capacity availability), B3 (LSP capacity availability), and B4 (LSP order fulfillment (push)). B4 is included here, as excess orders can be fulfilled by outsourcing, which keeps capacity availability (Hsieh & Wu, 2008). Therefore, B4 helps maintain sustainability and resilience after both disruptions. Besides, we find that both B2 and B3 are dominant feedback loops for "LSP shipment time" after a producer capacity disruption, while B3 dominates the changes of both "LSP shipment time" and "Lost sales rate" after an LSP capacity disruption. To recover from a producer capacity disruption, the producer's surge capacity

serves as the precautionary buffer to protect products supply (Driver, 2000), while the LSP's surge capacity alleviates the impact of non-supply by accelerating goods-in-transit (Schmitt & Singh, 2012). To recover from an LSP capacity disruption, the LSP's surge capacity serves as a first aid to keep a reasonable throughput time (Boulaksil et al., 2011), so that the retailer will not perceive the disruption seriously (Zhu et al., 2016), ending up with few lost sales.

The third group, including B5 (Lost sales) and R2 (Maintained sales), is related to trust and commitment, which belongs to the ninth construct of Siddh et al.'s (2015) framework. "LSP desired shipment rate" from B5 and "Order fulfillment rate" from R2 decide the value of "Fraction of orders fulfilled", which is the information requested by the retailer to decide "Shared customer demand rate". However, if supply chain partners trust each other, they would not request such information but rely on each other's promises, especially when they encounter unforeseen disruptions (Wei et al., 2012). Ding et al. (2014) found that trust and commitment is a significant predictor for food quality, which is verified by our results that both B5 and R2 are dominant feedback loops for "LSP shipment time" after both disruptions. In contrast, only B5 dominates the change of "Lost sales rate" after both disruptions. R2 can maintain sales through keeping "Order fulfillment rate" close to "LSP desired shipment rate", but it cannot influence the change of "LSP desired shipment rate", which leads to lost sales.

Managerial implications
Our paper provides several managerial implications for a cheese supply chain, or more broadly speaking, for a supply chain of perishable goods with long production delay. To manage a sustainable and resilient supply chain for the dynamic market, managers are advised to invest in three fields: information transparency, surge capacity, and trust and commitment. Information technology packages like warehousing management system (WMS) and transportation management system (TMS) (Wu et al., 2014) are mostly beneficial for a resilient supply chain. Surge capacity, on the other hand, is more helpful for a sustainable supply chain. One exception is outsourcing after capacity disruptions, which can benefit both sustainability and resilience. However, as such outsourcing is always emergent thus costly, managers need to think carefully before making a decision. Similarly, trust and commitment helps both sustainability and resilience, but it takes a long time to build. Therefore, a long-term orientation should be shared by supply chain partners.

Limitations and future research
There are two feedback loops (i.e. B7 and R1) that do not dominate any variable of interest after both disruptions. However, it may be due to the limitations of this research and thus worth researching in the future. For B7 (Retailer sales availability), we assumed that "Retailer sales time" was 1 week. However, if future researchers consider issues like price discount (Kaipia et al., 2013), "Retailer sales time" should not be fixed and thus B7 may become a dominant feedback loop. Such issues can be cost of quality and quality of marketing (the third and seventh constructs of Siddh et al.'s (2015) framework). For R1 (Producer order fulfillment (pull)), rationing and shortage gaming (Lee et al., 1997) is an interesting issue to be added. If so, it would trigger another discussion on trust and commitment (the ninth constructs of Siddh et al.'s (2015) framework).

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DEVELOPMENT AND VALIDATION OF A MEASUREMENT INSTRUMENT FOR HALAL FOOD SUPPLY CHAIN IMPLEMENTATION

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ABSTRACT

Purpose of this paper: This study develops and validates the dimensions for the halal food supply chain implementation (HFSCI) model and confirms the measurement model using four underlying dimensions.

Design/methodology/approach: The items of the dimensions used in the model are developed and validated based on a comprehensive multi-step approach prior to the large-scale survey. A questionnaire-based survey is distributed to 600 Malaysian halal certified food and beverage organisations. A total of 240 usable questionnaires are collected to confirm the underlying dimensions empirically. Confirmatory factor analysis is conducted to examine the measurement models of HFSCI, both for first-order and the higher-order measurement models.

Findings: The results suggest that all four dimensions including physical attributes, process capability, ethical practice, and management capability significantly define the HFSCI model. The results also suggest that both the first-order and the second-order models for HFSCI are reliable and valid.

Value: To our knowledge this is the first attempt to develop and validate the measurement instrument for HFSCI. Thus theoretically this study contributes to the body of knowledge regarding implementation dimensions of halal food supply chain. Furthermore, it provides a valid measurement instrument for further research in the context of other countries and markets.

Research limitations/implications (if applicable): The study is in the context of the halal food supply chains of processed food and beverage industry sector. Therefore, the results of this study may not be generalised for other industry sectors such as cosmetics and personal care and healthcare and pharmaceuticals.

Practical implications (if applicable): The findings of this study can be used as a guide to future practices. Furthermore, the validated items and dimensions may assist managers to identify areas for improvement and to formulate strategic initiatives in the halal food industry.

Keywords: *Halal, Halal Food Supply Chain Implementation, Processed Foods and Beverages*

INTRODUCTION

Muslims are permitted only to consume halal food products (Al-Qaradawi 2007). Halal is an exclusive term which means an act or product that is lawful and permitted (DoS 2013). The global demand for halal food products is growing with the increase and spread of Muslim population globally. It has been projected that the global Muslim population will grow from 1.6 billion in 2010 to 2.7 billion in 2050 which means that approximately 1.1 billion Muslim populations will be added to the world's population over the next forty years (Pew Research 2015). Due to the share size of the Muslim consumer base, the halal food business has turned into a major global food business (Lodhi 2009). A recent estimate suggests that the total value of the global halal market is nearly US$2.3 trillion (HDC 2014). The increased number of products, processes, and partners in the business lead the global supply chain of halal food becomes more complex. As a result, halal needs a supply chain approach where all its supply chain activities must comply with the general principles of Shariah law. This concept is vital to food manufacturers to deliver credibility and trust to Muslim consumers.

Recently, the global halal food supply chain has not only become complex but also exposed Muslims to various ingredients and manufactured foods due to developments in

food technology and distribution systems (Talib, Zailani & Zainuddin 2010). There is a concern amongst the halal consumers whether the halal status of food products can be guaranteed throughout the supply chain since halal products are now sourced from various parts of the world including non-Muslim countries. The possibility of cross-contamination with non-halal products at various critical points throughout the supply chain process is considerable. Moreover, the halal integrity risk is huge if the suppliers and sub-suppliers are located in other non-Muslim countries (Ali et al. 2014) because the level of awareness of halal requirements is still in its infancy.

Halal products need to be produced with credence quality attributes and conform to more stringent requirements to maintain halal standards, and integrity throughout the supply chain. Lately, several issues exist in this industry such as lack control of halal food norms, halal food authenticity and adulteration (Tieman, Vorst & Ghazali 2012; Bonne & Verbeke 2008; Tieman 2011; Fadzlillah et al. 2011). Halal food authenticity is defined as the process where the verified food conforms to the label description (Dennies 1998; Nakyinsige, Man & Sazili 2012). The authenticity issue is also concern whether the materials involved in halal food products have been mixed intentionally with cheaper non-halal materials, an act known as adulteration (Nakyinsige, Man & Sazili 2012). Furthermore, the image of the halal food industry has been tarnished by the rising issues of fraudulent halal logo and cross-contamination with non-halal products (Norman, Nasir & Azmi 2008; Zailani et al. 2010; Mohd Albakir & Mohd-Mokhtar 2011). This controversy had created confusion and uncertainty among consumers about whether the products offered are truly halal or not (Abdul Talib, Mohd Ali & Jamaludin 2008; Melatu Samsi, Tasnim & Ibrahim 2011). This discussion clearly points to the fact that there is a need to design, develop and manage halal food supply chain model so that trust and credibility can be delivered to the relevant consumers.

Academic research on halal food management and halal food supply chain implementation (HFSCI) in particular is relatively new (Wan Omar, Rahman & Jie 2015). Although there are few studies conducted on halal food supply chain, however, this area is still remained under-researched. Prior studies have focused mainly on consumer studies such as consumer awareness of halal products, purchasing behavior of Muslim consumers, product adoption and branding (Alam & Sayuti 2011; Hanzaee & Ramezani 2011; Wan Omar, Muhammad & Omar 2008; Wilson & Liu 2010). So far, no effort has been made to develop and validate the constructs for halal food supply chain implementation (HFSCI). Taking a holistic view of halal and considering multiple dimensions of halalness, this study identifies HFSCI dimensions, and develops and validates a measurement instrument for HFSCI. The rest of the paper is structured as follows. The next section presents a brief review of related literature on the constructs of halal food supply chain and proposed a conceptual framework. Then it provides the research methodology section, followed by a section on data analysis of large-scale survey and confirmatory factor analysis. The following section discusses the major findings, and the research implications are discussed right after that. Finally, the paper concludes with future research directions and limitation.

BACKGROUND OF THE STUDY

The halal industry is not merely about meat and poultry but also incorporates processed food, dairy products, food ingredients and even non-food products (Alserhan 2010). Today, halal has entered the realm of business and trade (Hanzaee & Ramezani 2011). This has been proven with the rise of global halal food market size from US$587 billion in 2004 to US$642 billion in 2010 (Sungkar 2009), and estimated to reach US$1.6 trillion by 2018 (Bowling 2014). The increase in halal food market expenditure globally is interpreted as the stronger buying power of halal consumers, suggesting that the industry is potentially competitive. The halal products can be grouped into seven categories. These are processed foods and beverages, pharmaceutical, bakery products, primary meat, cosmetics and personal care, nutraceutical and confectionary (HDC 2014). Among these categories, the processed foods and beverages category has the highest

market share with 35% of the global halal market and has huge business opportunity globally. Therefore, in this study we consider the processed foods and beverages category of food to develop and validate a measurement instrument for HFSCI.

Over the last two decades, Malaysia has been working towards becoming an international halal hub and accordingly, the government has developed strategies and plans to attain the objective. These strategies and plans are: i) Second Industrial Master Plan 1996 – 2005; ii) National Agriculture Policy 1998 – 2010; iii) Ninth Malaysia Plan (9MP) 2006 – 2010; and Third Industrial Master Plan (IMP3) 2006 – 2020 (HDC 2014). These efforts have paid off and currently, Malaysia is one of the leading producers of halal foods. In 2013, its exports of halal food amounted to US$9.8 billion which made it one of the largest suppliers amongst the Organization of Islamic Cooperation (OIC) countries (Batrawy 2014). Hence, this makes Malaysia a significant research setting.

REVIEW OF LITERATURE

An extensive review of halal food management literature published in peer-reviewed journals and conference proceedings was conducted by investigating major bibliographic databases for works published between 2003 and 2015. The major bibliographic databases used in searching the relevant articles are Business Source Premier (EBSCO Host), Emerald Insight, Science Direct (Elsevier), Scopus, Springer Link and IEEE Xplore. Keywords or terms such as <Halal>, <Halal food> and <Halal food supply chain> were employed. As a result, the review of relevant literature provides and defines four dimensions of HFSCI: physical attributes, process capability, ethical practice and management capability.

Physical Attributes

To focus on physical attributes of products is critical in halal concept as it should reflect the elements of cleanliness, safety, health and nutrition in halal products (Mohamad & Hassan 2011). Furthermore, products must adhere to Islamic dietary laws. Cleanliness, sanitation, and safety of the products are considered to be the foundations of halal food preparation, and these features should be in line with the Halalan Toyyiban concept. In halal supply chain, it needs to be clean and halal from farm to fork. Furthermore, health and nutritional values are also indicators of consumers' purchase decisions on halal food products (Sungkar 2009). One of the most important aspects of a Muslim's life is food and dietary code as revealed in the Quran and recorded in the Hadith (compilation of the traditions of the Prophet Muhammad) (Bonne & Verbeke 2008) and these constitute the two major sources of Islamic dietary law. A Muslim who adheres to the Islamic dietary law is demonstrating his or her faith in religion and avoiding foods that do not meet dietary standards (Riaz & Chaudry 2004). Hence, the physical attributes are significant dimensions of HFSCI construct. A summary of literature on physical attributes is shown in Table 1.

Dimensions	Literature
Physical Attributes • Cleanliness • Safety • Health and Religion	Riaz & Chaudry (2004), Talib, Ali & Jamaludin (2008), Mohamad & Hassan (2011), Pahim, Jemali & Mohamad (2012), Bahrudin, Illyas & Desa (2011), Rezai, Mohamed & Shamsuddin (2011), Kamaruddin, Iberahim & Shabudin (2012), Al-Qaradawi (2007), Ireland & Rajabzadeh (2011), Kordnaeij, Askaripoor & Bakhshizadeh (2013), Wilson & Liu (2010), Spiegel et al. (2012), Hanzaee & Ramezani (2011), Bonne & Verbeke (2008); Verbeke et al. (2013); Abdul et al. (2009); Daud et al. (2012); Talib, Zailani & Zainuddin (2010); Kamali (2010); Zainalabidin, Golnaz & Mad (2011); Talib, Ali & Jamaludin (2008); Lam & Alhashmi (2008)
Process Capability • Physical Segregation • Production and Handlings • Packaging and Labelling	Bonne & Verbeke (2008), Spiegel et al. (2012), Talib & Johan (2012), Ngah & Zainuddin (2012), Nakyinsige, Man & Sazili (2012), Tieman (2011), Tieman & Ghazali (2012), Lodhi (2009), Malaysian Standard (MS 1500:2009), Omar, Jaafar & Osman (2013), IHI Alliance (2009), Ngah, Zainuddin & Thurasamy (2013), Ali et al. (2014)
Ethical Practice	Al-Qaradawi (2007), Mohamad & Hassan (2012), Irfan (2010), Mohammed (2013)

Management Capability	Tieman, Vorst & Ghazali (2012), Zailani et al. (2010), Malaysian Standard
• Halal Trained and Personnel	(MS 1500:2009), Kamaruddin, Iberahim & Shabudin (2012), Omar,
• Innovation Capability	Jaafar & Osman (2013), Pahim, Jemali & Mohamad (2012), Noordin, Noor
• Sufficient Resources	& Samicho (2012), Lam & Alhashmi (2008), Machfud et al. (2011),
	Bahrudin, Ilyas & Desa (2011), Yang & Bao (2011), Samsi, Ibrahim &
	Tasnim (2012), Shafii & Nasir (2012), Tan, Razalli & Desa (2012), Tan,
	Razalli & Husny (2012), Di Foggia et al. (2011), Bakar et al. (2013),
	Fadzlillah et al. (2012), Norman, Nasir & Azmi (2008), Yang & Bao
	(2010), Junaini & Abdullah (2008), Ali et al. (2014)

(Source: Compiled by authors)

Table 1: Studies on halal food supply chain implementation dimensions

Process Capability

The process capability is considered as an element of operational strategy (Slack et al. 2010). In the manufacture of halal products, it is imperative that all possible sources of contamination are eliminated during the production process (Riaz & Chaudry 2004). For Muslim consumers, trust in halal food relates to the process attributes and how it is being processed. During the processing stage, such as storage and display, halal products must be physically segregated from non-halal products to prevent cross-contamination (Ali et al., 2014; Nakyinsige, Man & Sazili 2012). Halal and non-halal products should be kept separately in storage during transportation and distribution to avoid contamination (Ngah & Zainuddin 2012). Furthermore, dedicated equipment and facilities must be used for halal products (DoS 2009). The process of packaging and labeling products must also be considered to create a genuine and wholesome halal product (Ab Talib & Mohd Johan 2012). Consequently, the nature of process capability is considered as one of the dimensions of HFSCI. A summary of literature on process capability is shown in Table 1.

Ethical Practices

The development of a halal product must be ethical and therefore, consistent with Shariah principles. The ethical features are: being environmentally friendly, considering animals' welfare, having an organic character, respectful Islamic financing and fair trade attributes (Mohamad & Hassan 2012). Al-Qaradawi (2007) emphasized the principle of permissibility where it is not only limited to the things and objects being used but also includes all human actions and behaviors. Additionally, having ethical producers who are practically involved in fair trade and are socially responsible within the whole production chain do constitutes a major concern in the halal industry (Irfan 2010). Thus, the ethical practices may significantly define HFSCI model. Table 1 provides some of the relevant literature on ethical practices.

Management Capability

Management capability is one of the important elements in complementing the halal food supply chain model. Generally, management should be able to provide trained personnel in halal, adequate resources and be innovative. To develop a sustainable pool of knowledge workers and professionals in the halal industry, training is essential and management should be able to ensure everyone is appropriately trained (Ali et al., 2014; Tieman, Vorst & Ghazali 2012). Organisations have to ensure that workers are aware and understand the halal requirements in order to minimize the probabilities of human error in the production of halal products. Furthermore, management needs to be actively involved in innovation such as developing a halal traceability and tracking system which can improve halal transparency in the production as well as over the entire supply chain (Zailani et al. 2010). At the same time, management needs to ensure that sufficient resources such as manpower, infrastructure, machinery and equipment and finances are provided prior to halal production (DoS 2009). A summary of literature on physical attributes is shown in Table 1. Based on the discussion above the management capability is considered as a dimension of the HFSCI model.

Based on the above discussion on this conceptualisation of halal food supply chain implementation (HFSCI) as having physical attributes (PA), process capability (PC), ethical practices (EP) and management capability (MC) dimensions, the following hypothesis is proposed:

H1. Halal food supply chain implementation (HFSCI) is defined as higher-order construct which represents *(a)* physical attributes, *(b)* process capability, *(d)* ethical practices, and *(e)* management capability.
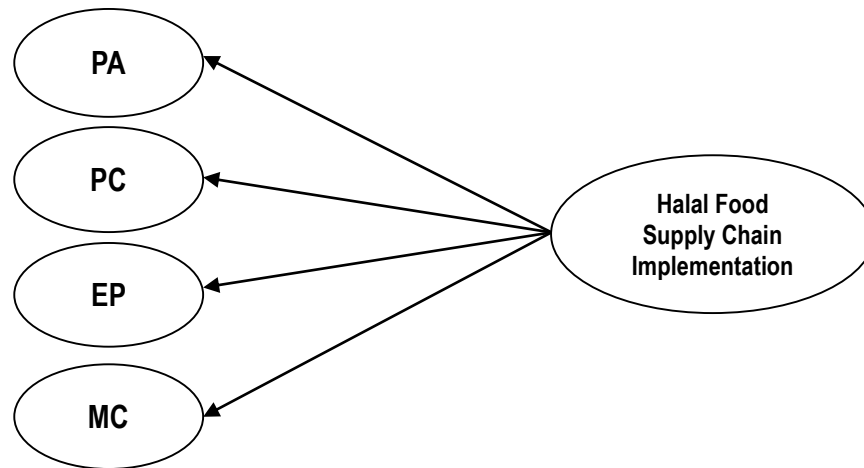

Figure 1: A proposed conceptual model of HFSCI

METHODOLOGY
Prior halal food supply chain studies have predominantly been case studies (Omar & Jaafar 2011; Tieman, Vorst & Ghazali 2012; Ali et al. 2014). Within the context of the quantitative method category, a vast majority of research in halal supply chain employ either descriptive statistics or regression (Wan Omar, Rahman & Jie 2015). This research seeks to develop and validate a theoretical model comprising testable hypotheses. Consequently, quantitative approach is an appropriate method that entailed verification of hypotheses, providing strong reliability and validity (Amaratunga 2002). This study adopts and rationalizes a comprehensive multi-step approach suggested by Shah and Ward (2007) during the development and validation process. Each of these processes is described below.

Scale Development
The measurement scale for the halal food supply chain implementation (HFSCI) is developed in two ways; (i) adopting a list of potential validated items from the past literature and (ii) developing the items based on extensive review of literature and inputs from industrial experts. A list of 55 measurement items on HFSCI is developed. Dimensions have been operationalised using seven-point Likert scales (1=strongly disagree to 7=strongly agree). These items are refined by conducting a pre-test with two industrial experts and two academics to assess face and content validity of the measurement items. These experts are chosen based on their vast experience in the halal industry specifically in halal food and beverage industry sector. Some refinements of the items were made based on their feedbacks and suggestions.

Pilot Study
To ensure that the questionnaire design, wording, and measurement scales are appropriate, a pilot study is administered to 100 certified halal organizations in Malaysia's processed food and beverage industry sector. The questionnaire is distributed during the Penang International Halal Expo and Conference 2015 (PIHEC 2015), and the respondents are randomly selected from the conference directory. The reliability of the

items was measured based on the Cronbach alpha coefficient which varied between 0.735 and 0.935 (coefficient alpha of PA = 0.935, PC = 0.935, EP = 0.735, and MC = 0.838). No item was deleted based on the acceptable thresholds for coefficient alpha (0.7) (Nunnally 1978, Hair et al. 2010). Minor changes are made to the layout of the questionnaires to make it more readable before the large-scale survey is carried out.

Exploratory Factor Analysis – Assessment of Dimensionality

Exploratory factor analysis (EFA) is employed to assess the dimensionality of the constructs. The subsequent factors derived from EFA are the starting point for the confirmatory analysis (CFA). Results show the eigenvalues greater than 1.0 and the total variance explained is 70.5% (total variance needs to be at least 60% or higher, according to Hair et al (2010). KMO, a measure of sampling adequacy, found to be 0.890, indicating sufficient inter-correlations while Bartlett's Test of Sphericity found significant (Chi-square = 12238.405, p<0.01). Based on the value of the cross-loading and factor loading 10 items with values <0.05 (Hair et al 2010) are removed from the list. Thus, the results confirm that each dimension is uni-dimensional and factorial distinct.

DATA ANALYSIS: LARGE-SCALE STUDY

The survey method is conducted involving the distribution of 600 self-administered questionnaires to identified Malaysian halal certified food and beverage organisations of which 240 usable questionnaires are collected, yielding a response rate of 40%. By using the drop-and-collect method, respondents are identified and contacted personally, prior to dropping off the questionnaires. The completed questionnaires are then personally collected by the researcher. Data collected from three states and one federal territory in Malaysia. Since more than 60% of halal certified companies are located in these areas, the choice of these areas is legitimate. The final version of the questionnaire is translated into Malay by a certified linguistic specialist. The actual data is screened to check whether data are correctly entered, missing values, free outliers, and to confirm that the distribution of the variables is normal. Then, the confirmatory factor analysis (CFA) approach is employed to verify the structure of the measurement models.

Profile of Respondents

The position, level of education and employment in the halal food and beverage industry sector vary from one respondent to another. Most of the respondents are managers (30.4%), and most have completed graduate studies (51.7%). The other 48.3% have post-graduate, diploma, post-secondary and secondary degrees. Approximately 32.1% indicated that they have been working in the organization for between 6 and 10 years, followed by 30% having worked as managers for 5 years or less. Of 240 respondents, most (36.9%) had between 6 to 10 years of managerial experience in the halal food and beverage industry sector. Regarding the participating organisations, majority of them were medium-sized enterprises (51.2%) with between 75 to 200 employees, followed by small-sized enterprises (34.6%) with between 5 to 74 workers. Only 40 organisations have operated for more than 25 years, the most (35.8%) between 6 to 15 years.

CONFIRMATORY FACTOR ANALYSIS
Assessment of First-order Measurement Model

The measurement model of each construct is tested by a confirmatory factor analysis using covariance based software called IBM SPSS Amos 22. The measurement models are assessed in terms of reliability, convergent validity, construct validity and discriminant validity of the latent constructs. The results of this assessment are shown in Table 2. The requirement of reliability can be checked through the process of internal reliability and construct reliability. Internal consistency of the measurement items is assessed using Cronbach alpha coefficient. The results reveal that Cronbach alpha coefficient scores range between 0.78 and 0.92 for all constructs demonstrate a good level of internal consistency (Nunnally 1978; Hair et al 2010). Furthermore, the composite reliability of every construct for this study range from 0.71 to 0.93, higher

than the acceptable threshold value of 0.60 (Bagozzi & Yi 1988; Awang 2012). The standardised factor loadings of all items of the four dimensions reported are significant and the average variance extracted (AVE) are ranged from a minimum of 0.50 to 0.69, exceeding the standard value of ≥ 0.5 (Fornell & Larcker 1981). In the first-order model, discriminant validity is achieved for all cases where the correlation between constructs range between 0.25 and 0.77 which is ≤ the threshold value of 0.85. Based on the results, we conclude that reliability and validity of the measurement models are assured. The fitness indices indicate how well the proposed model captures the covariance among items in the measurement model (Awang 2012). Hair et al. (2010) and Holmes-Smith (2006) recommend the use of at least three fit indices by including at least one index in each category: absolute fit, incremental fit, and parsimonious fit. For this study, model fitness for each of the first-order and higher-order dimensions is checked by using several fitness indices: Chisq/df, RMSEA, GFI, CFI, AGFI, and TLI. The first-order measurement model indicates that physical attributes (PA), process capability (PC), ethical practice (EP) and management capability (MC) are correlated measurement dimensions for HFSCI. The fitness indices suggest an acceptable fit for the first-order measurement model. The AGFI is 0.84 and GFI is close to 0.90 which are considered acceptable fit for the measurement model (Zhu, Sarkis & Lai 2008). Furthermore, the ChiSq/df = 1.65; CFI = 0.95, TLI = 0.94 and RMSEA = 0.05, are within the acceptable threshold values (Chau & Hu 2001), thus indicates the significant fit for the first-order measurement model.

Dimensions	Items	Standardized Loading	CR	AVE	α
Physical Attributes (PA)	C1	0.60	0.90	0.54	0.86
	C2	0.76			
	C3	0.76			
	C4	0.79			
	S1	0.62			
	S2	0.82			
	HR1	0.86			
	HR2	0.61			
Process Capability (PC)	PS1	0.90	0.93	0.66	0.92
	PS2	0.90			
	PS3	0.74			
	PH1	0.66			
	PH2	0.78			
	PL1	0.83			
	PL2	0.85			
Ethical Practices (EP)	EP1	0.87	0.84	0.57	0.78
	EP2	0.79			
	EP3	0.66			
	EP4	0.69			
Management Capability (MC)	HT1	0.89	0.93	0.69	0.87
	HT2	0.94			
	HT3	0.84			
	IC1	0.70			
	IC2	0.83			
	IC3	0.76			

Fitness Indices: ChiSq/df (1.65), GFI (0.87), AGFI (0.84), CFI (0.95), TLI (0.94), RMSEA (0.05)

Table 2: Results of CFA first-order measurement model

Assessment of the Higher-order Measurement Model
The test is further assessed on the higher-order measurement model to confirm the constructs in defining the HFSCI. As shown in Figure 2, the measurement model-fit indices exceed common acceptance levels. The ChiSq/df for the model is 1.65 ≤ 3.0, suggesting that the measurement model is fitted to the sample data well. The value for GFI (0.87) and AGFI (0.84) remained the same. On the contrary, the value for CFI (0.94) is slightly reduced from first-order measurement order. However, the value is

acceptable fit for the measurement model (Zhu, Sarkis & Lai 2008). RMSEA value remains as 0.05, suggesting acceptable fit. The higher-order standardized loadings on HFSCI model are 0.84 for PA, 0.94 for PC, 0.46 for EP and 0.80 for MC. Overall, the goodness-of-fit indices demonstrate that there is no difference between first-order measurement model and higher-order measurement model. Furthermore, the findings reveal all paths are statistically significant (p<0.01). As illustrated in Table 3, the standardized estimates of all four dimensions of HFSCI are found to be supported. Thus, HFSCI can be conceptualized as a higher-order multidimensional construct comprising of PA, PC, EP and MC.
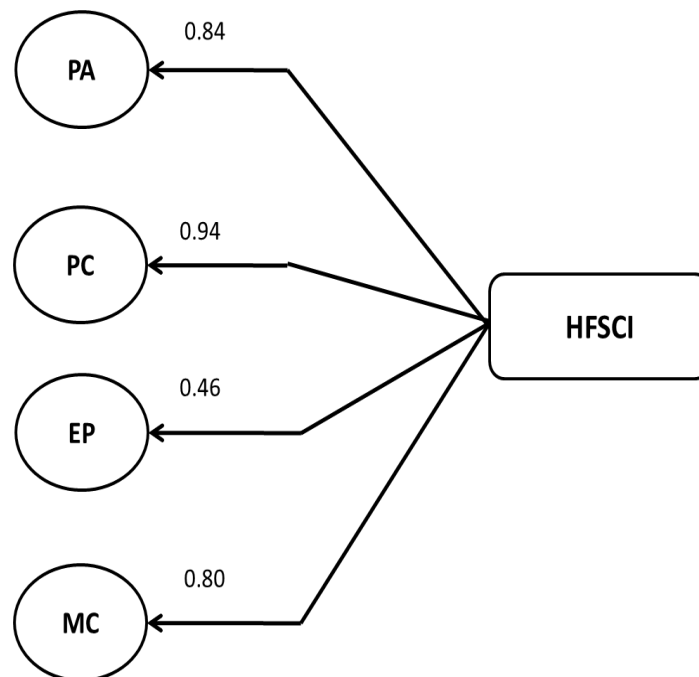
Where, Fitness Indices: ChiSq/df (1.68), GFI (0.87), AGFI (0.84), CFI (0.94), TLI (0.94), RMSEA (0.05)

Figure 2: HFSCI as Higher-order Construct

Path coefficient			Estimate (β)	t-value	Result
PA	← - - -	HFSCI	0.84	7.45	Supported
PC	← - - -	HFSCI	0.94	9.36	Supported
EP	← - - -	HFSCI	0.46	5.77	Supported
MC	← - - -	HFSCI	0.80	8.81	Supported

Table 3: The Regression weights for HFSCI as Higher-order Construct

DISCUSSION

This study pre-determines the dimensions of HFSCI by conducting an extensive literature review of halal food management, supply chain management, and general food chains. Pre-test and pilot test are conducted to assess the content validity and to check the consistency of the measurement items. Dimensionality is accomplished using exploratory factor analysis (EFA) by deleting 10 items. As a result, only 45 valid items are used for large-scale survey and generate data for the analysis. All the dimensions are found to be factorial distinct. Using drop and collect method, the questionnaires are distributed to the halal certified food and beverage organisations in Malaysia. The measurement items used to evaluate the halal food supply chain implementation (HFSCI) are categorized into four underlying dimensions: physical attributes (PA), process capability (PC), ethical practice (EP) and management capability (MC). Then, the measurement items for the dimensions are tested for its validity and reliability. The purpose of conducting such

analysis is to assess whether the instrument used able to measure what is supposed to be measured and how reliable the items used in measuring the intended dimension. All measurement items were found to be reliable and valid. Furthermore, to confirm the measurement model with underlying dimensions, confirmatory factor analysis (CFA) is used to test both first-order and higher-order measurement models. Both of the models are found to be acceptable fit, and the second-order models' paths are statistically significant. We therefore provide concise HFSCI dimensional elements and the model can be conceptualized as a higher-order multi-dimensional construct. Based on the results, the underlying dimension of EP looks quite low and less promising compared to other dimensions whereas PC becomes the most significant underlying dimension for the model. From the findings, the multi-dimensional conceptualization provides insight to manufacturers as a reference model rather than concentrating on individual items.

RESEARCH IMPLICATIONS

So far research in halal food supply chain management is limited (Tieman 2013; Wan Omar, Rahman & Jie 2015). To the best of our knowledge, this study is the first attempt to develop and validate the measurement instrument for halal food supply chain implementation. This study contributes to the literature on empirical assessment of the dimensions for HFSCI. It provides the future researchers with validated measurement models for further studies in halal food supply chain context. Furthermore, the majority of the halal food research is either case study based or base on applied descriptive statistics. Thus, this study contributes as a reference for future research in terms of rigorous statistical analysis in confirming the underlying dimensions by employing the confirmatory factor analysis (CFA). From the practical perspective, the findings of the study can be used as a foundation to guide the evolution of future halal food supply chain practices. Furthermore, the validated items and dimensions may assist managers identifying areas for improvement in the implementation of halal food supply chain and for formulating strategic initiatives in the halal food industry.

CONCLUSIONS AND LIMITATION

The main contribution of this study is to propose a halal food supply chain framework with the intention to develop the underlying dimensions and validating the measurement items for halal food supply chain implementation (HFSCI). Based on the overall findings, it can be suggested that the manufacturers should emphasize on four underlying dimensions which include physical attributes, process capability, ethical practice and management capability. Furthermore, the results provide valuable insights that can assist the managers in strengthening and improvise their strategies and capabilities particularly in the context of the halal food industry as to remain competitive in the market. This study is conducted in the context of the processed food and beverage industry sector in Malaysia. Hence, the results may not be generalised for other industry sectors and countries.

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*Full list of references can be made available upon request to the corresponding author.

Appendix

The finalized list of measurement items for Halal Food Supply Chain Implementation (HFSCI) is shown in Table A below.

Table A
List of Measurement Items for HFSCI

Constructs	Measurement items
Physical Attributes (PA)	1. Our organization believes that cleanliness is a pre-requisite in halal food manufacturing (C1) 2. Our food products are manufactured in a clean working premise (C2) 3. Our food products are manufactured using clean devices, utensils, machines and processing aids (C3) 4. Our suppliers able to supply materials which are not contaminated with any non-halal elements (C4) 5. Our organization believes that safety is a pre-requisite in halal food manufacturing (S1) 6. Our food products are not hazardous to people's health (S2) 7. Our organization strictly not allowed the unlawful (haram) elements in our halal food manufacturing (HR1) 8. Our organization is aware that food products made from unlawful (haram) elements such as dead meat, blood, flesh of swine and intoxicants can cause illnesses (HR2)
Process Capability (PC)	1. Our organization has separate processing lines for halal food production (PS1) 2. Our organization stores materials for halal food production using separate warehouses (PS2) 3. Our organization uses separate bonded trucks to transfer halal food products (PS3) 4. Our organization inspects, sorts raw materials, ingredients and packaging materials before processing (PH1) 5. Our organization will make sure that the production lines and equipment used are constantly cleaned and sanitized (PH2) 6. Our organization only uses packaging materials which do not have any toxic effect on the product (PL1) 7. Our food product packaging is provided to consumers with information on all ingredients (PL2)
Ethical Practices (EP)	1. Our organization recycles food waste when possible (EP1) 2. Our organization participates in the design of products for recycling or reuse (EP2)

	3. Our organization uses halal certified and safe chemicals (EP3) 4. Our organization stores harmful chemical substances away from food products (EP4)
Management Capability (MC)	1. Our organization has a group of trained workers to handle halal food production (HT1) 2. Our employees are trained to understand the importance and correct way of producing halal food products (HT2) 3. Our organization gives extensive halal training to distributors and retailers if and when needed (HT3) 4. Our management team is actively exploring innovative ideas on halal matters (IC1) 5. Our organizations has the capacity to develop new product design to satisfy customers' needs (IC2) 6. Our organization has the capacity to develop halal traceability and tracking systems in order to protect the authenticity of halal food products (IC3)

A seven-point scale: 1 = strongly disagree to 7 = strongly agree

DEVELOPMENT OF A FRAMEWORK FOR BIG DATA ANALYTICS IN COLD CHAIN LOGISTICS

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ABSTRACT

Purpose of this paper
The safety of the products handled in the cold chain (CC) is very sensitive to freshness and can easily cause adverse effects on human health and on prices. Developing countries, such as China, have to deal with diverse problems including lack of temperature standards, deficient infrastructural facilities, out-of-date technologies, and shortage of professionals (Luo et al., 2016). Recent advances in ubiquitous technologies, particularly wireless sensor networks, can help tracking the data in CC for traceability control, food safety and security, risk management issues. Even if technologies are available, there is a lack of understanding of the appropriate data points to be collected, and the appropriate technologies to be used when collecting such data. In addition, it remains unclear how 'big data' can be effectively used for improved decision making.

Design/methodology/approach
The framework is designed based on a systematic literature review on applications of ICT in cold chains. We used the search string ("cold chain" AND food OR (technology OR "ubiquitous technology") OR (RFID OR sensors) OR ("big data" OR "internet of things") using ABI-INFORM database. The review was followed by an exploratory workshop where researchers and industry participants were asked to provide their thoughts on next generation CCs, barriers, possible mechanisms to overcome those barriers and to identify future research opportunities.

Findings
Our review shows that the data that are useful for CCs are covering both the more traditional environmental conditions such as temperature, but also begins to expand more towards capturing product conditions. Even temperature data are mostly not exchanged within the CCs; there is a lack of "SC thinking". The adoption of electronic traceability systems in order to improve the food supply chain has not been as fast as

expected. Moreover, there is limited discussion of how analytics capability may impact overall CC performance in terms of responsiveness, cost efficiency, environment footprint, flexibility etc. The study developed a decision making framework for investing in technology in CCs.

What is original/value of paper
This paper is one of the earliest to recognize the need for a comprehensive framework for adoption and application of 'big data' analytics in CC management. It has value for researchers since it provides directions for future research to demonstrate how seamless decision making using "big data" can help improve overall performance of the CCs. The value for practitioners is in proposing a step-by step decision making framework for developing 'big data' analytics capabilities across the CC.

INTRODUCTION
The safety of the products handled in cold chains is very sensitive to freshness and consequently can easily cause adverse effects on human health and on prices. While about 70 percent of all the food consumed in the USA is handled by cold chains, less than 25 percent of the meat and about 5 percent of the fruits and vegetable consumed in China is handled by cold chains (Rodrigue et al., 2013). It has been estimated that about 30% of perishable products are to become subject of spoilage at some point of supply chain, resulting in substantial financial loses (Virtanen et al., 2014). Developing countries, such as China, have to deal with diverse problems including a lack of temperature standards, deficient infrastructural facilities, out-of-date technologies, and shortage of professionals (Luo et al., 2016). Risks like lack of traceability, transport delays/breakdowns and temperature abuse, cross-contamination in transport and storage even though have been identified to have medium driver and dependence powers (Srivastava et al. 2015), fresh food retail organizations should pay attention to mitigate these risks as they influence multiple other risks and performance measures and get influenced by them. On a global level, real-time monitoring of quality and flow of perishable foods in cold chains remains a challenge. In this connection, recent advances in ubiquitous technologies, particularly wireless sensor networks, can help tracking the data presence in cold supply chains for traceability control, food safety and security, risk management issues. These technologies generate a lot of 'Big data', which refers to high-volume, high-velocity, and high-variety sets of dynamic data that exceed the processing capabilities of traditional data management approaches (Chen and Zhang, 2014). Even if technologies are available to capture such 'big data' in cold chains, there is a lack of understanding of the appropriate data points to be collected across the cold chains network, and the appropriate technology and mechanisms to be used for collecting such data. In addition, it remains unclear how such 'big data' can be effectively used for improved decision making in cold chains, as was evident from the literature review and workshop with academics and practitioners. To address the above gap, the study reviewed literature on cold chain management and associated technology, and developed a decision making framework for investing in technology in cold chains. Lastly, it provides directions for future research to demonstrate how seamless decision making using such data can help improve overall performance of the cold chains.

METHODOLOGY
The framework is designed based on a systematic literature review on applications of ICT in cold chains. We used the search string ("cold chain" AND food OR (technology OR "ubiquitous technology") OR (RFID OR sensors) OR ("big data" OR "internet of things") using ABI-INFORM database. This process resulted in 439 papers, the abstracts which were read and analysed for relevance to this research. We also decided to include papers

which focussed only on food products being handled in cold chains. This shortlisting process resulted in 41 papers. We also searched Google Scholar for "cold chain" and technology and from the first 100 hits, selected 13 papers based on relevance. Out of these 13 papers, 4 were common to those obtained from ABI-INFORM yielding 9 unique papers and overall 50 papers for review.

The journals with highest number of papers in our review are British Food Journal (8 papers), International Journal of Physical Distribution and Logistics Management (3 papers) and International Journal of Production Economics, Industrial Management and Data Systems, Business Process Management Journal, Journal of Food Engineering, Journal of Food Science and Technology, Information Systems Frontiers and Sensor Review (2 papers each) representing 50 percent of the total number of papers reviewed. Out of the papers reviewed, 34 percent are from the discipline of Operations Management, Supply Chain and Logistics Management, 28 percent are from Food Technology and Management, 14 percent are from Information Systems and Technology, 6 percent from Operations Research and remaining 18 percent are from miscellaneous disciplines like Finance, Industrial Marketing etc.

The review was followed by an exploratory workshop where researchers and industry participants were asked to provide their thoughts on next generation cold chains, barriers, possible mechanisms to overcome those barriers and to identify future research opportunities. The workshop started with presentations by the research team and a question "What are the most pressing issues likely to be faced in managing cold supply chains in the next five to ten years?" was posed to the participants. Each workshop participant was asked to write 5 issues –one on each post-it note. All such post-it notes and hence the issues were grouped into clusters. Risk and quality management, technology, sustainability, cost and collaboration were identified as the 5 clusters. The participants aligned themselves according to the 5 clusters and discussed in their group the two questions - "How can the specific cluster issues identified earlier be addressed?" and "What are the likely/potential constraints or barriers?" Each cluster group discussed amongst themselves and then made plenary presentations also identifying some potential research questions. Three research questions identified from the workshop were: "What kind of data should be collected, shared and analysed in cold chains?", "Who will assume the role of coordinator for seamless data and information exchange in collaborative cold chains?" and "How to improve decision-making in cold chain logistics using real time data?"

LITERATURE REVIEW AND WORKSHOP FINDINGS
Data to be captured in cold chains

Real-time data from the field: Tracing these data is relevant in order to monitor the crops growing process or control environmental conditions in greenhouses, to make accurate planning of interventions and strategies by farmers for increased quality and productivity (Pang et al., 2015).

Temperature: Efficient temperature monitoring and the effective management of temperature data is an important prerequisite for providing high quality and safe products and to avoid economic losses across the cold chain (Raab et al., 2011). Temperature data is often combined with time data and as such used to predict shelf-life. Records of environmental conditions could be provided to the customer to achieve sales premium (Pang et al. 2015).

Location: Lütjen et al. (2013) proposed an intelligent container, which can provide necessary information about its location and the quality conditions of its loaded goods.

Light, humidity and other environmental conditions: These data can indicate if the product has been treated under optimal conditions or if there is potential for damage or decrease of quality (Manzini et al. 2014, Abad et al. 2009).

Chemical data: Different gas and bio-sensors can help identifying if certain microbiological growth has emerged. This data can be used to control the quality of the product.

Technology infrastructure for capturing 'big data'

A technology solution can be represented in a way in which it covers one or more of the following three layers: *connectivity*, *middleware* and *application*. Connectivity refers to the devices and protocols for collecting the data and can be based on passive devices such as Radio Frequency Identification Device (RFID), battery-powered devices (Wireless Sensor Networks (WSN) or active RFIDs, or a combination thereof. Middleware refers to the solution for collecting the data offered by the connectivity solution and storing it or processing it in order to represent it in a form that is suitable for the application. The application layer refers to the services and interfaces that offer insights into the collected data and facilitate decisions. In the following, we structure the reviewed papers according to their dominant focus.

Connectivity and middleware. Ubiquitous technologies like RFID along with sensors have been suggested to improve traceability (Kelepouris et al., 2007; Parreño-Marchante et al., 2014) and enable risk management in cold chains (Kim et al., 2016). By applying RFID tags on the cases or pallets of each lot, all chain partners can use the Electronic Product Code (EPC) for identification without any data inconsistency and need of data synchronization. RFID can also help link supply chain partners, thus significantly facilitating forward traceability. One barrier for implementing traceability across the cold chain is that each partner in the supply chain needs to implement traceability internally and then share information with the rest of supply chain partners for forward traceability to be enabled.

There are lots of applications in this area. Abad et al. (2009) developed a RFID smart tag attached to a fish product that is able to integrate light, temperature and humidity sensors. Key aspect of the proposed RFID system is that the data can be read-out at any time of the logistic chain without opening the boxes containing the fish and the tags. Hafliðason et al. (2012) demonstrate application of WSN considering both temperature abuse and the severity of the abuse to develop temperature alerts in cod supply chains. In general, WSN have been used in agri-food sector for environmental monitoring, precision agriculture, cold chain control and traceability (Prasad, 2015). Pang et al. (2015) proposed a procedure to derive sensor portfolios related to shelf-life prediction, precision agriculture, and sales premium (providing consumers with records of handling and environmental conditions). Lütjen et al. (2013) proposed an intelligent container, which can provide necessary information about its location and the quality conditions of its loaded goods. Virtanen et al. (2014) developed passive wireless temperature tag based on UHF RFID technology and a dual port sensing concept. Their solution should increase the accuracy of the sensor readout in environments with interference, reduce the user-created errors and the measurement time, and requires reader units with less strict hardware capabilities. Mohebi and Marqez (2015), based on literature, reviewed and proposed indicators and sensors for meat spoilage and evaluate them according to economic aspects and usability in packaging. One of the technologies, namely, electronic nose, consists of sensor, signal processing and pattern recognition subsystems. The different sensors reviewed were: chemical-, optoelectronic-, colorimetric-, enzyme-,

oxygen sensors. They also identified different indicators such as time-temperature, gas and freshness indicators.

Application: Li et al. (2012) proposed and discussed the architecture of a cloud platform for cold chain logistics. Cloud computing could on the one hand meet the changing requirements of enterprises and on the other hand decrease IT investment. This is also of great interest for small/medium cold chain logistic companies to achieve high-quality IT service with minimal investment (Jede and Teuteberg, 2015). Cloud computing brings better cooperation between cold chain logistics and customers, realizes co-control of product sales information, accelerates the speed of cold chain logistics and maximizes the interests of all parties (Li et al., 2012).

All three layers: Kelepouris et al. (2007) suggested an architecture that simplifies many of the tasks required by the supply chain partners, thus resulting in significant cost reduction and elimination of major barriers. Pang et al. (2015) designed and pilot-tested a value-centric business-technology joint design framework. As part of the framework they propose three-tier information fusion architecture that could be used for shelf-life prediction and real-time supply chain re-planning. Parreño-Marchante et al. (2014) developed a novel traceability system architecture based on web services by integrating traceability data captured through RFID systems with environmental data collected with WSN infrastructure and pilot it in two aquaculture supply chains. Their proposed system consists of four components: (1) RFID Readers, sensors and Data Input devices, (2) set of capture and query applications that act as a connector to the traceability repository of the physical data received from the hardware devices, (3) traceability repository used to store the relevant traceability data generated during the company operations, (4) set of web services which provide the product information to the customer through a web browser or a mobile application. The above system demonstrates that several technologies can be integrated and different industry standards can be used to improve traceability in fish farm industries. More recently, Luo et al. (2016) proposed an intelligent tracking system consisting of sensing layer, network layer, and application layer. The sensing layer collects real-time data about temperature and humidity status and physical position of goods in cold storages and during refrigerated transport. When data are transmitted to remote monitoring centres via mobile telecommunication networks, servers located in remote monitoring centres process it first and display the real-time status of goods on liquid crystal displays (LCDs). Personnel in remote monitoring centres can easily track the status of goods on LCDs and if the status of goods is not as per requirements, alerts can be generated by applications installed in servers so that remote monitoring centres can notify on-site personnel to take actions immediately (Luo et al., 2016).

Using the 'big data' for improved decision-making in cold chain

Raab et al. (2011) provided a comprehensive review of temperature monitoring in meat supply chains and suggested that temperature monitoring will help in development of food models for predicting food quality and remaining shelf life based on microbiological growth. The rapid calculation of the remaining shelf life and risk assessment based on the temperature history allows the optimization of storage management from the First-In-First-Out (FIFO) concept to the Least-Shelf life-First-Out (LSFO) concept (Koutsoumanis and Taoukis, 2005). Kim et al. (2016) suggested an intelligent risk management framework which can accommodate various types of risk situations by introducing the notion of context-aware real-time risk management using RFID tags and sensors by defining rules for risk management functions, context identification, risk detection, and response action judgment in semantic ontologies. Lütjen et al. (2013)

recommended quality driven customer order decoupling Point which ensures a quality-driven distribution of perishable goods. Thus, in cases of changes in the product quality, a new allocation of goods to customer orders can take place.

Collection of temperature data along a cold chain from the source (e.g. farm) to the final destination (e.g. store) will also help in estimating the rate of decay of the product using suitable decay functions as suggested by Blackburn and Scudder (2009) and Nakandala et al. (2016). Analyzing such data over longer periods will help in estimating the cost of product devalued due to temperature variations along the cold chain. Such estimation will be needed to create the business case for not only temperature monitoring but also pointing out the value of improved decision-making using the data. For example the analysis of temperature data and estimation of product devaluation can help in redesigning the cold chain network by separating the responsive and efficient part of the cold chain which will help in ensuring product quality at the minimum cost (Blackburn and Scudder, 2009) as well as deciding the optimal route, the speed of the transportation and optimal temperature to be maintained to ensure high product quality at the lowest cost (Nakandala et al., 2016).

Conclusion from review and workshop

Our review shows that the useful data for cold supply chains not only are covering the more traditional environmental conditions such as temperature, but also begin to expand more towards capturing product conditions. Collaboration among supply chain members in terms of monitoring and control is often missing (Raab et al., 2011). Even temperature data are mostly not exchanged within the cold chains. There is also a lack of "supply chain thinking". White and Cheong (2012) learnt from their communications with senior food industry executives that it is common that food temperature is recorded but not transmitted in transit and that these data are used at the destination to determine whether or not the freight is accepted or rejected.

Similarly, the adoption of electronic traceability systems in order to improve the food supply chain has not been as fast as expected (Parreño-Marchante et al., 2014). Development of systems for monitoring temperature and ensuring traceability across the supply chain will be needed before data captured through such systems can be monitored and analysed on a real time basis for improved decision-making in the cold chain. There is limited literature on how data captured can be effectively used for decision-making. Moreover, there is limited discussion of how analytics capability may impact overall cold chain performance in terms of responsiveness, cost efficiency, environment footprint, flexibility etc.

The workshop participants also identified that there is a need to understand what data to collect, share and analyze in cold chains for later decision-making stages, especially if collaboration is needed. Based on the above findings this paper develops an integrative framework for investing in technology in cold chains, outlines the data which need to be collected and analyzed by each entity in the chain and how seamless decision-making using such data can help improve overall performance of the cold chains.

Development of framework for big data analytics in cold chain logistics

We propose a step-by step decision making framework for developing 'big data' analytics capabilities across the cold chain. It is illustrated in Figure 1.
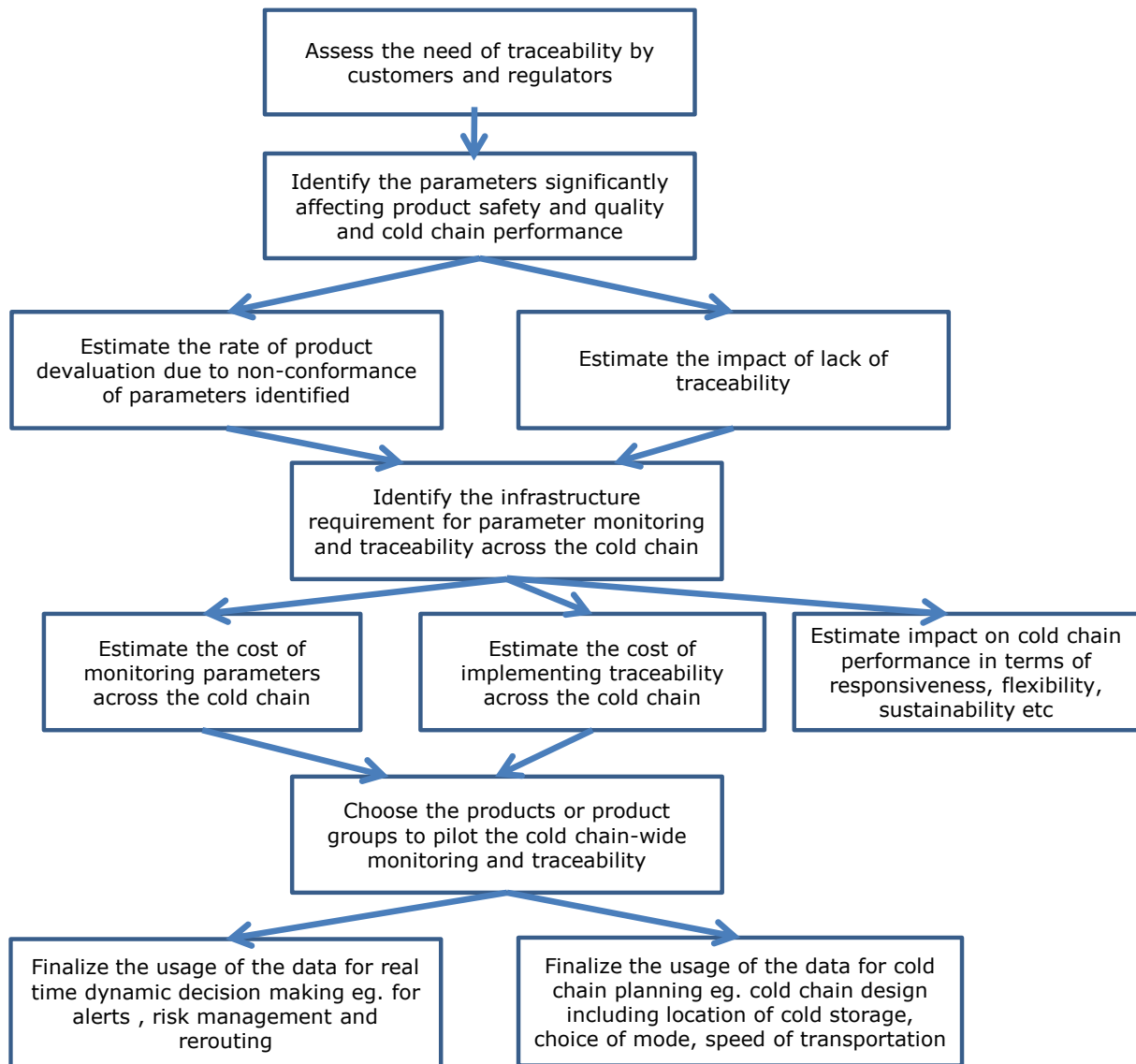
Figure 1: Framework for 'big data' development and implementation in CC logistics

It requires identification of the customer and regulatory requirements for traceability as well as product-specific relevant parameters affecting safety and quality (e.g. temperature, humidity etc.) and other parameters affecting cold chain performance (e.g. speed of transportation, CO_2 emission, and so on). This will be followed by estimating the rate of product devaluation due to non-conformance of parameters and estimating the impact of a lack of traceability across the chain. In the next step, it will be necessary to identify the infrastructure requirement for parameter monitoring and traceability across the cod chain. This will be followed by estimating the cost of monitoring parameters and ensuring traceability across the cold chain and the potential impact on cold chain performance. Based on the above cost-benefit analysis it may be decided for which product categories the parameter monitoring and traceability may be piloted or prioritized. Finally, the usage of the captured 'big data' for both real time dynamic operational decision making i.e. for generating alerts, rerouting and risk management as well as for strategic and tactical planning i.e. cold chain redesign, location of cold storages, and so on, can be finalized.

Players in the cold chain will be motivated to capture 'big data' and use those for improved decision-making if the potential benefits in terms of overall cold chain

performance can be established. Despite the initial investments, we believe the improved decision making using 'big data' will result in long term cost efficiency, improve overall flexibility to handle multiple types of products, reroute products to ensure quality and ensure development of optimal routes and optimal speed which can also improve overall environmental footprint of the cold chain.

CONCLUSION
This paper is one of the earliest to recognize the need for a comprehensive framework for adoption and application of 'big data' analytics in cold chain management and provides directions for future research. This research is based on a systematic literature review and insights from academic and industry participants gathered through a focus workshop. A thorough understanding of the challenges faced by players in cold chain both regarding decision making and adoption of technology will be needed to refine and validate the proposed framework. The proposed framework can be beneficial for multiple players involved in the cold chain like food processing companies, logistics service providers, ports and wholesalers and retailers to understand how 'big data' can be effectively used for better decision making in cold chain. To ensure adoption of 'big data' analytics across the cold chain, it is also important to identify the player in the cold chain which will drive and coordinate the effort. Future research should also focus on identifying that player in the cold chain and possibly explore contracting mechanisms to ensure compliance across the cold chain.

Sharma and Pai (2015) suggested using temperature monitoring systems, traceability, infrastructure, electronics and information technology, standardization, ability of handlers, quality of communication, transaction costs and government policies to measure the effectiveness of cold chain. There are opportunities to thoroughly assess the impact of 'big data' analytics on the cold chain performance measures. Future research should both empirically validate those as well as demonstrate the true benefits using modelling or simulations of specific cold chains.

Finally, the information about the efficiency, the quality, traceability, the environmental sustainability of manufacturing, consolidation and distribution processes should play a crucial role in influencing the purchasing habits and prices of perishable food products (Manzini et al., 2014). Future research may also be directed to estimate the value of 'big data' analytics in cold chains on consumer perceptions and buying behavior if such information and particularly traceability is shared with consumers.

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DEVELOPING A COMPETITIVE COLD CHAIN IN EMERGING MARKETS: INSIGHTS FROM CASES IN CHINA

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Abstract
Purpose of this paper:
This paper aims to summarize practices conducted by Chinese logistics service providers for developing a sustainable cold chain. The economic, social and environmental outcomes of these practices are examined. By depicting key features of tasks and the institutional environment in which a cold chain is embedded, both internal and external inhibitors, which significantly hinder the development of a sustainable cold chain, are identified. Finally, some insights are generated and some suggestions are proposed.

Design/methodology/approach:
Five cold chain logistics service providers in China from different industries are selected as cases. These firms deal with the business of perishable food, beverages, tobaccos, pharmaceuticals and reagents, which nearly cover all representative products in cold chains. A literature review is conducted for elaborating the framework of semi-structured interviews. For the principal of triangulation, key informants from different levels in each firm are recruited, and some other sources of materials, such as archive and on-site observations, are also complemented. Then we code these materials for further analysis.

Findings:
Our preliminary study confirms that the cold chain has its uniqueness as a special logistics service. Since cold chain logistics is still in its very early development stage in emerging markets, practices are influenced significantly by legal and industrial institutions. To achieve a sustainable cold chain, more efforts are required from both the government and firms.

Value:
This paper is among the earliest studies attempting to describe and categorize cold chain practices. It also reveals the economic, social and environmental outcomes from different practices. A deeper understanding of the cold chain environment and its inhibitors extends the knowledge landscape of this research area. In addition, all these contributions pave the way for further cold chain empirical studies.

Practical implications:
Decision makers can leverage the results of this research as a tool kit or guidelines for improving their own practices and developing a more tailored sustainable cold chain strategy.

INTRODUCTION

A "cold chain" is a supply chain with perishable products, which must be stored and transported on particular range of temperature and humidity conditions (Bishara, 2006; Bogataj, 2005).   These perishable products are enormous, ranging from food, beverages to pharmaceuticals and medical devices.   It is the cold chain that determines the freshness of products directly, which has a great impact on customers' choice and human health (Olafsdottir et al., 2010).

However, most of the existing literature focus on food cold chain, and leave other kind of important cold chains less developed.   The landscape of this knowledge area is fragmented and in silos, which intends to deal with technical details, such as RFID implementation, and isolate problems mitigated by mathematical models (Abad et al., 2009; Goyal & Giri, 2001). There seems no study trying to depict a clear and systematic picture of cold chains and the environments they embedded in.   This gap makes the novices harder to get started their researches and blocks the communication of researchers in different sub-topics.   The lag between industrial demands and academic response disappoints these practical pioneers.

To fill this gap and pave the way for further empirical researches, we take a snapshot of cold chains in emerging markets with four cases selected in China.   Based on this multi-cases analysis methodology, we summarize the innovative practices conducted by Chinese logistic service providers for developing a competitive cold chain, the problems and inhibitors they are facing, the risks they identified, and key features of environments they embedded in.

LITERATURE REVIEW

The research of cold chain management appears in its infancy, and there is an increase in attentions from the academia during recent decades.   However, these existing literature focus on industries in an imbalanced way.   As mentioned above, most of the works conducted on agri-fresh products, especially on food cold chain (Shukla & Jharkharia, 2013). Many papers are published on the journals such as *Food Control*, belonging to other disciplines (Likar & Jevšnik, 2006).   Moreover, these overlooked industries such as pharmaceuticals and medical devices are quite different comparing to food.   They are more closely related to human health (Thakker & Woods, 1992).   The knowledge generated from a food context leads to queries on its external validity to other settings.   This imbalance of research concerns calls for a more comprehensive view to depict cold chain.

In the existing cold chain literature, majority is to deal with waste reduction in cold chain operations and improve efficiency (e.g. Raafat 1991; Goyal & Giri 2001; Widodo et al., 2005). The methodology adopted often followed an operations research tradition, including mathematic models, computer simulations, econometric forecasting, etc.

Few but growing literatures seek for more managerial insights to improve cold chains management. For example, Kaipia, Dukovska-Popovska and Loikkanen (2013) conducted a multi-cases analysis to discuss how information sharing can facilitating sustainable performance and waste reduction.   Fearne and Hughes (1999) identified success factors in the fresh produce supply chain in the UK.   Joshi, Banwet and Shankar (2009) summarized

inhibitors of Indian cold chain in milk, fruits and vegetables industries. Joshi, Banwet and Shankar (2011) employed a Delphi method to identify key performance factors of cold chains in India. Although these papers have enhanced conceptual knowledge on cold chains management, our paper extends this stream by investigating interactions between cold chains and the institutional environment through case study to establish the understanding of cold chains management in the emerging market—China.

In brief, the imbalanced focusing on particular industries, the fragmented nature of the knowledge landscape, the quantitative methodology tradition, and the unaware of interaction between cold chain and environment, all of these are calling for a more comprehensive way to understand cold chains. Figure 1 shows the research framework. In this paper, by establishing a multi-cases analysis, we summarize innovative practices conducted by logistics service providers in emerging market for developing competitive cold chains, and their competitive outcomes. We also delineate the task and institutional environment in which a cold chain embedded (Scott, 2003), and identify internal or external inhibitors. Finally, some insights are generated and some suggestions are proposed.
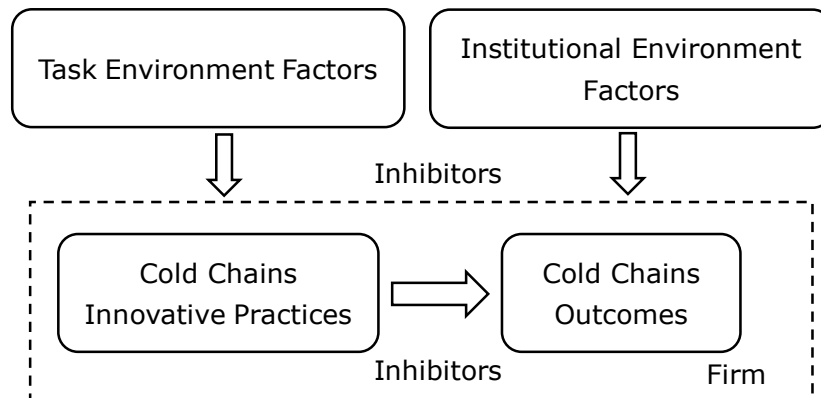
Figure 1: Research framework

METHODOLOGY

Case study is a kind of empirical study, and serves for both exploratory and confirmatory purposes (Yin, 2013). It is also a great tool to recognize latent patterns of the research objects through plentiful materials (Yin, 2013). One other key advantage is that it generate insights on real-life context, and do not have to isolate some variables from its environment (Babbie, 2007). It is crucial when the research objects have many interactions with the context or each other, and research questions cannot be simplified with relationships between several constructs. In addition, considering the number of cases should be selected, Eisenhardt and Graebner (2007) suggested that multi-cases typically can yields more robust and generalizable theories than a single-case research.

The purpose of this paper is an exploratory one, which cannot be fulfilled by other quantitative methods. The practices and other factors we concerned, are related with among others in a complex manner. To depict these interactions, case study is an appropriate tool for record the details. Limited to the resources and time, we cannot

investigated all the stakeholders over the cold chain. So we chose cold chain logistics service providers as entry points, since they have the best connections with other stakeholders, and they are always considered as the biggest risk source over the whole chain (Kim, Kim, Kim, & Jung, 2016). Four outstanding firms that are ahead of their industry were selected as cases. They provide cold chain inventory service for perishable food, beverages, pharmaceuticals and medicals, which almost cover all representative products in cold chains. This selection also conforms to the theoretical sampling principle (Eisenhardt, 1989). Table 1 shows the background of selected firms.

Table 1: Background of selected firms

Firm	Logistics Service for	Description
H	Pharmaceuticals	Largest provider with more than one third sales within the provincial market
Y	Reagents for in-vitro diagnosis (Medical device)	One of the first companies to get the certifications, a leading company in local market
N	Fruits, vegetables, meat and aquatic products	Largest port logistics service provider in local market
Z	aquatic products	Largest logistics service provider in local market

Two different versions of questionnaire were developed. One short version had been sent to the informants for preview, whereas the other more detailed version supported interviewers during interviews. Questionnaires were organized into six sections, including the basic information, operating environments, cold chain practices, outcomes, risk managements and inhibitors. Pilot interviews were also performed for generating the final versions. One interview was taken for each firm with the general manager, vice-general manager dealing with cold chain business, and other executives, and lasted for two hours. After these semi-structured interviews, some documents and archives were provided for further analysis.

KEY FINDINGS
In this section, we presents some interesting findings based on the cases, then summarizes details according to the research framework.

Cold chains with pharmaceuticals and medical devices
Both pharmaceuticals and medical devices market are immersed in a system of detailed regulations. The enforceability of these regulations is conducted by different government agencies. For example, the distribution of these products is supervised by the China Food and Drugs Administration (CFDA), the operation of medical institutions is supervised by the Health and Family Planning Commission (HFPC), and the development of logistics is guided by the Development and Reform Commission (DRC). Safety is the first priority. The strong voice from government leads to weak industrial associations. Medical institutions, especially public hospitals, are the receiver. In China, they control the distribution channels and usually supported by government. This endows them a great market power on upstream companies. For promoting their long-term orientation and trust, both H and

Y provide free detecting devices and internal logistics service to hospitals. Firm H even customized temperature detected systems to some big hospitals and afford reverse logistics.

Hospitals are not clients of the logistics provider, while upstream companies who delegate them are. Figure 2 shows a general conceptual structure of cold chains in both industries. Both H and Y are wholly-owned by other companies and get more than 90% business from their parent company. Even through operating independently, any flaws of the products will impair the reputation of parent company, and then decrease the willing of cooperation from hospitals and other producers or agents for popular products.
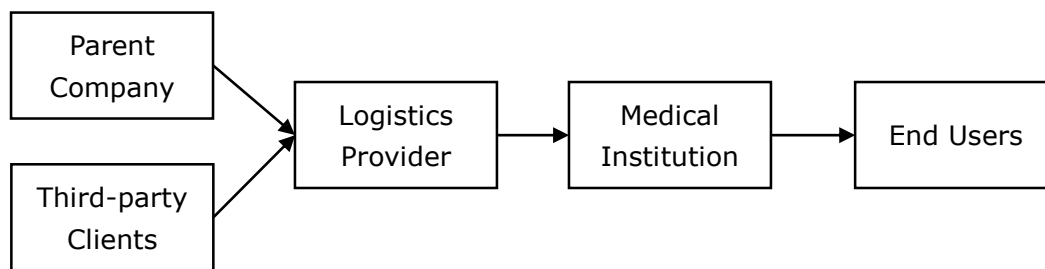

Figure 2: Cold chain with pharmaceuticals and medical devices

For themselves, regulations, such as *Good Supply Practice* (GSP) and its supplementary terms, provide instructions for nearly every operational detail for stakeholders and their facilities. Both of them invest a lot on this. If the medical institutions comply with regulations strictly, these assets will turn to valuable resources and generate competitive advantages for them.

Cold chains in port logistics

Even though not as detailed as medical industry, the regulation system in food and beverage industry is also covered in every phase of distribution. The port logistics may be one of the most important phases due to that it involves not only refrigerated storage and transportation, but also the customs and quality inspection by different government agencies. In a traditional situation, the refrigerated containers need to be open at least twice in the harbor by different workers, and usually cannot guarantee sufficient electricity supplement when waiting for leave. This results into a cold chain disruption and a huge rate a waste. Moreover, the port is a hub for import and export trade, which makes it an ideal starting point for facilitating value-added traceability service.

Firm N is a port logistics service provider. Recognizing the gaps and unique advantage, firm N stretched its traditional business as a port refrigerated logistics center to other fields. First, it brought the Administration of Customs (AC) and Bureau of Quality and Technical Supervision (BQTS) together to establish an inspection center. The cargoes are stored in its refrigeration houses or just charged in its original refrigerated container according to regulations. All the inspections and laboratory tests can be done in the same park with the doors one time open in a cold buffer zone. This reengineering of traditional processes provide a one-stop service for international food and beverage trade. Second, depending

on these business and tax subsidy policy offered by local government, firm N established a transaction center for cold chain products. When it gets prosper, they believe, the transaction center will re-facilitate its logistics service business. Third, firm N also collaborated with other stakeholders and participated in a traceability platform. By paying for this service, its clients can trace key point information during the whole processes of customs clearance and quality inspection. Besides, if the products finish all the processes successfully, a security code tag with its abroad and entry information is added on. This information endorsed by the government and can be retrieved online.

Cold chains with aquatic products

Firm Z are transferring itself from an aquatic products logistics service provider into a supply chain service provider. It split its assets into light and heavy category, then established new subsidiaries to undertake both business respectively. As a traditional logistics service provider, firm Z offers refrigerated inventory and transportation service among marine-fishing enterprises, factories and downstream distributors. As a supply chain service provider, it tries to offer other value-added services based on their knowledge and accumulated networks in aquatic products cold chain. First, to mitigate the seasonal financial stress of upstream companies, firm Z collaborates with local banks and offers loans to its clients as long as there are products preserved in its warehouse as collaterals. They are the experts for aquatic products distribution so that it is easy to realize these collaterals if necessary. Firm Z also tries to cooperate with other famous supply chain companies and qualifies the bills of lading they offered as collaterals. Second, firm Z invests on local stores or other existing channels to enhance its control of the downstream distribution. They provide reliable channels for these high value-added products and some other daily community services for end consumers. Third, firm Z developed new tools for value-added service by their own or cooperating with other research institutions. For example, they invented a new metal tray to replace the old wooden one in the refrigeration house. This metal tray is more durable and can keep a better appearance for some aquatic products, which is helpful to maintain a higher price.

After a brief description of these four cases, we summarize the detailed results in Table2. Referring to innovative practices, Damanpour (1991) suggested that innovation can be a new product or service, a new production process, or a new structure or administrative system.   In the cases studied, we noted innovation plays significant role in the competitive cold chains management. For instance, a reengineering of customs and quality inspection process offers a new valuable service for customers (Firm N); a new process like collaborating with downstream partners leads to new subsidiaries established (Firm Z). Moreover, there are also other innovative practices such as inventing new facilities, which are management structure related innovation.   Therefore, we separate cold chains innovative practices into two categories: performance-driven innovation and business model innovation.   Performance-driven innovation are practices that improve efficiency or cost reduction on its original business (exploitation), while business model innovation creates new value-propositions, and constructs a new system to fulfill them (exploration). Detailed are showed in Table 2.

DISCUSSTION

Based on the results summarized above, some general insights are generated in this section. A few propositions are also presented.

Innovation is a key factor in cold chains practices. The existing literature in cold chains focus less on innovation than it deserves. Fearne and Hughes (1999) identified innovation as key drivers of fresh product supply chains in developed countries. Meanwhile, Joshi, Banwet, Shankar and Gandhi (2012) treat new launch of technology and service as key attributes contributing to cold chain performance in India. However, they both fail to recognize the profound effects of innovation in emerging market and reveal the details of the way they generate competitive advantages. Nearly all the informants we interviewed emphasized on the importance of innovation, and different firms act it in different manner. For cold chains firms in emerging market, investing on new technologies may not be their first priority, since the capital intense nature of innovation and high risks. On the contrary, it's quite easy for them to adopt existing technologies for catching up in a reasonable cost. The key point may be how to employ technologies to establish a new business model and supply new value-added services.

Proposition 1: Innovation is the first driver for developing competitive colds chains in emerging markets.

Proposition 2: Establishing new business models and constructing new value-added services are appropriate strategies for innovation in emerging markets.

Cold chains are always under the influence of regulations. In different industries, regulations and its enforceability may play different roles on the adoption of innovation strategies. For example, in pharmaceuticals cold chains, a bunch of detailed and widely covering regulations limits firms' imagination on processes reengineering and business model innovation, so that firms may focus more on facilities improvement (e.g. new tools or software) While in a less detailed regulation system, firm will choose business model innovation strategy (e.g. creating new value propositions with new processes or structure system), since once established the new model may serve as a more inimitable and nonsubstitutable resource (Barney, Wright, & Ketchen, 2001).

The bridging to the institutional environment also serves as a valuable resource (Scott, 2003). All the four firms participate in associations with a governmental background.

Table 2: Summary of the cases

Firm	H	Y	N	Z
Task Environment	Over 300 competitors Long-term cooperation with little demand fluctuation	Over 4000 competitors High value-added industry with high profits; developing rapidly	High rate of waste Supported by shareholders (an influential state-owned firm and a private logistics service provider)	High variation of the total fishing production Long-term cooperation with transportation providers
	Powerful customers Trust and reputation is important Well-established traceability		Lack of product standardization on upstream Variety of the cargoes Low pressure on competition	
Institutional Environment	Strong regulations with different government agencies Extremely sensitive on safety Lack of industrial collaboration		Regulations with different government agencies Increasing demand for safety; Various industrial associations with different government agencies' support	
Inhibitors /Problems	Supply of particular facilities	Lack of involvement in policy making and government support	Hard to trace Intense investments with slow return on asset Lack of government support (institutional barriers, subsidy)	
	Fragmentations with government agencies control; Policy enforceability			
Performance driven innovation	Facilities with sensors; Handheld PDA; Customized WMS &TMS	Inventing new facilities; Customized order online system	Solar roof; Efficient facility layout;	Inventing new facilities with other research institution;
Business model innovation	Downstream development for free	Additional downstream service for free	Combining custom and quality inspection; Offering traceability service; Building a port market	Developing financial business based on cold chain; Splitting asset light and heavy; Building new subsidiaries for new business
			Outsourcing the transportation; Investing on or collaborating with downstream channels	
Outcomes	Cost reduction; Profit; Social responsibility;	Service level; Cost reduction	Profit; Transaction volume; Social responsibility	Profit; Community service

These associations are platforms for the conversation between firms and the government. Maintaining a constructive relationship with government is the basis for building a new business model, such as firm N, since this offered an opportunity to overcoming the fragmented institutional barriers. This effects may be more obvious in an emerging market.

Proposition 3: The extent of regulations' coverage influence the adoption of firm's cold chains innovation strategy in emerging markets. This effects may be moderated by the regulations' enforceability.

Proposition 4: A constructive relationship with government is a kind of resource, and may lead to business model innovation.

Recalling for the relationship between cold chain practices and the triple-bottom-line outcomes (i.e. economic, social and environmental outcomes), we find that economic outcomes are the first consideration for all four firms. Even though there are practices leading to social and environmental outcomes, such as boosting local employment and paving a solar roof, the core logic is always sales, profit and cost reduction.   In an emerging market with plenty of competitors, survival is the top issue. Besides, firms also adopt other practices raising their costs for calculating a good reputation or responding to requirements from government and customers.

Proposition 5: Institutional pressures from competitors, market and regulations greatly influence the adoption of cold chains sustainability practices.

CONDLUSION

This research is one of the very first works depicting a systematic picture of cold chains in emerging markets. As an exploratory study, some interesting features of cold chain innovative practices, outcomes, the environments and inhibitors are presented. Based on the multi-cases analysis and literature reviews, 5 propositions are summarized. We find that innovation is the key driver for developing competitive cold chain in emerging markets, and both innovation adoption and cold chain practices adoption are influenced by institutional factors.

The limitations of this study offer opportunities for future research. First, even though we covered most of the representative products in cold chains, the external validity can still be improved for involve more cases in, especially cases from other emerging market settings. Second, the development of cold chain is on its starting phase in emerging market such as China. Most of the firms are established just for a few years. Longitude studies may be helpful to draw more solid conclusions. Finally, the propositions proposed in this paper need further empirical support.

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References available from corresponding author (jing.dai@nottingham.edu.cn) on request.

COLD SUPPLY CHAIN EXPENSIVE OR MISCONCEPTION: CASE STUDY AND FUTURE RESEARCH DIRECTIONS

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Abstract

Purpose: Effective monitoring and control of cold supply chain is essential to preserve the quality of temperature sensitive products but often not widely practiced due to huge costs involved in transporting, storing and handling perishable products at various stages of the supply chain. Previous studies have shown that inappropriate practices in the management of cold supply chains contribute adversely to the environment, carbon footprint as well as food waste. Given that there is a considerable waste of perishable products due to factors like non-availability of proper storage, transport and handling facilities, this raises an open question why the management of cold supply chain is so expensive or is it simply a misconception. This study attempts to understand the cost issues appertaining to cold chain's chemical, biological and technological processes as well as various stages of handling processes such as the preparation, storage, transportation and monitoring of perishable products.

Methodology: We employed a focus group approach coupled with comprehensive literature review to categorise various cost challenges. The focus group included senior researchers and professional with substantial experience in cold and supply chain operations. The focus group started with open questions related to cost from each participant and the responses were categorised into sections such as investments in infrastructure, transport, cost of allocation or sharing resources and quality. Subsequently, the group identified major barriers related to cold chain costs such as preparedness of investors, market scale in terms of efficiency, market acceptance and diversity of perishable products. Based on the summary of discussion the study carried

out detail investigation of past studies to understand critical research gaps related to cost category classification.

Findings: Initial findings of cost issues with respect to each category are requirement of higher initial investment for creation of basic facilities and identification of suitable infrastructure under investment category, high cost of last mile transport, cost of linkages between different transport modes and exploration of arctic routes under transport category; sharing increased cost among supply chain players, measuring real cost of cold chain, balancing cost structure between inventory consolidation and transportation and cost involved in regional distribution. Typical issues related to quality are customer awareness towards cost of chilled/frozen foods, way forward to reduce loss of perishable products with respect to country and industry contexts, monitor and control of quality over time and labour costs.

Value: The study is an attempt to decode the misconception of cost issues related to cold chain based on its science, technology and processes.

Research limitation: The study identifies potential research gaps based on a focused group and comprehensive literature review which needs to be further underpinned with empirical evidence to deal with potential issues according to specific industry and country contexts.

Practical implications: The study would be useful to practitioners to better understand potential options and research pathways relating to cost issues. These could include, how to model perishable products supply chain considering location, allocation and transportation that will increase market share of all stakeholders? How to use big data analysis for market acceptance considering sales characteristics? How to deal diversity of perishable goods more efficiently.

INTRODUCTION
Effective monitoring and control of cold supply chain is essential to preserve the quality of temperature sensitive products but it is not widely used because of huge cost involved to transport, store and handle perishable products at various stages of the supply chain. Previous studies have shown that inappropriate practices in the management of cold supply chains contributes adversely to the environment as well as huge loss of carbon footprint due to food loss and wastage. Given that there is a considerable waste of perishable products due to factors like non-availability of proper storage, transport and handling facilities, this raises an open question why the management of cold supply chain is so expensive or is it simply a misconception. This study attempts to understand the cost issues appertaining to cold chain's chemical, biological and technological processes as well as various stages of handling processes such as preparation, storage, transportation and monitoring of perishable products.

We employed a focus group approach coupled with comprehensive literature review to categorise various cost challenges. The focus group includes senior researchers and professional with substantial experience in cold and supply chain operations. The focus group started with open questions related to cost from each participant and categorised them related to investments in infrastructure, transport, cost of allocation or sharing resources and quality. Subsequently, the group identified major barriers related to cold chain costs such as preparedness of investors, market scale in terms of efficiency, market acceptance and diversity of perishable products. Based on the summary of

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The study is an attempt to decode the misconception of cost issues related to cold chain based on its science, technology and processes. Using case study this paper explains how vital the cold chain for food products produced and sold in China compared to wastage. The study identifies potential research gaps based on a focused group and comprehensive literature review which needs to be further underpinned with large empirical evidence to deal with potential issues according to specific industry and country contexts. The study would be useful to practitioners to better understand potential options and research pathways relating to cost issues. These could include, how to model perishable products supply chain considering location, allocation and transportation that will increase market share of all stakeholders? How to use big data analysis for market acceptance considering sales characteristics? How to deal diversity of perishable goods more efficiently.

LITERATURE REVIEW
This section summarises the issues through comprehensive review of literature as per the chemical, biological and technological processes as well as various stages of handling processes such as preparation, storage, transportation and monitoring of perishable products.

Chemical aspects: Degree of deterioration varies between different products based on sensitivity of product to time and temperature. Replenishment cycle is inversely related to temperature i.e. higher temperature will lead to small cycle time (Zanoni, and Zavanella, 2012). Different holding temperature requirement imposes restriction on clubbing cold items together for shipment and storage (Bozorgi, 2016). Controlled Atmosphere (CA) and Modified Atmosphere (MA) are complementary technologies for cold storage comprising of refrigeration. CA is used in static cold stores for long shelf life products like apples and pears by reducing oxygen levels and increasing carbon dioxide levels. MA is utilized in form of packaging material using respiration rate of products (Dodd and Bouwer, 2014).

Biological aspects: Nutrients characteristics of food and meat products starts to deplete instantly after harvest or butchery (Zanoni and Zavanella, 2012). Food contamination depends on external factors (humidity, temperature) and internal factors (microbial contamination and composition) along with time duration of exposure to these conditions (Thakur and Forås, 2015).

Technological Aspect: There is a strong need for development of real-time environment monitoring technologies for maintaining safety and quality of perishable food products. Transportation and storage conditions such as state of motion of transporting vehicle, vibrations, unexpected fall, loading, unloading and power management in non-joined status are significant factors affecting value added attributes of food products (Wang et al., 2015).

Preparation aspects: Producing large variety of products from a few input recipes, poses problems in terms of cleaning, sterilizing and re-tuning issues for pipes and mixing units with respect to cold chain logistic. Thus, set-up and changeover times based on sequence impacts the production and increases costs. Production planning and scheduling aspect for a perishable supply chain is necessary to keep a track of the age of inventories and/or products (Sel, et al. 2015).

Storage aspects: Cold supply chains requires storage and transportation of associated products in vicinity or below the freezing point putting emphasis on setting of refrigerated warehouse and trucks to fulfill the needs of customer. Warehouse capacity is dependent on throughput (or demand requirement) and actual stock keeping capacity for conventional supply chain. Operating cost for cold storage increases drastically with addition of refrigeration system resulting in warehouse capacity driven by demand pattern, inventory policy and customer service requirements along with actual physical capacity (Saif et al., 2016).

Handling aspects: Temperature control and monitoring of cold chain products are considered as important factors for cold chain since drastic temperature losses could result in deterioration of food safety and loss in consumer confidence. It is challenging to preserve temperature at all stages of cold chain distribution particularly during loading, unloading, transportation and display cabinet (Hsiao and Huang, 2016).

Transportation aspects: Identification of "family of products" for capacity sharing with respect to transportation units and amount of inventory allocated for each product within the family (Bozorgi, 2016). The managerial insights drawn from study inferred that multi-product sharing model is more valuable when transportation capacity is higher as compared to storage capacity. Clustering of cold items such as dairy products (milk, chocolate milk, etc.) can be facilitated by enabling sharing of storage and transportation capacity in fulfilling the demand requirement.

COLD CHAIN ECONOMIC CHALLENGES
Infrastructure: Producers have variable cost depending upon batch size influencing cooling and treatment whereas fixed costs depends on set-up costs for cooling and treatment units (Zanoni and Zavanella, 2012). However, a study listed few cost-based indicators for port evaluation and they are asset-liability ratio, receivable accounts while benefit-based indicators comprises of port throughput, container throughput, ROE (Return on Equity), Net profit, current ratio, earnings, earnings per share and net assets per share (Jiang and Li, 2015).

Scheduling and Allocation: Coelho and Laporte (2014) emphasized on importance of inventory control for products with limited shelf life. Inventory holding cost is dependent on age and value of product for short shelf life products. Consumer perception based on age of products affects the price of product and hence revenue. The choice between Fresh First (FF) and Old First (OF) selling priority for perishable product depends upon trade-off between inventory and revenue of the product i.e. Optimized Priority (OP) which doesn't impose constraint on age of product. Inventory holding cost will depend upon inventory depreciation cost driven by value and cost of product based on its state (Shen, et al., 2011).

Coordination: Consumer behavior and lack of coordination between supply chain actors have been cited as primary reason for food loss in medium and high income countries (Thakur and Forås, 2015). Muriana (2016) identified the need for evaluating remaining Shelf Life (SL) of "open-dating" or packaged perishable products at retailers with cycle time. The products with SL remaining event after end of cycle time are likely to be disposed-off or sold at discounted price to markets with less stringent quality norms. Hence, there is a need to overcome such discarding costs and effective warehouse decision making by ensuring monitoring of SL during cycle time.

Transportation: Large retailers are transported in separate trucks for chilled, frozen and ambient products while small retailers are transported as combined loads to improve truck utilization and consequently transportation cost (Aung and Chang, 2014). 19% of energy for refrigerated containers is used for refrigeration during its transportation (Fitzgerald et al., 2011). Nguyen et al. (2014) consolidated multiple shipments from various agricultural suppliers to a single destination for delivery of perishable products. The result revealed that consolidation is beneficial when suppliers have low demand leading to full utilization by consolidating smaller shipments.

CASE STUDY
To understand in detail the economic challenges at micro level we selected a large wholesale market namely Zhebei Agricultural Products Wholesale Market in China as a sample of our study. The choice of this market is to understand the cost issues because it has a cold storage facility, it is relatively modern in terms of facilities and has huge sales. We gathered preliminary information through observations and interview with administrators by one of the authors to understand the details of the cost issues involved in managing the market and shipping the fresh food products. The information gathered revealed that the market is using different cost standards of refrigeration services and they are 1000 RMB/m^2 and 5000 RMB/m^2. The price varies depending on the insulation board, temperature indicators, control devices and the type of refrigerant (Freon). In addition high investment cost leads to lower energy consumption with protection of environment and better temperature control.

On supply side we observed issues related to farmers, storage and shipping of food products. For example carrot farmers in Fujian province have to deal with asymmetric information, carrots cannot be sold immediately, buyers have strong bargain power against farmers and presently a few farmers are capable to establish their own cold storages to avoid falling prey to buyers. In addition few farmers expressed they need awareness of pre-cold procedure which is important to prepare perishable products before shipping as well as there is a strong need of cold storages nearer to the production spot. Moreover the life cycle of perishable products needs to be taken care

and need to be shipped before the start of maturity of the product to suit the long distance travel. From the human point of view lack of supervision and drivers are so cautious to save fuel by switching of the engine during long stop without thinking about the shipment of perishable products.

Through interaction with several administrators we gathered further information about Chinese food supply chain. It is interesting to note that 30% of cold storage facilities are available in Shanghai compared to overall 10% in China. Shanghai facilities have huge capacities such as 13,000 tonnes to 15, 000 tonnes. In terms of seafood China farms and exports 70% and interestingly 80% of production places didn't have cold storage facilities. In particular scallops farmed in one coastal area, Dalian is having higher quality and could be saleable at higher cost compared to rest of China and it depends on temperature and oxygen level. This good quality scallops need to be shipped to Hong Kong in 52 hours to keep it fresh. However meat category requires different storage temperature and they are fresh meat requires ordinary temperature, cold fresh meet needs 0 to 4 degree centigrade and frozen meet needs -18 degree centigrade. Out of the three cold storage meat needs higher preservation cost and its market share is less than 15%.

To understand the cold chain cost issues at micro level we use sample as leaf vegetables including Chinese cabbage, celery, spinach, etc. as product for our analysis. These leaf vegetables occupy 70% in 1350 tons (i.e. 945 tons). In terms of vegetables and fruits 4~5% of fruits becomes waste in wholesale process where as 8~10% of vegetables becomes waste in wholesale process. In case of transportation 20%~25% of vegetables and 15%~20% to fruits becomes waste. The cold storage temperature level of the facility ranges from +5℃~-5℃ and permissible tolerance for drop down temperatures for both products are 1~2% as shown in table 1.

Table 1: Vegetable and fruits waste

Type of agricultural products	Waste rate during wholesale (within cold storage)	Waste rate during maturity & transport
Vegetables	8~10% (1~2%)	20%~25%
Fruits	4~5% (1~2%)	15%~20%

Sample of vegetable supply and waste at the case market is shown in table 2. Approximately 85 tons of leaf vegetables becomes waste in our case.

Table 2: Vegetable supply and waste

Daily vegetable supply	Leaf vegetable (70%)	Leaf vegetable waste (9%)
1350 tons	945 tons	85 tons

At the time of information gathering we found cabbage's current wholesale price as 0.7RMB/KG and the cost of small cold storage's with the capacity of 15 square meters including 6 tons is 27,000RMB. The cost comparison is shown in table 3.

Table 3: Cost of storage and waste comparison

waste value (700 RMB/t)	small cold storage rent (13 RMB/t)
≈60,000 RMB	≈1,100 RMB

Table 3 shows significant difference in cost saving if there is a cold storage facility. The comparison didn't include scrap value of the perishable vegetables, the labor and other cost such as inability of sufficient volume small wholesalers to rent a cold storage.

CONCLUDING REMARKS AND FUTURE RESEARCH DIRECTIONS
We attempted to unravel the myths of costs issues related to cold chain with respect to food products and its wastage. This study employed mixed methodology consisting of comprehensive literature review, focus group and case analysis. The study using a single case explains cold chain cost is relatively cheaper that wastage. In addition detailed study is essential to validate the cost involved in chemical, biological and technological aspects. Similarly, it is essential to decode the cost issues related to perishable products shipping such as storage, handling, scheduling, allocation, coordination and quality aspects. Based on our preliminary empirical findings we are able to conclude that cold chain cost will be cheaper compared to waste if we consider both process and shipping aspects for all industries. The study is the first of kind to de-myth the misconceptions through empirical findings considering only the last part of supply chain and in future we are planning to extend the study to capture cost aspects starting from farming to delivery of products. Few potential research directions are given below

- What are cost aspects for maintaining temperature when combining perishable products during storage and shipment?
- Is there any relation between costs related to biological processes and the value of the products?
- To what extent cost of real time monitoring using latest technology is related with wastage.
- How to reduce set-up and change over time during preparation stage to reduce overall cost for cold chain?
- How to reduce operations cost considering demand pattern, inventory policy and customer service requirements?
- Influence of deterioration cost during loading, unloading, transport and displays.
- Information sharing cost impact on storage and transportation.

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Section 12: Supply chain performance management

THE IMPACT OF SUPPLY CHAIN STRATEGY ON THE FINANCIAL PERFORMANCE: A CASE STUDY OF A MANUFACTURING COMPANY

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Abstract
Purpose of this paper:
The aim of this paper is to propose a systems view to link supply chain (SC) strategy to a company's financial performance by developing a scenario approach. The paper applies five scenarios under differing financial performance contexts to analyse the relationship between supply chain performance and the overall financial performance.

Design/methodology/approach:
An integrated supply chain performance measurement system was created and implemented to demonstrate and utilise the relationship between SC performance metrics and the financial performance metrics. A scenario analysis approach was undertaken using five main alternative scenarios in order to explore how this procedure could be applied with regard to various possible financial results. A case study of a manufacturing company was conducted and analysed to illustrate the applicability of the research procedure.

Findings:
The results reflected the improvement in the efficiency and the effectiveness of SC strategy in connection with the company's short-term strategic financial objectives. The analysis showed that any improvement in the SC operations' performance will lead to better supply chain management (SCM), and consequently enhance the company's overall financial performance. An improvement in SC performance as well as financial performance has been shown for the three conditions (optimistic, normal and pessimistic) following the proposed procedure.

Value:
A systems view is introduced to integrate SC strategy and the company's overall financial strategy under different possible scenarios based on the systems view problem-solving model. Five main alternative scenarios are defined given the related targeted financial outcomes and their corresponding present paths (managing SC costs, increasing SC agility, improving SC reliability, increasing SC responsiveness and managing SC assets).
The system can be operated in two directions given two possible loops. A company can formulate SC strategy to achieve targeted strategic financial objectives or it can start with an unsatisfactory financial performance and then formulate the corresponding SC strategy to enhance it.

Research limitations/implications:
The research study makes an original contribution in the direction of linking SC strategy to a company's financial strategy through focusing on studying the relationships between SCM practices and financial performance improvements. Further research should investigate and

compare the results from several companies in different sectors of manufacturers in different locations.

Practical implications:
The paper follows a systems view which can help in determining the most appropriate SC strategy with regard to targeted financial objectives. This paper benefits from data extracted from a manufacturing company by evaluating the applicability of the model developed under a different set of scenarios.

1. INTRODUCTION

Supply chain management (SCM) has been documented to be positively associated with enhanced competitiveness and improved company performance (Li et al., 2006). Limited research has been proposed to investigate links between supply chain (SC) performance and improved financial performance (Wagner et al., 2012). This paper aims at studying the relationship between supply chain performance and the overall financial performance. In this essence, the paper further develops from the work considered in Elgazzar et al. (2012b) by proposing a scenario approach linking SC performance to financial performance. This work also demonstrates the practical applicability of the proposed scenarios through conducting a case study of a manufacturing company.

2. LITERATURE REVIEW

Financial performance measures are governed by rules and guidelines which make them a simple and clear source of useful information about financial outcomes and the internal operations shown in the financial statements (Zuriekat et al., 2011). However, relying on traditional financial methods and techniques alone to measure company performance is no longer the norm in large organisations (Basu, 2001).

Although most companies realise the importance of combining financial and non-financial performance measures, they have failed to represent them in a balanced framework (Gunasekaran et al., 2004). Developing an integrated performance measurement system is critical to achieve successful implementation of SCM practices (Cagnazzo et al., 2010). A limited number of studies have been conducted to demonstrate the potential impact of managing SC day-to-day practices on improving a company's financial performance (Gunasekaran et al., 2004; Presutti Jr. and Mawhinney, 2007; Woei, 2008; Kremers, 2010; Wisner, 2011; Wagner et al., 2012). Previous frameworks proposed in this area had a limited impact on enhancing an organisation's performance due to the inability to capture the critical link between SC performance and overall business performance in a way that covers all business dimensions and incorporates different levels of decision making (Camerinelli and Cantu', 2006; Toyli et al., 2008; Prajogo et al., 2016).

This consequently leads to the need for an applied methodology linking supply chain strategy to the company's financial performance. Case-based studies to analyse the impact of managing SC operations' performance on enhancing a company's overall financial performance are worthy of investigation.

3. THE RESEARCH FRAMEWORK

Elgazzar et al. (2012b) introduced a scenario analysis approach to link SC strategy to a company's financial performance. The financial performance was evaluated and analysed in terms of profitability and operating efficiency through assessing the contribution of each financial performance driver (revenue, cost and assets). Three different paths were identified to achieve the short-term strategic financial objectives, namely: increasing revenue, managing costs and improving asset utilisation. The appropriate path is selected through assessing the contribution of each financial performance driver to the company's profitability

and/or operating efficiency. To correspond to the different possible paths, five main SC performance alternative scenarios (managing SC costs, increasing SC agility, improving SC reliability, increasing SC responsiveness and managing SC assets) were introduced based on the supply chain operation reference (SCOR) model performance metrics.

In this paper, a systems view of the scenarios is introduced to demonstrate the way in which SC strategy and the company's overall financial strategy can be integrated under different possible scenarios based on the systems view problem-solving model developed by Mitroff et al. (1974). Based on the system view of the scenarios, five main alternative scenarios are defined given the related targeted financial outcomes and their corresponding present paths. Both scenario one (managing SC costs) and scenario two (increasing SC agility) are relevant when the company's short-term strategic financial objective is to increase its profitability and the analysis of financial performance results highlights cost as the financial driver that most requires attention. Both scenario three (improving SC reliability) and scenario four (increasing SC responsiveness) are relevant when the analysis of financial performance results highlights revenue as the financial driver that most requires attention. Scenario five (managing SC assets) is relevant when the company's short-term strategic financial objective is to improve its efficiency and the analysis of financial performance results highlights assets as the financial driver that most requires attention. In addition, the analysis of SC performance indicates that SC processes to which asset management measures correspond register the poorest performance among all SC processes.

The system can be operated in two directions given two possible loops: (II, III, IV and I) and (I, II, III and IV). The systems view of the scenarios reflects the integration between SC strategy and the company's overall financial strategy. A company can formulate SC strategy to achieve targeted strategic financial objectives or it can start with an unsatisfactory financial performance and then formulate the corresponding SC strategy to enhance it.
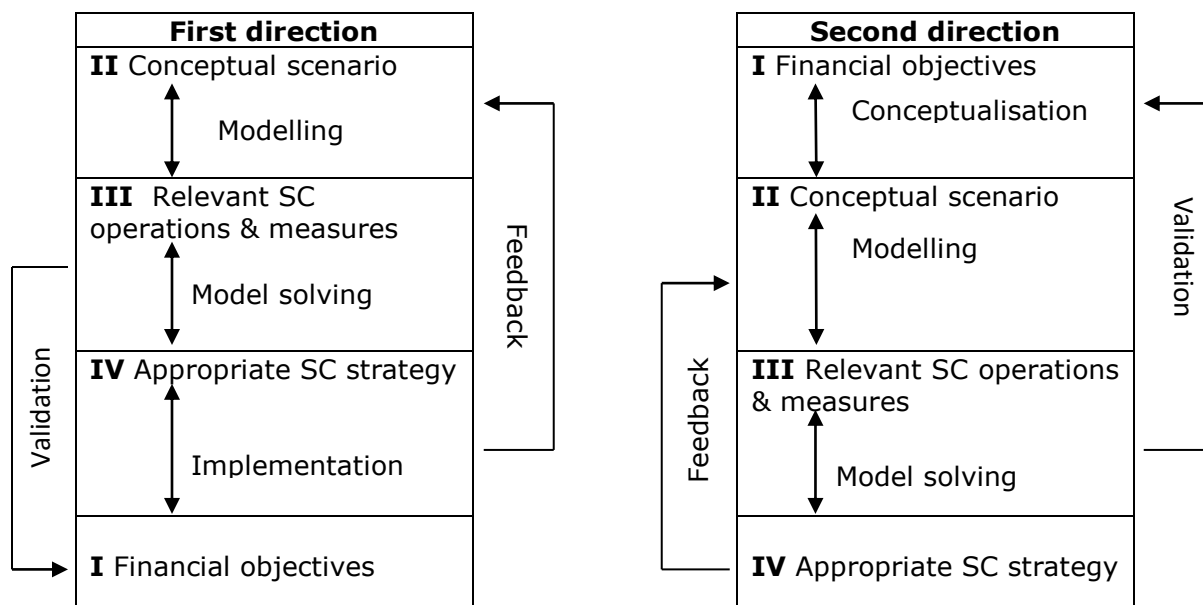
Figure 1: Systems view of the scenario analysis

Fig. 1 shows how a systems point of view can be adapted to carry out the proposed scenarios in two possible directions. The first direction starts with five main conceptual alternative scenarios (II). Then, a scientific model is formed to determine the relevant scenario that will be modelled and implemented (III). At this stage, the focus area for enhancing the financial performance is identified through assessing the contribution of each financial performance driver (revenue, cost and asset) and tracing their related SC operations. Then, SC operations that need improvement and their corresponding

performance measures can be identified, and the relevant scenario is determined (managing SC costs, increasing SC agility, improving SC reliability, increasing SC responsiveness or managing SC assets). Consequently, the appropriate SC strategy is formulated (IV) and implemented to achieve the targeted financial outcomes (I). As illustrated in fig. 1, the second direction starts with an inappropriate financial performance result (I). In this case, the relevant scenario is constructed theoretically based on the recognition of a real problem situation (II). Once the relevant scenario is identified, the scientific model can be formed through tracing the source of poor performance in terms of relevant SC operations and then the corresponding SC performance measures can be determined based on the SCOR model standard performance metrics (III). Finally, the appropriate SC strategy is formulated to improve the performance of relevant SC operations, and consequently enhance financial performance results (IV).

According to the proposed system, first, the contribution of each financial performance driver is evaluated in order to determine the priorities of financial performance (increasing profitability and/or improving efficiency). Then, the SCOR FAHP technique developed by Elgazzar et al. (2010) is utilised to assess the SC performance. The weighted rates (WR) of all SC performance measures are calculated and aggregated throughout the hierarchy of the SC in order to determine the company's SC index (SCI). SCI traces the source of poor performance in terms of the relevant SC operations that need improvement and consequently identifying the corresponding SC performance measurement category (reliability (RL), responsiveness (RS), agility (AG), cost (CO) and asset management (AM)). Finally, based on the relative weights of SC performance measures and the priorities of financial performance factors, the company's new SC strategy for the new accounting period is formulated with respect to the relevant alternative scenario in order to achieve the short-term strategic financial objective (targeted outcome) through adopting the appropriate present path (increasing revenue, managing cost or improving asset utilisation).

Alternative scenarios	DS/ AHP	Present paths	Possible outcomes
SC performance metrics (SCOR FAHP technique)		Financial performance drivers	Financial performance metrics
Improving SC reliability		Revenue	Profitability & Efficiency factor
Increasing SC responsiveness			
Increasing SC agility		Cost	Profitability factor
Managing SC costs			
Managing SC assets		Assets	Efficiency factor

Figure 2: The applied framework of the SCPMS
(Developed from: Elgazzar, 2013)

A Supply Chain Financial Link Index (SCFLI) is calculated before and after implementing the new SC strategy to test the extent to which SC processes' performance is linked to the company's financial strategic objectives. The applied framework of the research method is presented in fig. 2. To demonstrate the applicability of SCPMS, a case study of a manufacturing company is presented and analysed in the next section. The data was collected for one year (referred to it in the text as period 1).

4. CASE STUDY

4.1 Evaluating SC operations' performance
The SCOR FAHP was implemented to evaluate SC operations' performance. The company's SCI was calculated by aggregating the performance of the main five SC performance measurement categories (RL, RS, AG, CO and AM). As illustrated in table 1, the company's SCI for period 1 was 0.56 revealing that the company's SC performance in this period was good on average (see equation 1).

Measure	SCI			Assessment rate
	R	W	WR	
RL	0.72	20%	0.143	Very good (VG)
RS	0.62	20%	0.123	VG
AG	0.64	20%	0.127	VG
CO	0.29	20%	0.059	Poor (P)
AM	0.53	20%	0.105	Good (G)
SUM	2.8	100%	0.557	G

Table 1: SCI for period 1

$$\text{SC index (SCI)} = \frac{\sum R}{N} = \frac{2.8}{5} = 0.56 \tag{1}$$

where N represents the number of the main SC performance measures.

4.2 Evaluating the company's current financial performance and determining the priorities of financial performance factors
A negative return on asset ratio was registered by the company. The analysis revealed that the company had a good Total Asset Turnover compared to the industrial average, while the company's Net Profit Margin was below the industry average which indicated that the company had a problem in generating profit from its sales. Structured interviews were conducted with a group of decision makers at the strategic level in order to assign the priorities of the financial performance factors –with respect to financial results- using the pair-wise questionnaire scale. The priority weight given to the profitability factor was 84.5% compared to only 15.5% assigned to the efficiency factor.

4.3 Determining the relative weights of the five main SC performance measures with respect to the financial performance priorities
Following the procedures developed by Elgazzar et al. (2012a), the group of decision makers was asked to rank the five main SC performance measures priority with regard to each financial performance factor. Structured interviews were conducted. Then, using the Dempster Shafer/Analytical Hierarchy Processes (DS/AHP) method the relative importance weights of the five main SC performance measures were calculated and ranked.

Subsets	SUMm1(P)M2(E)	$m_{sc\ performance\ measures}$	Weight(W)	Priority
RL	0.074417	0.122968	12%	3
RS	0.074417	0.122968	12%	3
AG	**0.150384**	**0.248496**	**25%**	**2**
CO	**0.185864**	**0.307123**	**31%**	**1**
AM	0.045707	0.075526	8%	4
θ	0.074386	0.122917	12%	

Table 2: The relative importance weights of the SC performance measures

As illustrated in table 2, CO and AG presented the most important SC performance measurement categories to focus on for the purpose of aligning with the company's short-term strategic financial priorities. Also, table 2 indicates an ignorance factor (θ) equal to 0.12, which reflects the influence weight of the other unknown or uncontrollable factors that may impact the company's financial performance.

4.4 Evaluating the efficiency and the effectiveness of current SC strategy
As illustrated in table 3, the SCFLI for period 1 was 0.514 revealing the good contribution on average of SC operations' performance in enhancing the overall financial performance (see equation 2).

Measure	SCI			SCFLI			Assessment rate
	R	W	WR	R	W	WR	
RL	0.72	20%	0.143	0.72	12%	0.086	VG
RS	0.62	20%	0.123	0.62	12%	0.074	VG
AG	0.64	20%	0.127	0.64	25%	0.159	VG
CO	0.29	20%	0.059	0.29	31%	0.091	P
AM	0.53	20%	0.105	0.53	8%	0.042	G
SUM	2.8	100%	0.557	2.8	88%	0.452	G

Table 3: SCFLI for period 1

$$\text{Supply chain financial link index (SCFLI)} = \frac{\sum WR}{\sum W} = \frac{0.452}{0.88} = 0.514 \tag{2}$$

Based on the previous results, the company's short-term strategic financial objective was improving its profitability especially through managing its costs and this consequently lead to assigning the highest priority weight at the top level of the SCOR hierarchy to cost measures. Accordingly, the appropriate scenario to apply was Scenario One (managing SC costs) through formulating SC strategy aimed at enhancing the processes to which cost performance measures correspond. Finally, the subsequent objectives and action plans required to implement this strategy were identified.

4.5 Formulating new SC strategy based on the company's short-term strategic financial priorities

Table 4: The aggregated performance of the company's SC cost measures

Supply Chain Cost measures	Min	Max	W	Period 1 performance	Assessm -ent Rate	R	WR
SCM Cost	0.2	1	0.33	-	P	0.26	0.084
Cost of Goods Sold	0.2	1	0.67		P	0.31	0.209
Freight expense	0.17	0.11	0.65	0.17	VP	0.2	0.13
Marketing expense	0.08	0.04	0.07	0.08	VP	0.2	0.014
Sales expense	0.2	0.15	0.21	0.21	VP	0.2	0.042
Administrative expense	0.02	0.01	0.07	0.01	E	1	0.07
Cost to Make	0.2	1			-		
Material Cost	0.75	0.54	0.56	0.67	P	0.4	0.224
Labour Cost	0.15	0.09	0.15	0.14	VP	0.2	0.03
Indirect Costs	0.25	0.14	0.29	0.19	VP	0.2	0.058

Table 4 shows the analysis of the performance of SC cost measures; the highest priority was assigned to SC processes to which the freight expense measure corresponds. Managing freight expense could highly impact SC cost performance since it had a very poor (VP)

performance and the highest relative importance weight. The second priority was given to *Material cost* as it had a poor (P) performance and the highest relative importance weight compared to other cost to make measures. The third priority was assigned to direct *Sales expense* as it had a very poor performance and a relatively high importance weight. The fourth priority was managing SC processes that impact *Indirect costs* related to making product, while a lesser priority was assigned to *Labour cost* and direct marketing expense.

4.6 Evaluating the contribution of the new SC strategy in achieving the company's short-term financial strategic objectives

The authors assumed that the suggested strategy would be applied to demonstrate how improving the relevant SC operations could influence the outcome in terms of the company's financial performance after one financial year under three different conditions (optimistic, normal and pessimistic).

Considering an optimistic assumption that the company would carry out the proposed strategy in full and all objectives would be accomplished, SC total cost would decrease by 28.8% between period 1 and period 2. As illustrated in table 4, the changes in SC costs would impact the performance of the related SC performance measures. SC cost measures and some of the SC asset management measures would be affected positively by decreasing SC costs resulting in improvement in the overall SC performance assuming that all other variables would not change and remain constant. As a result, SCI for the end of period 2 would increase to be 0.717 revealing very good SC operations' performance for this period. In addition, managing SC costs would impact financial performance components (revenue, cost and assets). The company's total costs would be affected directly, while revenue and assets would be affected indirectly through increasing Net Income and efficiency of asset management. The company's SCFLI (period 2) would increase by approximately 26 percentage points and by 50% compared to (period 1) revealing improvement in the efficiency and the effectiveness of SC strategy in connecting to the company's short-term strategic financial objectives (see table 4).

Table 5 shows how the results would change if the proposed strategy was partially undertaken. Another two conditions are assumed (normal and pessimistic conditions). The normal condition assumes that only the first four objectives would be accomplished (reducing freight expense, reducing direct material cost, reducing direct sales expense and reducing labour cost). The pessimistic condition assumes that only the first two objectives would be accomplished (reducing freight expense and reducing direct material cost).

Supply Chain Cost measures	Period 1	For period 2		
		Optimistic condition	Normal condition	Pessimistic condition
Freight expense (% of total cost)	17%	10.8%	10.8%	10.8%
Direct marketing expense (% of total cost)	8%	3.6%	8%	8%
Direct sales expense (% of total cost)	21%	15.3%	15.3%	21%
Administrative expense (% of total cost)	1%	1%	1%	1%
Material Cost (% of total manufacturing cost)	67%	54%	54%	54%
Labour Cost(% of total manufacturing cost)	14%	9%	9%	14%
Indirect Costs Related To Making Product (% of total manufacturing cost)	19%	13.5%	19%	19%
Supply Chain Asset Management	Period 1	For period 2		
		Optimistic condition	Normal condition	Pessimistic condition
Return on working capital	-1%	5%	3.7%	1.8%
Return on SC Fixed Assets	-6%	31%	22%	11%
Return on SC total Assets	-3.42%	18%	12.6%	6.3%
Supply chain's performance indices	Period 1	For period 2		
		Optimistic condition	Normal condition	Pessimistic condition
SCI	0.56	0.717	0.68	0.64
SCFLI	0.567	0.772	0.71	0.656

Table 5: The performance before and after applying the suggested SC strategy

Under the normal condition, SC total cost would decrease by 21.8% from period 1 to period 2, while it would decrease by 13.2% under the pessimistic condition. The results under both condition show improvement in SC performance as well as financial performance. SCI would improve to be 0.68 in the normal condition and 0.64 in the pessimistic condition revealing improvement in the company's SC operations' performance under both conditions. Also, the SCFLI would increase to reach 0.71 under the normal conditions and 0.656 under the pessimistic conditions which reflects the improvement in the efficiency and the effectiveness of SC strategy in connecting to the company's short-term strategic financial objectives. Many other conditions could arise, however, as shown in the previous three assumed conditions, any improvement in the SC operations' performance will lead to better SCM, and consequently enhance the company's overall financial performance.

5. CONCLUSION AND FURTHER WORK

The research study makes an original contribution in the direction of linking SC strategy to a company's financial strategy through focusing on studying the relationships between SCM practices and financial performance improvements. An integrated supply chain performance measurement system was created and implemented to demonstrate and utilise the relationship between SC performance metrics and financial performance metrics. A scenario analysis approach was undertaken using five main alternative scenarios in order to explore how this procedure could be applied with regard to various possible financial results. A case

study of a manufacturing company was conducted and analysed to illustrate the applicability of the research procedures.

Future research should consider collecting data for more than one financial year so as to investigate the impact of implementing the suggested SC strategy on improving SC operations' performance and enhancing the overall financial performance. In addition, further work should investigate and compare the results from several companies in different manufacturing sectors in different locations. Since the SCOR model provides standard descriptions of SC processes and standard metrics to measure the performance, the research procedure can be generalised to be applicable in any manufacturing company from any other sector.

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INVESTIGATING STOCK-OUTS IN THE WAREHOUSE RETAIL LIQUOR SECTOR IN JOHANNESBURG

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ABSTRACT

Purpose of this paper: Inefficiencies in three management levers namely; the management of demand variability, supply chain synchronisation and collaboration, have been found to be probable causes of stock-outs. Many retail businesses in South Africa face the phenomena of stock-outs, resulting in lost sales. The aim of this exploratory study is to investigate management practices that contribute to stock-outs in warehouse retail liquor retailers in Johannesburg.

Research design and methodology: The focus of this study was formal trade warehouse retail outlets that sell to other retailers as well as consumers in Johannesburg. A multi-case approach was used to determine the association between business management practices and stock-outs. To improve the generalisability of the findings, five general methodological phases were used. First, three research questions were formulated. Second, a questionnaire was developed; third, field data were gathered; fourth, interviews were transcribed and analysis performed using coding schemes and cross-case comparisons; and finally, findings were disseminated to improve validity. Interviews were conducted with managers in the areas of procurement, sales and supply chain management from the retailers.

Findings: The results revealed that retailers based demand forecasting on judgement, naïve or simple moving average forecast methods. As a result during periods of unusual activity, demand was difficult to predict. Excel spread sheets and computerised systems were utilised to track demand. There was no evidence of data analysis or use of forecasting methods. Inventory decisions were based on simple standards set by management. There was no consideration of advanced modelling that included variability, lead-time or a targeted customer service level to achieve optimal inventory levels. Instead safety stock involved holding a two week stock cover for all products throughout the year, leading to stock-outs particularly in periods of unusual activity. Store operations were adhered to and thus were not a hindrance in fulfilling customer demand. However, product breakages were common implying that data inaccuracies and stock-outs were probable. The sharing of information between the retailers and suppliers was lacking as there were no formal collaboration programmes. Suppliers thus lacked the flexibility to react to retailers' needs.

Value: This exploratory study extends existing literature by synthesising two research areas, i.e. supply chain management practices and stock-outs, to illustrate the effects of these on each other. Additionally, empirical evidence of this relationship from the warehouse retail liquor businesses in Johannesburg is provided.

The limitations of this study are that the results are based on the opinions of respondents and may present a bias by describing adequate competency when interviewed.

Practical implications: It is recommended that, where stock-outs are the result of trends and seasonality, management consider other methods of forecasting. In addition, collaboration with suppliers should be established to improve synchronisation. This will enable flexibility to quickly react to retailer's needs and ensure that customer service quality is maintained. Improvements in three focus areas namely; demand forecasting, collaboration and training of employees will assist in closing the gap of poor management practices in retail outlets and reduce stock-outs.

INTRODUCTION

Stock-outs happen when inventory is not available on the shelf for a customer to purchase (Aastrup & Kotzab, 2009; Grant & Fernie, 2008). Customers will do one of the following when faced with a stock-out (i) switch stores to locate the same product (ii) change brands to get a similar utility from a similar product (iii) postponement of the purchase

to whenever the product becomes available, or (iv) completely drop the purchase (Van Woensel et al., 2007). However, about 84% of customers tend to substitute their product purchase when faced with a stock-out owing to the immediacy effect, defined as customer demand for a product for immediate consumption (Van Woensel et al., 2007). Customers may switch to another brand in the short term in the same store, thus the outlet benefits by not losing a sale (Van Woensel et al., 2007; Sloot, Verhoef & Franses, 2002). If continuous stock-outs occur, consumers will switch stores permanently, leading to a diminishing customer base, poor customer retention, loss of store loyalty, reduction of sales turnover and diminishing profits in the long run (Van Woensel et al., 2007). Stock-out situations are of particular concern to the fast moving consumer goods (FMCG) sector where more than 50% of buyers are reported to not make a purchase at all when faced with a stock out (Corsten & Gruen, 2004; Ehrenthal & Stolzle, 2013).

Customer behaviour and buying patterns are critical predictors of sales turnover (Pearson, 2011). Stock-outs make the monitoring of demand patterns difficult as brand switching takes place which causes increased demand variability (Corsten & Gruen, 2003). Demand variability is a deviation from a supply chain process (Coyle et al., 2012). The beer game categorises three management levers namely; the management of demand variability, supply chain synchronisation and collaboration (communication). Inefficiencies in these three levers have been found to be the probable causes of stock-outs in the retail business (Van Woensel et al., 2007).

Many retail businesses in South Africa, particularly in the FMCG sector face the phenomena of stock-outs, resulting in lost sales (Pearson, 2011). Stock-outs in the retail sector have been consistent over the past 10 years and have not improved. The problem of stock-outs can result in up to 4% loss of annual sales turnover for an average retailer in South Africa (Pearson, 2011).

By extension, it is conceivable that new insights might be gained by considering that an association exists between business management levers in the form of supply chain management practices and processes and stock-outs. The aim of this study is to investigate management practices that contribute to stock-outs in warehouse retail liquor businesses in Johannesburg. This exploratory enquiry reviews the causal relationship of business management processes and practices to stock-outs. In doing so, this paper makes two contributions. This study extends existing literature by synthesizing two research areas, i.e. supply chain management practices and stock-outs, to illustrate the effects of these on each other. Additionally, this exploratory research offers empirical evidence of this relationship from the warehouse retail liquor businesses in Johannesburg.

LITERATURE REVIEW
Supply chain synchronisation is the integration of operations to achieve a mutual goal between supply chain entities (Simatupang, Sandroto & Lubis, 2004). A lack of synchronisation results in variability (Van Woensel et al., 2007; Corsten & Gruen, 2003). High levels of variability in process flows for product, information and finances are correlated to either stock-outs or over supply (Aastrup & Kotzab, 2009; Pramatari & Miliotis, 2008).
Papakiriakopoulos and Perpetual (2011) postulated that the identification and measurement of variables that measure of stock-outs is the best strategy to mitigate the negative effect of OOS. To explore the nature of stock-outs in the supply chain, two broad streams of research are particularly informative: the beer game and the bullwhip effect. The former explores how business management practices are characterised by variability, synchronisation and collaboration and how these impact business performance. The latter provides the basis for understanding demand variability. Combined, these provide an understanding of the association between business management practices and stock-outs.

The Beer Game

A retail organisation can be faced with stock-outs if there is a lack of synchronisation of customer demand signals from one supply chain entity to the next in the process flow (Goodwin & Franklin, 1994). The beer game simulation illustrates the process of entities of a supply chain receiving and processing information and products.

Throughout the beer game, supply chain entities are exposed to batch ordering and adjust ordering patterns to match demand with supply. These attempts to adjust ordering patterns are known as reactive decisions in the form of operating policy formulation (Goodwin & Franklin, 1994). The existence of these policies illustrates managerial inefficiencies in demand signalling, synchronisation, collaboration and inventory stocking policies (Lee et al., 2014). The operating policies that participants establish in the beer game result in the bullwhip effect, which increases variability in the supply chain.

The beer game highlights that demand forecasting methods, safety stock modelling and inventory replenishment policies are critical inventory management processes that influence synchronisation and the management of variability (Goodwin & Franklin, 1994).

Bullwhip effect
Supply chain variability can also be characterised as the bullwhip effect (Lee et al., 1997). The bullwhip effect is defined as amplified customer order variability in the supply chain, as orders move up the supply chain. Each entity of the supply chain may increase the order volume in order to earn quantity discounts, thus distorting the initial order information (Parsonsons, 2013; Lee et al., 1997). The impact of the bullwhip, i.e. the transfer of distorted information to each supply chain entity, results in inefficiencies such as excessive inventory or stock-outs and subsequent poor customer service due to poor matching of demand with supply.

The bullwhip is caused by demand forecast updating; order batching; price fluctuations; and rationing and shortage gaming. Demand variability is due to i) heterogeneous customers making purchasing decisions based on different product types in retail outlets and ii) demand patterns based on macro-economic conditions which affect the micro-economics of the business, seasonal or brand loyalty (Kalchschmidt, Verganti & Zotteri, 2006). Coyle et al. (2013) and Kalchschmidt et al. (2006) found that demand is clustered according to types of customer demands and purchases patterns. Understanding these products and customers is essential in creating synchronisation in the supply chain.

RESEARCH DESIGN AND METHODOLOGY
The focus of this study was formal trade warehouse retail outlets that sell to other retailers as well as consumers in Johannesburg. Formal trade is a category of the alcohol beverage industry, where businesses operate by keeping stock in their warehouses and trade to formal and informal customers (Herrick & Parnell, 2013). The population of the warehouse retail liquor outlets in Johannesburg is approximately 917 outlets. The population was stratified firstly according to sales volumes turn over then the extent of homogeneity. The highest turnover strata (i.e 70 outlets contribute 50% of the volume turnover of the 917 outlets) was selected for further analysis because it would typically be prone to stock-outs, due to the higher frequency of ordering and replenishment required to fulfil the high volume turnover (Corsten & Gruen, 2003). The extent of homogeneity was based on a similar trading and operating format to customers in the formal trade (Kubeka, 2013; Parsonson, 2013; Alborough, 2013). Resultantly 35% or 25 of the high volume outlets were targeted.

A multi-case approach was used to determine the association between business management practices and stock-outs. Interviews were used to obtain rich descriptions from the retailers. To improve the generalizability of the findings, five general methodological phases were used. First, three research questions were formulated. Second, a questionnaire was developed; third, field data were gathered; fourth, interviews were transcribed and analysis performed using coding schemes and cross-case comparisons; and finally, findings were disseminated to improve validity.

Data were collected using semi-structured interviews. The responses were scaled on a Likert and category scaling system (Zikmund, 2003). Interviews were conducted with managers in the areas of procurement, sales and supply chain management from the retailers. Data collected for eight months between March and October (assumed to be a reasonable time to provide an indication of stock-out reasons). The assumption was based on an interview with an alcohol manufacturer in South Africa who revealed that eight months were indicative of typical sales patterns of retail outlets (Kubeka, 2013).

RESULTS AND DISCUSSION
The sample size was 25; however 22 responses were valid for the analysis. Three were regarded as they were incomplete. Based on the conceptual framework findings were separated into three areas namely variability; synchronisation and communication.

Variability
Forecasting methodologies
Respondents were asked to indicate their forecasting methods. The key finding was that demand forecasting was mostly based on judgement, naïve or simple moving average forecast methods (see Figure 1). These methods are limited and less reliable in predicting demand in different situations. 50% of the respondents did not use statistical software to forecast customer demand. Only 9% of respondents recorded high use of statistical software. 73% of respondents used judgement or intuition to determine orders. This could be attributed to the number of years of experience in the business; making informed customer demand forecasting decisions based on prior knowledge (Nakano and Oji, 2012). 75% of respondents indicated their businesses were family owned and had been operating for 10 years or more. Of that, 36% had over 20 years' experience. The use of simple forecasting methods implies a high probability of sending poor demand signals to suppliers. Stock-outs would thus be highly probable. This is consistent with the beer game as poor order signals in the supply chain result in poor matching of demand with supply.

Respondents indicated that trend and seasonality were not factored into forecasting techniques. This is significant as the responses in Figure 3 illustrate that seasonal demand is one of the reasons for stock outs. Failing to implement more sophisticated forecasting techniques in high demand periods may result in stock-outs.

83% of respondents rated no/low adherence to cause and effect modelling for forecasting. This implies that demand events are probable cause of stock-outs. Events such as changing weather patterns, sporting events, music festivals and long weekends were cited as events that cause stock-outs due to difficulty predicting customer demand. Failing to implement a causal modelling techniques for demand events may result in stock-outs.
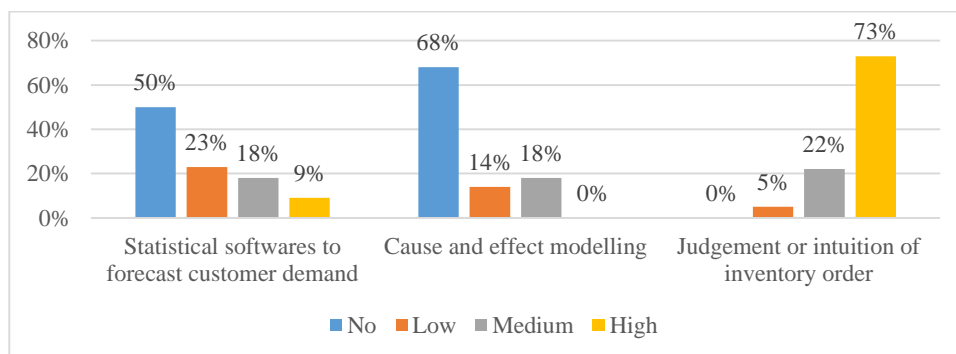

Figure 1: Forecasting methods used (Respondents' rating in %)

Customer demand patterns tracking or forecast tracking
There appeared to be tracking of demand data on excel spread sheets and computerised systems (capturing electronic point of sale data). 41%/27% of respondents indicated

medium/high tracking of demand data on excel spread sheets. However, there were low levels of data analysis or forecast tracking. By tracking forecast errors businesses would be able to switch to different forecasting techniques in an attempt to reduce variability. 68% of respondents captured electronic point of sales data whilst 32% did not. Respondents indicated that data was used for naïve or simple moving forecasting when ordering products. The data contained historical customer sales and stock information using last period customer sales to determine the forecast for the next period. The ordering procedure was based on this method.

46% of respondents recorded no/low adherence to safety stock modelling (see Figure 2). Respondents indicated that all inventory were based on a standard stock cover measure. There appeared to be no demand variability factored into the safety stock modelling techniques used by respondents. The primary reason for this was poor understanding of customer demand. Respondents indicated that between one and two weeks of stock was kept as safety stock for all product lines at all times.

Respondents indicated that a simpler version of determining lead-time, customer demand variability and customer service level based on a computerised stock system was used. These methods exclude trend and seasonality which may increase variability. Increased demand may lead to stock-outs.
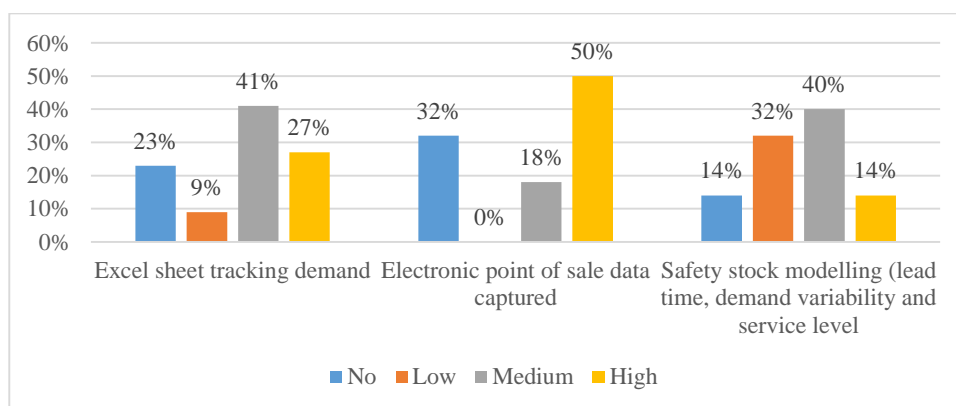

Figure 2: Forecast tracking methods (Respondents' rating in %)

Customer demand predictability

Respondents were asked to rate the level of predictability of demand patterns from low to high predictability. Figure 3 illustrates that demand predictability across different conditions is fairly low. Although demand data is recorded, advanced data modelling or analysis is poor. There appears to be a correlation with the lack of analysing demand data and the low level of demand predictability. Homogeneous customers' demands were fairly predictable as repeated buying patterns are easier to track and predict. Heterogeneous customers' demands were more difficult to predict. Heterogeneous customer demand patterns were further divided into behaviour categories.

32%/41% of respondents rated promotional activity to have no/low impact on predictability of demand. This also resulted in stock-outs. The seasonality category was reviewed in terms of seasons of the year that are prone to increased purchasing. 68% of respondents rated seasonal demand to have low predictability. The literature indicates that it is unlikely to accurately predict demand during seasonal periods without using an appropriate forecasting model. Poor demand forecasting methods result in stock-outs. This is confirmed in the inventory management techniques implemented as judgement or intuitive methods of forecasting are favoured (see Figure 1). Brand loyalty was reviewed in terms of new products entering the market. 78% of respondents indicated low predictability which suggests a probable cause of stock-outs.
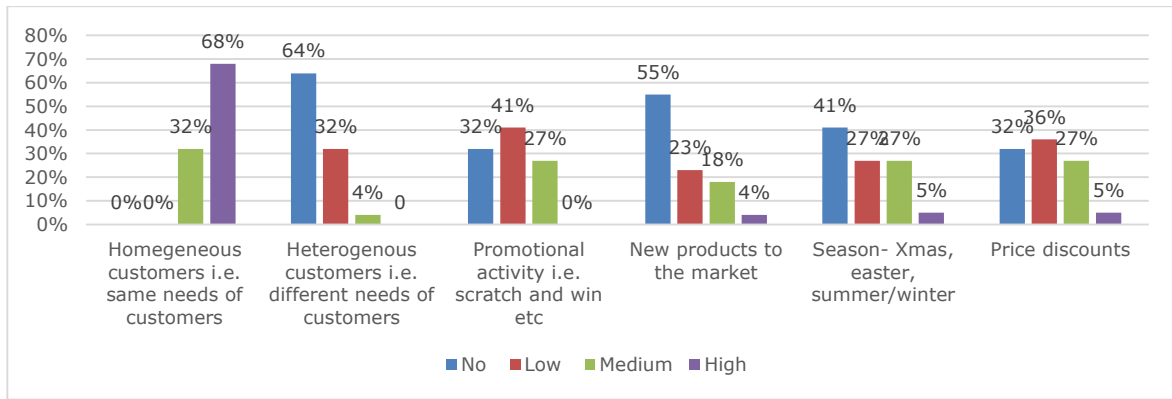
Figure 3: Customer demand predictability (Respondents' rating in %)

Synchronisation

Respondents were asked to rate adherence to retail operations process modelling from poor to high adherence. This modelling is based on three criteria, i.e. product item data accuracy, ordering and inventory accuracy and store and shelf replenishment.

Product item data accuracy

Respondents were asked to rate weekly stock count process, classification and documentation of stock received and updating price information in their store. Figure 4 illustrates that over 75% of respondents' rated medium/ high adherence to the stock count process, updating price information and classification and documentation of stock received. The medium/ high adherence to these processes minimises the probability of data inaccuracy which assists in reducing stock-outs.

Ordering and inventory accuracy

Figure 4 illustrates weekly ordering/purchasing processes. 86% of respondents rated high adherence to the ordering process. If regular ordering processes are in place, it reduces the probability of stock-outs. This is inconsistent with the finding on a lack of understanding of demand during seasonal, promotional, new products and price discounts. This suggests that where demand is difficult to predict the ordering process would be inadequate, resulting in stock-outs.

Store and shelf replenishment

Daily merchandising of shelves and handling of products to avoid breakages in stores was rated from poor to high adherence. Figure 4 illustrates that over 80% of respondents' rated high adherence to daily merchandising of shelves. This plays an important role in the final purchase decision for consumers in terms of stock availability. Over 60% of respondents rated handling of products to avoid breakages as low.
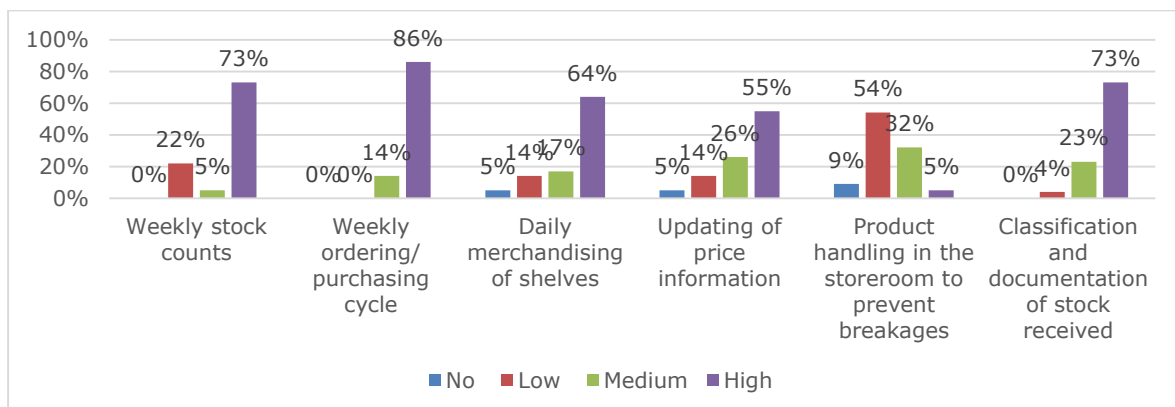

Figure 4: Retail and operations process modelling (Respondents' rating in %)

Communication

To test for collaborative relationships, respondents were asked to rate communication with suppliers in terms of order placing, information sharing and collaboration.

Order placing interaction

The ease of placing an order with a supplier by communication with a sales representative or call centre was rated. 96% of respondents rated this as medium/high (see Figure 5), suggesting that communication is relatively good and did not present a risk of stock outs.

Information sharing

Respondents were asked to rate the level of information sharing using electronic point of sale or inventory data with suppliers. Figure 5 illustrates that 59% of respondents indicated poor/low level of data sharing. Respondents indicated that sales and inventory data were not shared with suppliers indicating a lack of trust and hence collaboration, which affects the agility of the supplier in reacting to the retailer's needs.

Collaboration programmes

Respondents were asked to rate collaboration in place with suppliers, i.e. collaborative planning, forecasting and replenishment (CPFR) or vendor managed inventory (VMI). More than 86% of respondents rated this as poor/low quality. This suggests that the lack of collaboration to create synchronisation could result in stock-outs.
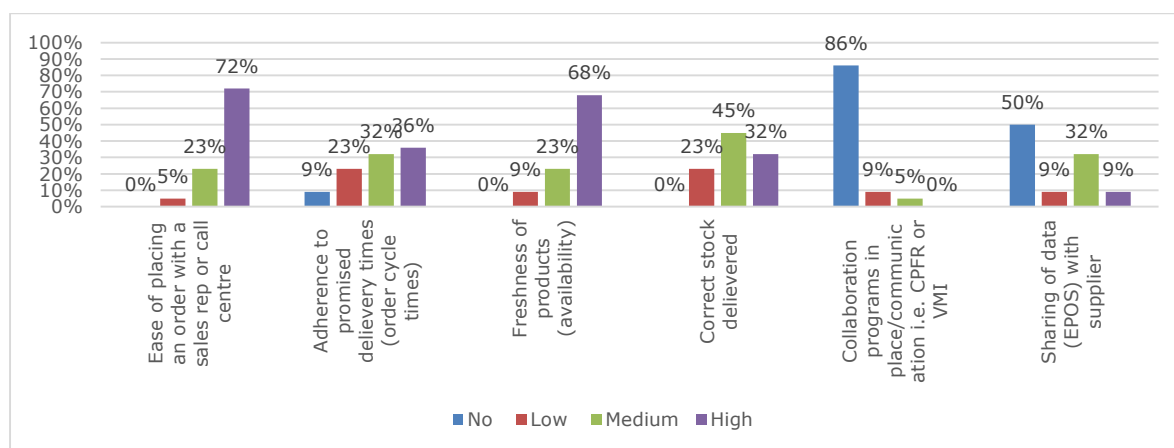

Figure 5: Supplier relationship (Respondents rating in %)

The effects of inefficient business processes and practices on business performance

Respondents were asked to rate what customers are likely to do when faced with stock-outs. 85% of respondents indicated that stock-outs had a medium/high impact on sales volumes, suggesting a relatively high impact on business performance. Figure 6 illustrates that 75% of customers tend to purchase from a competitor during a stock-out. This is consistent with the immediacy effect that causes consumers to shop elsewhere. Respondents indicated that customers would tend to shop at the next closest store stocking their brand. This correlates with the effect of brand loyalty and the customer behaviour on purchasing patterns. This implies that stock outs will negatively affect sales and competitive advantage in the alcohol retail industry.

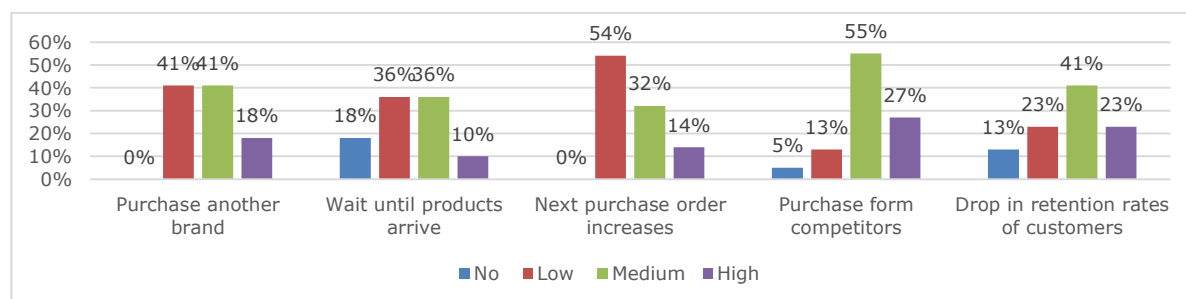Figure 6: Customer reaction to stock-out (Responses in %)

To a lesser extent respondents indicated that there was store loyalty. 45% of respondents indicated that customers would postpone the purchase until the product was available. Additionally, respondents indicated that customer retention decreased when customers were faced with stock-outs. In terms of the likelihood of customers purchasing another

brand when faced with a stock-out, 59% of the respondents agreed with this statement. This is contradictory to the brand loyalty theory. This appears to be in favour of the retailer; however literature suggests that if a consumer is faced with continuous stock-outs they will eventually become less store loyal. 55% of respondents agreed that, when faced with a stock out customers would not return to the store for future purchases.

CONCLUSIONS AND RECOMMENDATIONS

The aim of this study was to investigate the effect of business practices on demand variability and stock-out situations in warehouse retail liquor outlets in Johannesburg. Based on the conceptual framework, findings were separated into three areas i.e. variability, synchronisation and communication. The association between demand variability and stock-outs was investigated by exploring forecasting methods, forecast tracking and inventory management used by the outlets.

The results revealed that retailers based demand forecasting on judgement, naïve or simple moving average forecast methods. As a result during periods of unusual activity, demand was difficult to predict. This highlights that capabilities for advanced data modelling were limited. Poor forecasting methods resulted in the transfer of inaccurate demand signals to suppliers and stock-outs. This is consistent with the beer game as poor order signals through the supply chain result in poor matching of demand with supply.

Tracking demand data was generally done using excel spread sheets and computerised systems. There was no evidence of data analysis or use of forecasting methods. Inventory decisions were based on simple standards set by management. There was no consideration of advanced modelling that included variability, lead-time or a targeted customer service level to achieve optimal inventory levels. Instead safety stock involved holding a two week stock cover for all products throughout the year, leading to stock-outs particularly in periods of unusual activity.

Store operations, i.e. store shelving and merchandising, were adhered to and thus were not a hindrance in fulfilling customer demand. However, product breakages were common implying that data inaccuracies and stock-outs were probable. This suggests that capabilities in terms of product handling was lacking. The sharing of information between the retailers and suppliers was lacking as there were no formal collaboration programmes. Suppliers thus lacked the flexibility to react to retailers' needs.

The limitations of this study are that the results are based on the opinions of respondents and may present a bias by describing adequate competency when interviewed. It is recommended that, where stock-outs are the result of trends and seasonality, management consider other methods of forecasting. In addition, collaboration with suppliers should be established to improve synchronisation. This will enable flexibility to quickly react to retailer's needs and ensure that customer service quality is maintained. It is recommended that future studies be replicated in other FMCG sectors in order to compare the findings across different sectors.

In conclusion, this study has demonstrated that three focus areas namely; demand forecasting, collaboration and training of employees will assist in closing the gap of poor management practices in retail outlets and reduce stock-outs in Johannesburg.

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APPLYING SIX-SIGMA AND DMAIC METHODS FOR PROCESS IMPROVEMENT BY A CAR IMPORTER IN THAILAND

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ABSTRACT

Purpose This research paper investigates and solves a transport delay problem in the import of cars, by sea from Germany, by an automotive company in Thailand. It identifies the current process, possible improvements by the company, and guidelines for the 3PLs involved.

Design The research methodology used a combination of Six-Sigma and DMAIC techniques. Six-Sigma is a quantitative problem-solving method which uses statistical tools for process improvement by expelling quality defects. DMAIC is a data-driven cycle for improving and sustaining business processes, and is used to drive Six Sigma projects. Also, interviews were conducted with the company management, 3PLs, Customs, and the Transporter company.

Findings The lead time was reduced from 15 days to 6 days, by eliminating problems and errors within the company (such as cheque approval and release time), and in 3PLs (such as extra storage charges, and errors in billing and sea freight rates), and in Customs (such as inspection and release time), and in the Transporter company (such as delivery delays). All unnecessary costs were eliminated. such as storage charges and billing errors, amounting to US$100,000 p.a..

Value International trade chains, for imports and exports, are common and vulnerable. This paper's research analysis methods are popular but may suffer from insufficient attention to their limitations, which are explored here. The results could encourage other importers to tackle delay problems in which several parties are involved.

Research Limitations As there was only one focus company, in one country, the findings cannot be generalized. The data for analysis was limited to one complete year, 2014, which may not have been fully representative. Future research could extend the data period, and include other factors and models, as well as surveying customer satisfaction.

Practical Implications The identified problems and proposed improvements were accepted and implemented by the company and its external partners, and a plan made to maintain the improvements with a continuous review schedule. Other companies might profit from this report.

INTRODUCTION

This research focuses on a single company, AAA Thailand. The company name and the details have been made anonymous at the firm's request as a condition for conducting the research within the firm. AAA Thailand was founded as an engine manufacturer in Germany, expanding to automobile manufacturing in 1929. The firm's business, including personal mobility devices, motorcycles, and automobiles, are positioned in premium market segments.

The firm expanded into Thailand (here called AAA Thailand) as a direct investment project in 1997. The firm has a manufacturing plant in Rayong for certain models. These cars mainly meet the demand in Thailand and surrounding countries. The production volume of Thailand plant is 6,000 to 10,000 units per year, including domestic and export volume. However, AAA relies mainly on imported complete car from Germany. The firm is dependent on 3PLs for customs clearance, transportation, and warehousing of the parts and sub-assemblies for its manufacturing plant, some car models and other imported complete vehicles. The firm imports parts and complete car by either air or sea freight, using various 3PL processes. This research focused on the imported complete cars as they have the highest imported value.

LITERATURE REVIEW
1. Third-Party Logistics (3PLs)
3PLs has been used extensively in the automobile industry. The automotive industry was one of the first industries to adopt 3PLs, which helped the industry to ease and manage logistics issues caused by the international supply chain and suppliers (Hertz & Alfredsson, 2003). This is still common. There were some early problems with the implementation of 3PLs in the automotive industry, since it had distinct requirements from other industries (Hertz & Alfredsson, 2003). However, a recent study of the industry showed that the automotive industry is one of the main client industries for 3PLs in North America (Lieb & Lieb, 2012).

2. Six Sigma
Six Sigma is recognized as a problem-solving method that uses quality and statistical tools for basic process improvement. Six Sigma is now widely accepted as a highly performing strategy for driving defects out of a company's quality system. Six Sigma is also defined as a multifaceted, Customer-oriented, structured, systematic, proactive and quantitative philosophical approach for business improvements to increase quality, speed up the deliveries, and reduce costs (Mahanti & Antony, 2005).

3. DMAIC Technique
DMAIC refers to a data-driven improvement cycle used for improving, utilizing, and sustaining business processes and designs. The DMAIC improvement cycle is the core tool used to drive Six Sigma projects. However, DMAIC is not exclusive to Six Sigma and can be used as the framework for other improvement applications. DMAIC is an acronym of the five improvement steps: Define, Measure, Analyze, Improve and Control. All of the DMAIC process steps are required and always proceed in the given order (Antony, 2006; Desai & Shrivastava, 2008; Wiesenfelder, 2011).

RESEARCH METHODOLOGY
This study focused on the process improvement and developing performance by using Six Sigma DMAIC methodology. It identified the criteria of process improvement for importing complete car activities. Since importing complete car activities is one of current problems, the data for the research were drawn from the secondary data review and the data available at present. However, the data did not reflect the future, as the researcher considered only the historical data for one year in 2014 and primary interview data.

The data collected were analyzed through the use of the DMAIC methodology. Table 1 shows the tools and techniques suggested for DMAIC methodology in each step. In the next section, the Define Phase of the DMAIC is presented.

1. Define Phase
AAA Thailand has encountered delays in the import process. These problems on delays were gathered from the weekly and monthly report on 3PLs performance as well as from an initial informal interview with the members of the company including the Director of Import & Export, Manager of Logistics, and Manager of Transporter tasked with managing the import process for AAA Thailand. As an advantage, the researcher is currently working for AAA (Thailand) Import & Export department and has a direct experience on the whole process.

In this phase, the problems related to the import process were identified. The import process is related to both internal [i.e., AAA (Thailand) Import & Export, and Accounting] and external parties (i.e., 3PLs, Customs, and Transporter).

Table 1: Tools and Techniques for DMAIC Methodology

Step	Specific tasks	Tools and techniques
Define	- Identify improvement issues - Organize project team - Set-up improvement goal - Estimate financial benefit	- Interview
Measure	- Map process and identify inputs and outputs - Establish measurement system for inputs and outputs - Understand the existing capability of process	- Process mapping - Cause and effect diagrams
Analyze	- Identify sources of variation in process - Identify potential critical inputs - Determine tools used in the improvement step	- Performance Analysis
Improve	- Conduct improvement actions - Use experiments - Optimize critical inputs	- Brainstorming
Control	- Standardize the process - Maintain critical inputs in the optimal area - Verify long-term capability - Evaluate the results of improvement projects	- Control Sheet - Performance Measures

The problems related to the internal & external process were the late cheque approval and the long lead time for cheque release which contributed to the delays in the whole import process. These problems are explained in detail in Table 2.

Table 2: Problems Related to Import Process

| Problems	Description
Late cheque approval	Because of the high value of AAA's products, the only authorized person to approve and sign the cheque is the Financial Director. It is the duty of Accounting department to inform the Financial Director in advance to reserve the money and request for cheque. If the Financial Director takes a leave, he or she writes an official letter to authorize the Accounting Director to approve the amount requested. Sometimes delays occur in this process.
Long lead time for cheque release	The Accounting department cannot release cheque without the import ticket. This is a typical process that the import ticket will not be given in advance. It has to wait until the vessel arrives. Then, it takes around two days before the Import & Export team can forward this import ticket to the Accounting department. However, only the Financial Director can approve and sign the cheque before it can be released. This adds up the potential delays on this process.
Late delivery	3PLs cannot support AAA Thailand business in terms of on-time delivery as specified in the contract agreement. Due to the Customs clearance process is not complete on time, the loading and delivery process to the Customer is delayed.
Extra storage charge	Delayed delivery has resulted to an extra charge incurred for the temporary storing of vehicles at the port.
Incorrect import sea freight rate	3PLs does not thoroughly check import sea freight exchange rate. As a result, it declares the wrong value in an import ticket.
Billing errors	AAA has found that many 3PLs invoices show wrong service charge.
No back up persons and insufficient Customs specialists	3PLs has no back up persons to contact when 3PLs staff takes a leave. Also, 3PLs has insufficient Customs specialists.
Delayed Customs clearance process	The Customs has issued a new regulation (317/2547) to prevent the importer from declaring prices lower than the actual value. This is a concern for the Grey market which also affected overall customs clearance process for others. This new regulation adds up a step in the process as well as requires higher authority to approve the release. Sometimes the higher authority takes a leave, so the importer has to wait until he or she comes back. Otherwise, the importer has to negotiate with the customs officer to speed up the process. This affects the overall customs clearance process as it will take longer lead time to complete the process.
Long lead time for inspection & goods release	This inspection and good release activities depend on the Customs officer to perform the function. The long lead time is possible.
Long lead time for inspection & delivery	The Transporter must check the whole parts of vehicles and record the damage (if any) onto inspection sheet before moving and delivering them to the destination. The long lead time can be the result.

2. Measure Phase

In this measure phase, the researcher mapped the process and identified the activities and the lead time of import process starting from the vessel arrival at Thailand port until the delivery of vehicle to the end Customer. The researcher then brought the relevant problems to analyze in the next phase and set the question why AAA Thailand faces with such problems. The results of this process identified the causes of problems.

2.1 Process Mapping

Figure 1 illustrates the process mapping of vehicle import process related to all internal and external parties. Before the vessel arrives, AAA (Thailand) Import &Export prepares the technical data and invoice & packing list and identifies destination as well as reserves money for duty payment (in case of an urgent order). When the vessel arrives and 3PLs receives the complete Import Ticket, the Import & Export department sends a cheque request to Accounting department. It is noted that this cheque request activity has to wait two days for the Liner to submit the manifest (input data via E-Customs) and then forward to 3PLs. The Accounting department takes one day for the approval of the Financial Director and two days for the cheque release.

Figure 1: As-Is Vehicle Import Process and Lead Time of AAA Thailand
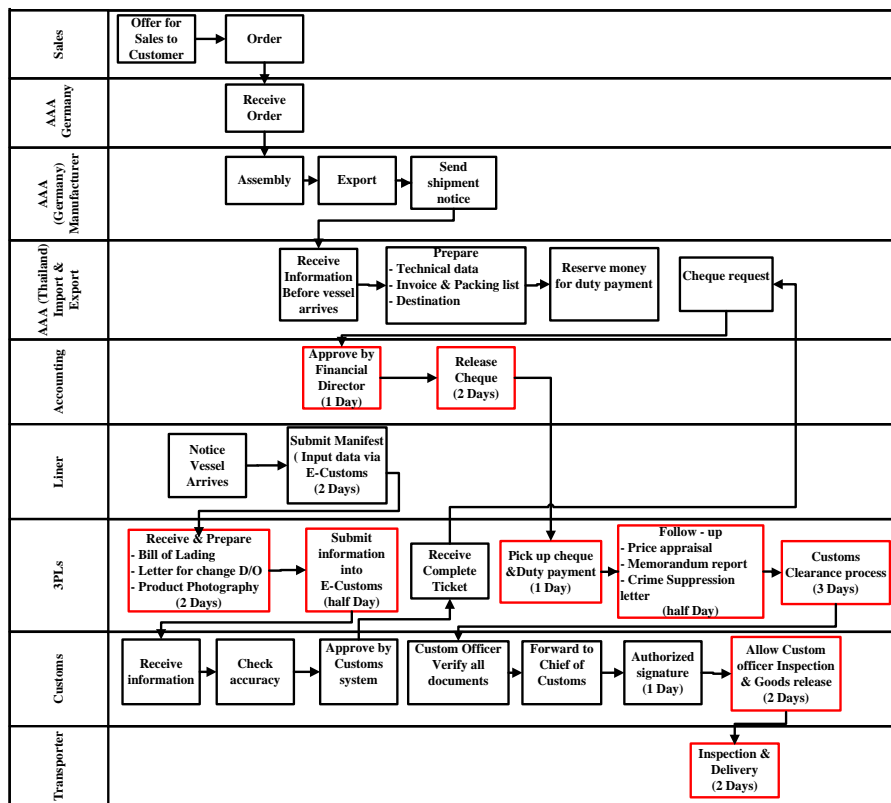
2.2 Cause and Effect (Fishbone) Diagram

A Fishbone diagram, also called a cause and effect diagram, is a visualization tool for categorizing the potential causes of a problem in order to identify its root causes. A fishbone diagram is useful in brainstorming sessions to focus conversation. Fishbone diagram is used in the "Measure & Analyze" phase of Six Sigma's DMAIC (Define, Measure, Analyze, Improve, and Control) approach to problem solving.

Next sections are the problems related to internal party [AAA (Thailand) Accounting department] and external parties (i.e., 3PLs, Customs, Transporter) which contribute to the delay in the whole import process. These problems are explained in detail in Figure 2 accordingly.

Figure 2: Cause and Effect Diagram of Delays
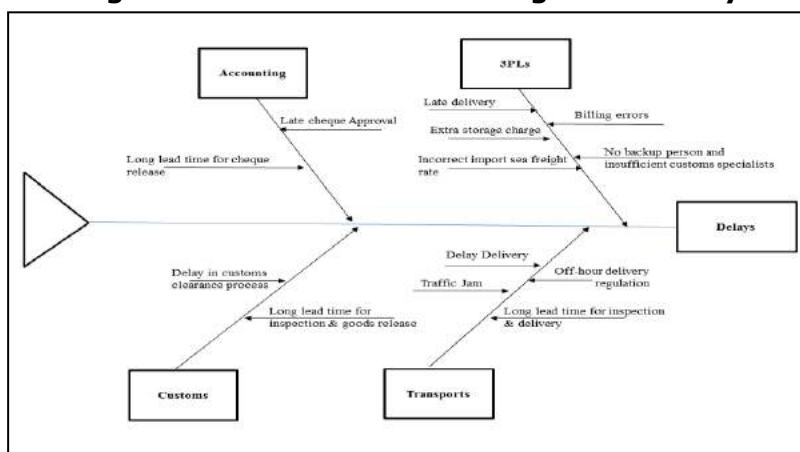
3. Analyze Phase

This section shows the total extra charges arising from delays in the import process of the year 2014. The information was collected from the report of extra storage charge, incorrect import sea freight rate, billing error, and customs overtime charge. The total amount of extra charges from the delays was THB 3,007,612.50. In order to remain in the business, AAA Thailand has to find the solution to reduce the cost in the import process to generate profits and revenues in detail in Table 3 accordingly.

Table 3: Total Amount of Extra Charges for the Year 2014

Month	Extra Storage Charge (THB)	Incorrect Import Sea Freight Rate (THB)	Billing Error (THB)	Customs Overtime Charge (THB)	Total Extra Charges / Month (THB)
January	138,000.00	-	60,709.00	35,000.00	233,709.00
February	41,760.00		80,907.00	20,000.00	142,667.00
March	68,480.00	-	89,429.00	45,000.00	202,909.00
April	143,680.00	124,746.00	77,927.00	45,000.00	391,353.00
May	235,610.00	64,737.50	78,792.00	45,000.00	424,139.50
June	91,620.00	15,327.50	86,625.00	32,000.00	225,572.50
July	8,440.00	117,617.50	90,662.00	20,000.00	236,719.50
August	42,340.00	87,780.00	91,230.00	35,000.00	256,350.00
September	11,680.00	65,346.50	89,790.00	30,000.00	196,816.50
October	17,820.00	-	69,892.00	20,000.00	107,712.00
November	82,360.00	132,009.00	57,880.00	30,000.00	302,249.00
December	89,640.00	93,077.50	54,698.00	50,000.00	287,415.50
Total Extra Charges (THB)					3,007,612.50

RESULTS

The presentation and a critical discussion of results from the current import process causing delays and incurring cost and the recommended new improved import processes. The Improve phase presents the solution of the problems; the results of interview with 3PLs; and the Customs and Transporter supported renew process for AAA Thailand to reduce lead time and cost. Finally, there is the Control phase to monitor and control the to-be process and to ensure that the improved import process will shorten the lead time without delay.

1. Results of Interviews

The researcher conducted an in-depth interview with the AAA Thailand management and relevant responsible parties related to all topics concerning the import of completed car and customs clearance processes. The interview focused on the point of choosing highly-experienced and diligent personnel for the company to increase its capability and improve its strategies. The business automotive company is faced with   high competition not different from the other companies. In order to cope with the   trend of customers' demand in the market, innovation should be created and applied to the product. Moreover, it (innovation) will increase the value added to the production.

1.1 Summary and Result of Cause of Delays

After the implementation of three phases of DMAIC methodology: Define, Measure, and Analyze, the researcher was able to draw a diagram/picture of the relationship between cause and effect, and the results obtained by the delay in the import process are shown in Figure 3.
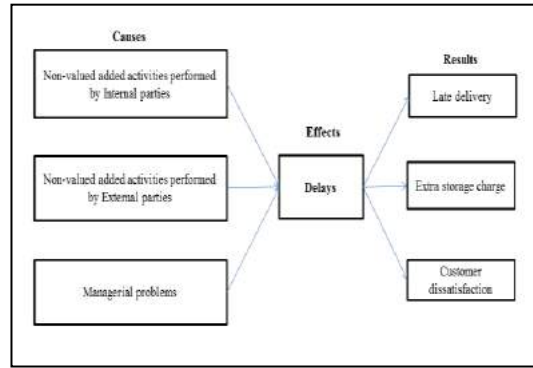
Figure 3: Cause of Delays and Results

Figure 3 shows the causes and effects of delays. Therefore, the researcher proposed an improvement plan.

2. Improve Phase

This phase proposes the new process (the to-be process) to reduce the long lead time of the import process and cost. After the root causes of problems were recognized, the researcher developed solutions and the to-be process to reduce the recurrent problems in the internal and external aspects of the import process. The improvement process is developed as follows:

2.1 Proposed Improvement

This improvement is expected to improve the lead time and delete the non-value added activities in the import process, which is related to internal units, i.e., the Accounting department to speed up the approval by the Financial Director and cheque release process. Then, the external processes of 3PLs, Customs, and Transporter will combine the process and delete the non-value added to the process to shorten the lead time.

The proposed improvements shown in Table 4 have been implemented since   May 2015. The result showed that the import process was reduced from fifteen days was six days at the first month of deployment. It also resulted to 100% decrease in unnecessary costs (becomes zero). The new To-be process is illustrated in Figure 4.

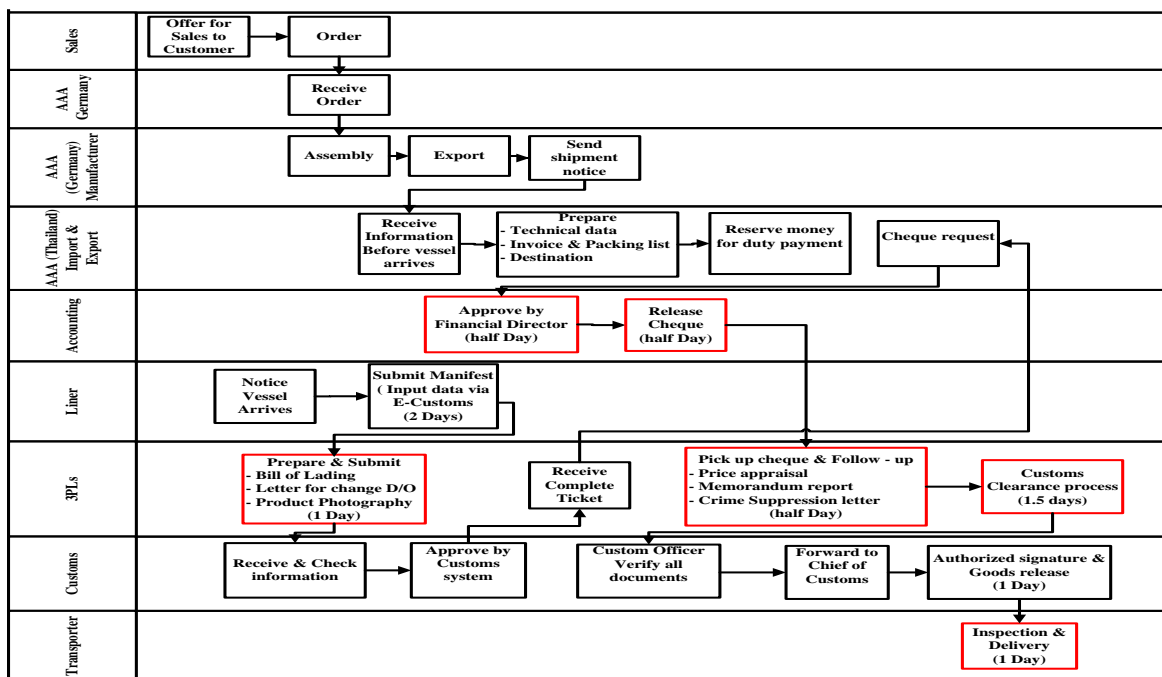**Figure 4: To-Be Vehicle Import Process and Lead Time of AAA Thailand**

Figure 5 shows the comparison lead time of import process As-Is Lead Time and To-Be Lead Time.

Figure 5: Comparison Lead Time of Import Process

Process Description	Operator	Details	As-Is Lead Time Day(s)	To-Be Lead Time Day(s)
Internal Process	Accounting	Approve by Financial Director	1	0.5
		Release Cheque	2	0.5
External Process	3PLs	Receive & Prepare	2	
		Submit information into E-Customs	0.5	1
		Pick up cheque & Duty payment	1	0.5
		Follow – up	0.5	
		Customs Clearance process	3	1.5
	Customs	Authorized signature	1	1
		Allow Customs officer Inspection & Goods release	2	0
	Transporter	Inspection & Delivery	2	1
Total Lead Time			**15**	**6**

2.2 Comparison of the Total Extra Charge

The new process began in May 2015. The researcher was able to use the new process for three months. Due to the limited time for testing the procedures presented, after the proposal was passed in March 2015, the researcher began collecting the data by interviews and taking action against people involved in the import process such as 3PLs, Customs authorities, and transport staff. By comparison, the total cost between January - July 2014 and January - July 2015 is shown in Figure 6. Before the new To-be process was implemented, there were still extra charges incurred in January – April 201. However, when the To-be process was implemented in May – July 2015, the total extra charges was reduced to zero. As a result, AAA Thailand expects that the import shipment will not incur cost from May onwards.

Figure 6: Comparison of the Total Extra Charge between January – July 2014 and

Month	2014					2015				
	Extra Storage Charge (THB)	Incorrect Import Sea Freight Rate (THB)	Billing Error (THB)	Customs Overtime Charge (THB)	Total Extra Charge / Month (THB)	Extra Storage Charge (THB)	Incorrect Import Sea Freight Rate (THB)	Billing Error (THB)	Customs Overtime Charge (THB)	Total Extra Charge / Month (THB)
January	138,000.00	-	60,709.00	35,000.00	233,709.00	20,700.00	-	9,106.00	5,250.00	35,056.00
February	41,760.00	-	80,907.00	20,000.00	142,667.00	2,088.00	-	4,045.00	1,000.00	7,133.00
March	68,480.00	-	89,429.00	45,000.00	202,909.00	58,200.00	40,320.00	120,729.00	39,600.00	258,849.00
April	143,680.00	124,746.00	77,927.00	45,000.00	391,353.00	165,232.00	130,983.00	89,616.00	73,350.00	459,181.00
May	235,610.00	64,737.50	78,792.00	45,000.00	424,139.50	-	-	-	-	-
June	91,620.00	15,327.50	86,625.00	32,000.00	225,572.50	-	-	-	-	-
July	8,440.00	117,617.50	90,662.00	20,000.00	236,719.50	-	-	-	-	-
Total Extra Charge (THB)					**1,857,069.50**	**Total Extra Charge (THB)**				**760,219.00**

January – July 2015

3. Control Phase

The last phase of DMAIC is the control phase, the purpose is to control the to-be process and to maintain the good results and make sure that the new solution makes lead time of import process and costs reduced. Performance measures of the improvement process can guarantee to be effective; the researcher has set the working instructions for this concern.

Figure 7: Control Sheets

Figure 7 shows the control sheet for checking delays & Extra Charge. This was created to keep the record of acknowledgement letters given to the internal and external parties to learn and follow and order.

DISCUSSION

The discussions in this study helped the research answer the research question: "How AAA Thailand can improve its import process to reduce lead time and costs?" In the define phase, AAA Thailand has encountered delays in the import process, where the total lead time import process was fifteen days and the extra cost that affected by the delays (data from January 2014 to December 2014). Then the researcher moved to the measure phase, the researcher mapped the process, identified the activities and lead time of import process starting from the vessel arrival at Thailand port until the vehicle delivery to the end Customer.

The researcher then identified the possible causes of the problem and analyzed them from the analysis diagram showing cause and effect. The data were collected from 3PLs report and Interview. The root cause analysis was from the Analyze Phase, the delays in the import process related to both internal [AAA (Thailand) Import & Export, and Accounting] and external parties (i.e., 3PLs, Customs, and Transporter). The long lead time spent in the non-value added activities performed by these parties contributed to the delays in the import process. For the last step of the analysis phase is the performance analysis.

Next, the researcher moved to the improvement phase. The points that needed to improve were proposed with the to-be process to reduce the long lead time of import process and cost. This phase illustrated the proposed improvement, including the reduction of import process time from fifteen days to six days, and the cost incurred was reduced to zero. The last phase of DMAIC is the control phase, the purpose is to control the to-be process and to maintain the good results and make sure that the new solution makes lead time of import process and costs reduced. The performance measures of the improvement process were guaranteed to be effective, and the researcher created the control sheets for performance measures.

CONCLUSION

This research was undertaken with three objectives in mind. These objectives included:
1. Identify and analyze the current import process of AAA Thailand;
2. Study how AAA Thailand can improve internal and external import process; and
3. Propose new process and create guidelines for 3PLs.
The combination of primary and secondary research has allowed the researcher to fulfill all of these objectives.

The study was conducted because AAA Thailand has encountered delays in the completed car import process. These problems on delays were gathered from weekly and monthly report on 3PLs performance as well from an initial informal interview with the members of the company including the Director of Import & Export, Manager of Logistics, Manager of Transporter tasked with managing the import process for AAA Thailand. The import process is related with both internal [AAA (Thailand) Import & Export, and Accounting] and external parties (i.e., 3PLs, Customs, and Transporter). The long lead time spent in the activities performed by these parties has contributed to the delays in the import process and in the extra cost incurred.

The researcher was aware of the problem, so the DMAIC methodology was used to determine, measure, and analyze to improve the internal and external processes. After analyzing the problem, the company has improved and controlled the import process beginning in May 2015. It has helped company reduce the import process lead time and cost incurred as 100%.

The results of the experiment have brought a new process and have got good results. Thus, using the new process to set as the standard process have to be used with internal & external parties which are relevant to the case study

LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

This study focused on process improvement and developing performance by using DMAIC methodology which identifies the criteria of process improvement for import completed car activities. There were some limitations to this study. One of these limitations was that, since it

was a case study of one company, it could not be generalized to other companies. This is a limitation of the method and cannot be removed.

The first recommendation for further study is to apply the other theories to improve the import process.

The second recommendation is to extend the analysis to other factors like the process improvement that was not possible in this study due to the limitation of action regarding the extent and scope of work. However, a longer study may include more factors that can contribute to the organizational success, increase revenues, and benefit more than the present.

The final recommendation for the future research is to conduct a survey of customer satisfaction. It is a part to improve the process which influences the purchasing decisions of customers and delivers results to the organization on the other side.

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A SYSTEMATIC REVIEW OF THE LOGISTICS AND SUPPLY CHAIN PERFORMANCE MEASUREMENT LITERATURE

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ABSTRACT

Purpose – The purpose of this paper is to provide a systematic review of the logistics and supply chain performance measurement literature that is combined with a citation network analysis. This will enable an identification of the main research clusters in the field of logistics and supply chain performance measurement.

Design/methodology/approach - A systematic review of the literature identified 38 scientific articles from 28 journals during the 2005-2015 period. The systematic review describes the article type, data collection method, year of publication, data analysis method, methodology and research context. The main research clusters were identified by following the guideline of Main Path Analysis (MPA) and analysed with the Pajek software 4.01.

Findings – There are two main findings from this systematic review. The first finding is that the majority of reviewed articles are published in engineering and others journals, such as economics and humanitarian. However, only 32% of the articles on the subject under review are published from logistics and supply chain journals. The main type of published research is based on empirical data with modelling and survey being the main research method. Conceptual or even other types of review are quite scarce. The second finding is that logistics and supply chain performance measurement can be split into 2 main research streams which are related to supply chain performance perspectives with six research clusters and another stream that focuses on measurement and metrics.

Research limitations/limitations - This manuscript only considered only published scientific articles but there are other sources that could be considered type as conference paper, trade journal, and white papers.

Practical implications - This systematic review provides practitioners and scholars with a classification of research clusters in logistics and supply chain performance measurement. (1) scope of performance measurement (2) total quality aspect (3) efficiency and efficacy (4) performance measurement KPIs (5) performance measurement method (6) impact of measurement system on firm's performance and (7) metrics measurement.

Originality/Value - There are many ways to measure the performance in logistics and supply chain management which depends on the objective or framework.

Keywords: Systematic review, Logistics and supply chain management, Performance measurement

INTRODUCTION

According to Mentzer and Konrad (1991), the evaluation of performance is a vital managerial function. There are many reasons as to why firms measure their performance. Some examples found in the literature are to see progress, identify success, report performance, evaluate performance, confirm what is already known, reveal what is not known, understand operating processes, assist operational personnel, identify problems and bottlenecks, form new objectives and targets, determining future courses of action and to confirm priorities (Gunnasekaran et al. 2004; Holmberg, 2000; Kennerley and Neely, 2003).

The purpose of this paper is to provide a systematic review of the logistics and supply chain performance measurement literature combined with a citation network analysis approach. This will enable the identification of the main research clusters in the field of logistics and supply chain performance measurement.

This paper is separated into 2 main sections. The first section will discuss the systematic review methodology while the 2nd section will focus on the findings of the review. The findings of the review will be presented through the use of the Pajek software and conclusions will be derived.

THE SYSTEMATIC REVIEW METHODOLOGY

This manuscript follows the guideline provided by Gopal and Thakkar (2012) as well as Hemingway and Brereton (2009). Figure 1 describes how the articles were selected, evaluated, analysed and interpreted.

The objective of this systematic review methodology will help identify the research streams related to performance measurement in the logistic and supply chain context. The first stage of the review process involved the identification of papers and research reports that were concerned with logistics and supply chain performance measurement. The authors identified electronic databases and websites that could provide potentially relevant articles. The following databases were searched: Emerald, Science Direct, Taylor & Francis, Springer, ABI/Inform, Scopus and Wiley Online Library. However, some journals are available in more than 1 database, such as IJPDLM which is published in Emerald but available in ABI/Inform. To ensure that there has no duplicated journals, ABI/Inform and Scopus were selected as the main database in this systematic review.

The period of publication of the journal articles is from 2005 to 2015. 2005 was chosen as the starting point for the review because it was the year that had the highest number of hits when keywords such as "Logistics" or "Supply Chain" or "Performance Measurement" were selected. Nonetheless, earlier literature was also included.

Figure 1: Review methodology
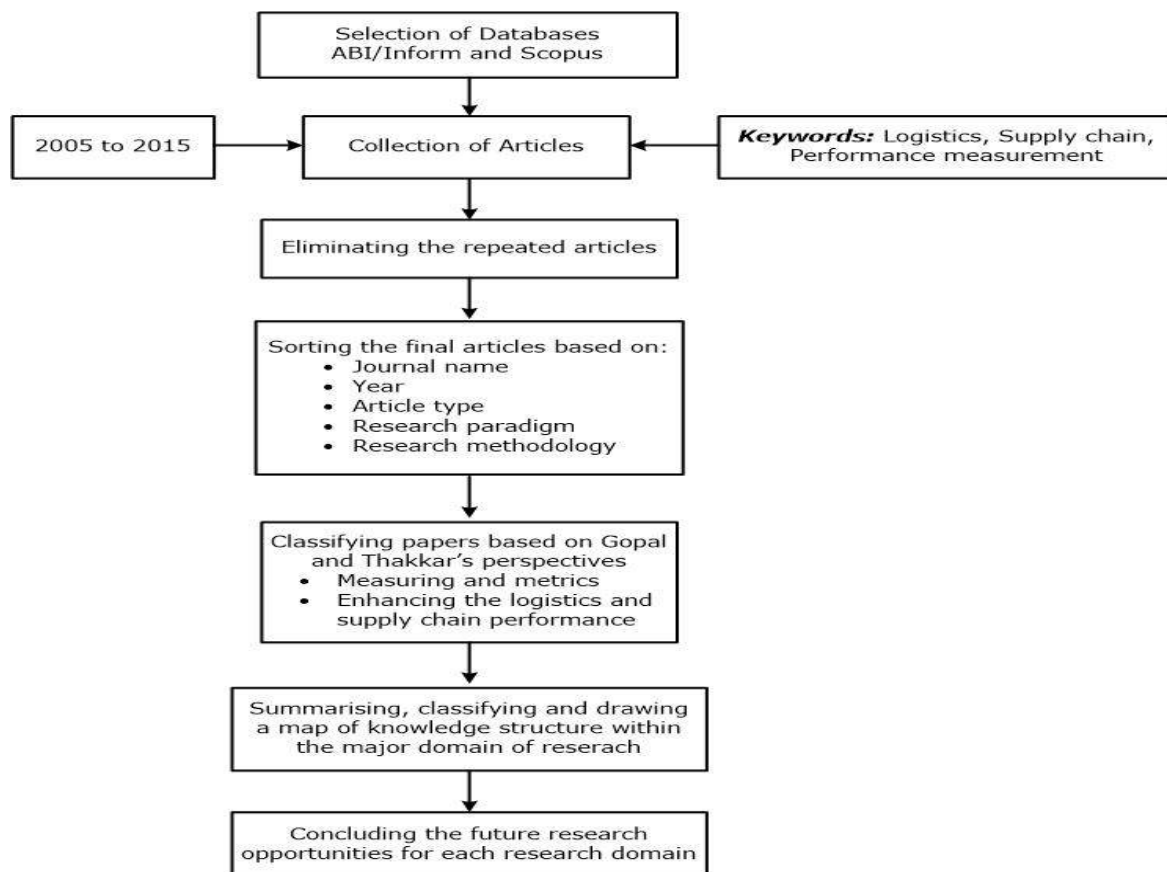
Source: adapted from Gopal and Thakkar (2012) & Hemingway and Brereton (2009)

There are three main keywords used in this review "logistics performance measurement", "supply chain performance measurement", "logistics and supply chain performance measurement" and equivalent keywords are also used for covering all the potential relevant papers. Table 1 summarises the keywords and the search results. This table shows the number of article identified.

Table 1: Search keywords and results (2005-2015)

Keywords	Equivalent keywords and search strings	Number of articles	
		ABI/Inform	**Scopus**
Logistics Performance Measurement	Logistics Performance Assessment; Logistics Performance Evaluation	269	2408
Supply Chain Performance Measurement	Supply Chain Logistics Performance Assessment; Supply Chain Logistics Performance Evaluation	530	948
Logistics and Supply Chain Performance Measurement	Logistics and Supply Chain Performance Assessment; Logistics and Supply Chain Performance Evaluation	76	132

Source: The Authors

In total 153 articles published in 99 journals were discovered. In order to reduce the number of potential papers related to logistics and supply chain performance measurement, the 153 abstracts were screened and 38 abstracts were determined based on their suitability for inclusion in the systematic literature review.

The next step was the analysis and interpretation of the selected articles by focusing on the authors, year of publication, research context (country and industry), objective, methodology, article type, data collection method, data analysis method, contributions and classification dimension according to Di Fan et al. (2014). The last step was focused on understanding the structure of the research domains by following the guideline of Main Path Analysis (MPA) (Colicchia and Strozzi, 2012) with the Pajek software 4.01 (De Nooy et al., 2005).

CLASSIFICATION OF RESEARCH DOMAINS

According to the authors initial finding, logistics and supply chain performance can be divided into two categories: (1) Supply chain measures and metrics and (2) Enhancing the supply chain performance. The 38 articles were further scrutinized on such perspective. It was observed that there were 16 papers related to enhancing logistics and supply chain performance while 22 papers focused on supply chain measures and metrics.

In the enhancing supply chain performance perspective, sub-themes were observed such as performance measurement practices for logistics and supply chain (Wagner, 2008), quality performance measurement (Shokri et al., 2013), logistics and supply chain performance improvement (Keebler and Plank, 2009), performance measurement development (Martin and Patterson, 2009), performance measurement tools (Chia et al., 2009) and impact of measurement system on firm's performance (Wong et al., 2014) as shown in figure 2.

Figure 2: Citation network of the articles in enhancing the supply chain performance perspective.
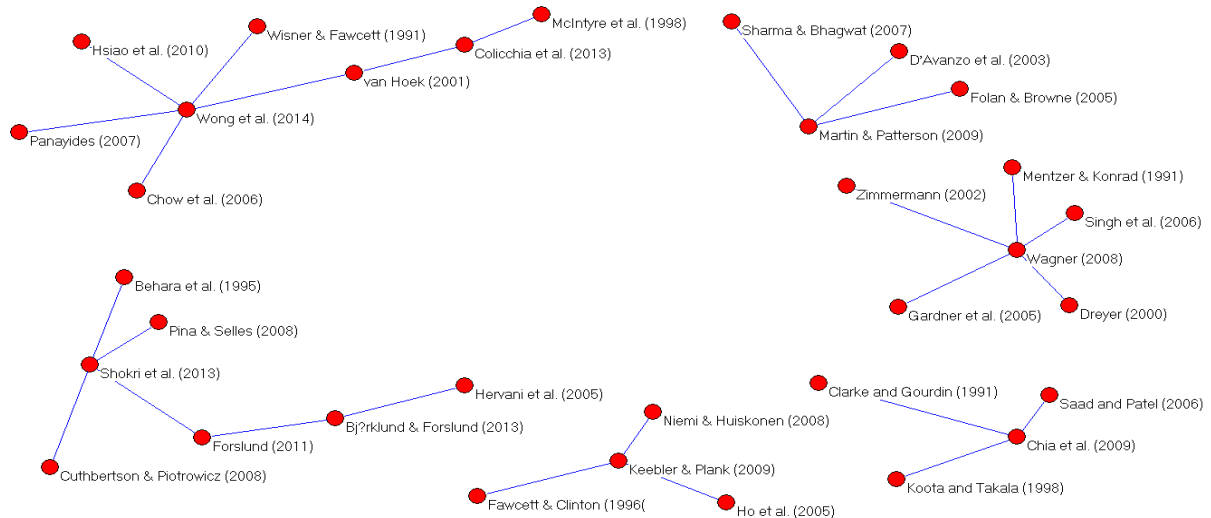
Source: The Authors

22 papers looked into logistics and supply chain measure and metrics perspective (Gunasekaran et al. 2004; Neely et al., 1995; Beamon, 1999) which explored supply chain metrics as shown in figure 3.

Figure 3: Citation network of supply chain metrics literature
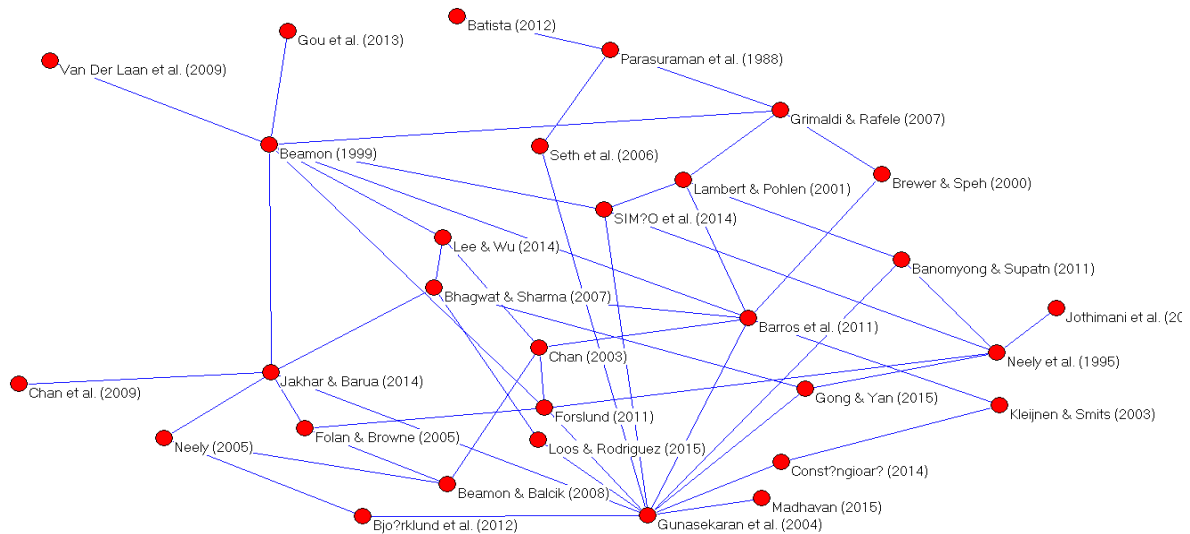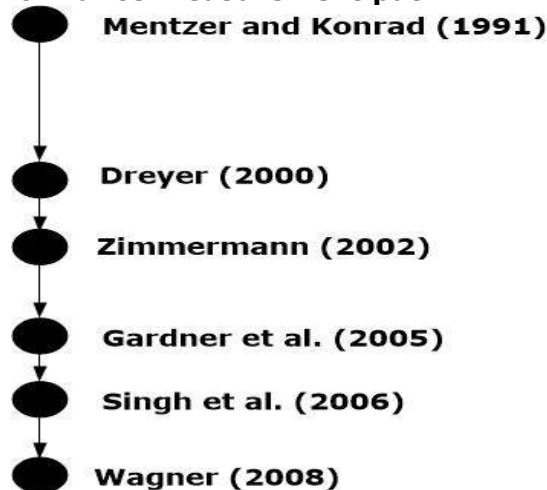

Source: The Authors

RESEARCH STREAMS PATH ANALYSIS

Figure 2 and Figure 3 illustrated the structure of two research domains which are enhancing logistics and supply chain performance as well as supply chain metrics by following Main Path Analysis (MPA) approach (Colicchia and Strozzi, 2012), the authors used the citation network as the key to link each article with Pajek software 4.01 (De Nooye et al., 2005).

Reviewing supply chain performance enhancement

There are six research clusters within this domain. The first stream is related to the scope of performance measurement in logistics and supply chain which was proposed by Wagner (2008). He overviewed and reviewed cost management practices which can support firms in influencing systems and human behaviour in a supply chain context. Figure 4 shows the growth of knowledge related to performance measurement practices for logistics and supply chain. Initially, Mentzer and Konrad (1991) proposed logistics performance measurement practices and suggested methods for improvement from an efficiency and effectiveness perspective. Dreyer (2000) suggested that organizations need effective metrics to enable them to evaluate business performance on a global basis through the development of a successful model for measuring supply chain performance. In year 2002, Zimmermann extended the development steps with an inter-enterprise Supply Chain Balanced Scorecard in order to implement joint supply chain strategies and to support supply chain improvement efforts. Moreover, Gardner et al. (2005) presented the top 20 key performance indicators recommended by APQC and CSCMP which consist of cost, time and reliability dimensions. Singh et al. (2006) stated that organisations need to recognise the strategic contribution of suppliers to total performance and increasingly expect their suppliers to offer cost, quality, time, flexibility, delivery and technological advantages.

Figure 4: Scope of performance measurement path

Source: The Authors

The second cluster is focused on total quality aspect which was proposed by Shokri et al. (2013) and Bejorklund and Forslund (2013) as shown in figure 5. The starting point came from an article by Behara et al. (1995), where they measured the probability of manufacturing a product or creating a service through the six sigma concept or zero defects to measure customer satisfaction.

Figure 5: Quality performance path
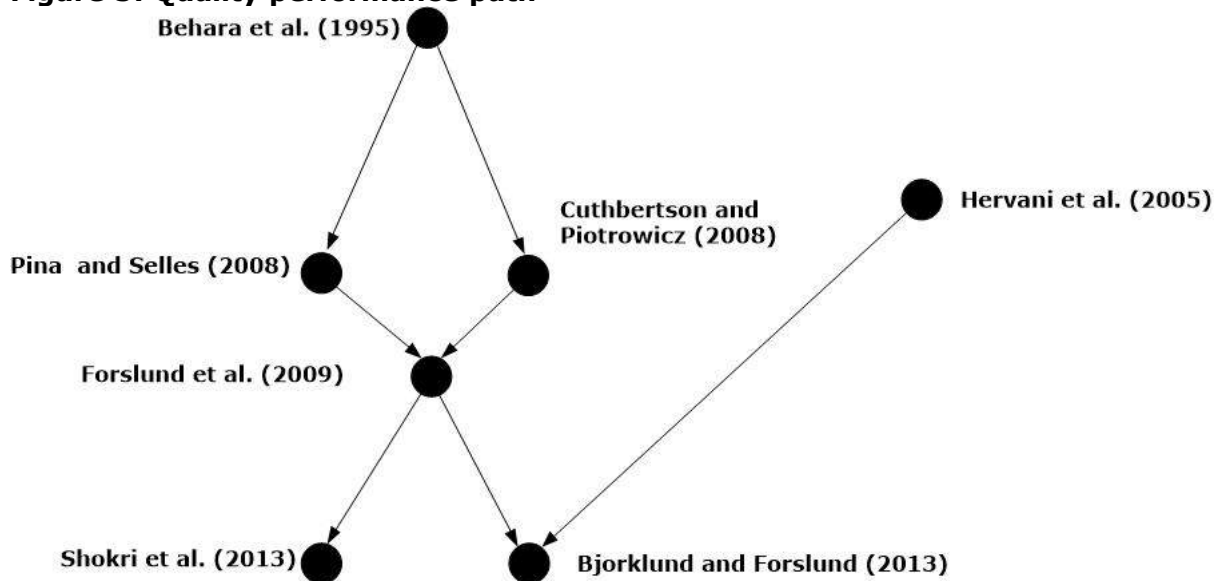
Source: The Authors

The next research cluster is an efficiency and efficacy in logistics and supply chain management proposed by Keebler and Plank in 2009. They described the state of logistics performance measurement in corporations and provided a benchmark for organizations assessing the quality of their logistics performance measurement practices to identify opportunities for significant improvement.

Figure 6: Efficiency and efficacy path

Fawcett and Clinton (1996)

Ho et al. (2005)

Niemi and Huiskonen (2008)

Keebler and Plank (2009)
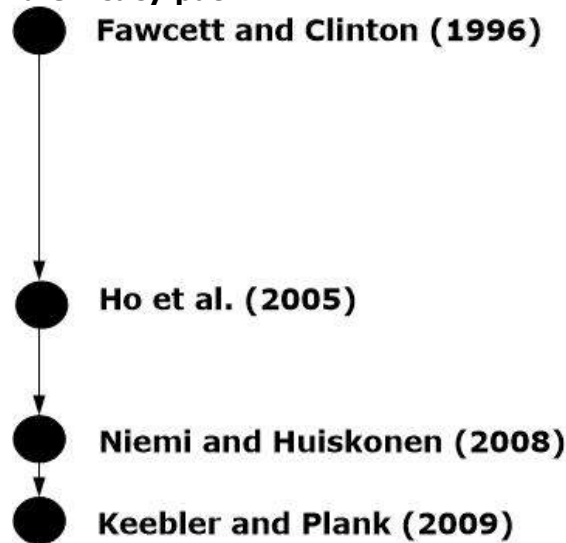
Source: The Authors

The next cluster is related to KPIs in logistics and supply chain performance measurement which is proposed by Martin and Patterson (2009). They introduced the effectiveness of information systems in supporting the extended supply chain and investigated the use of common measurement metrics in an attempt to determine which one(s) are most useful for measuring performance.

Figure 7: Performance measurement KPIs path

D'Avanzo et al. (2003)

Folan and Browne (2005)

Sharma and Bhagwat (2007)

Martin and Patterson (2009)
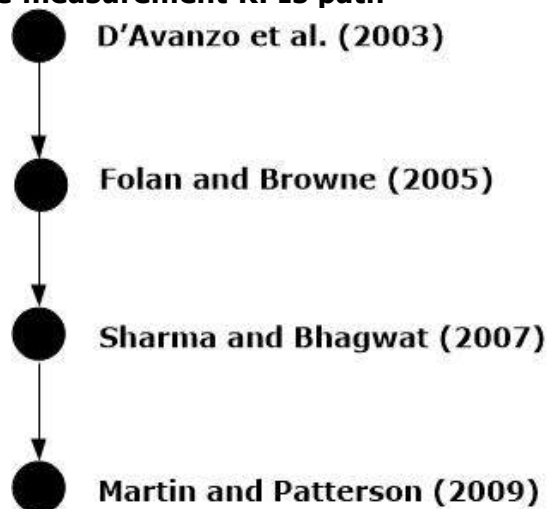
Source: The Authors

The next identified cluster focused on methodology of performance measurement as proposed by Chia et al. (2009). In order to manage a supply chain's overall performance necessitates the coordination of measures across the different entities on the supply chain, often requiring all entities to adopt a common balanced perspective in their performance management to facilitate the overall performance and competitiveness of the entire supply chain. However, the original idea came from Clarke and Gourdin (1991) as shown in figure 8.

Figure 8: Performance measurement method path
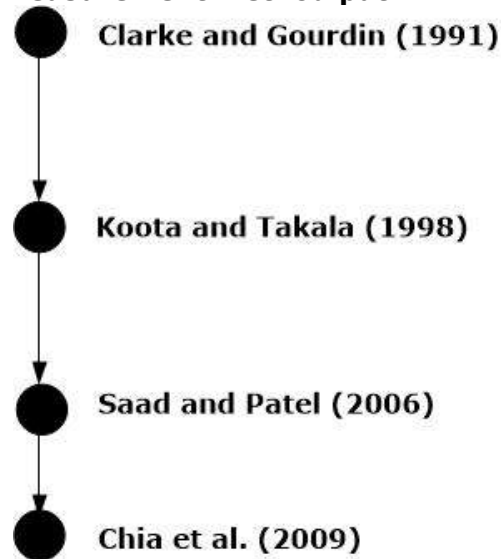
Source: The Authors

The last stream is the impact of measurement system on firm's performance as discussed by Wong et al. (2014). The starting point of this cluser came from Wisner and Fawcett (1991) who identified basic characteristics of world-class manufacturers.

Figure 9: Impact of measurement systems on firm's performance path
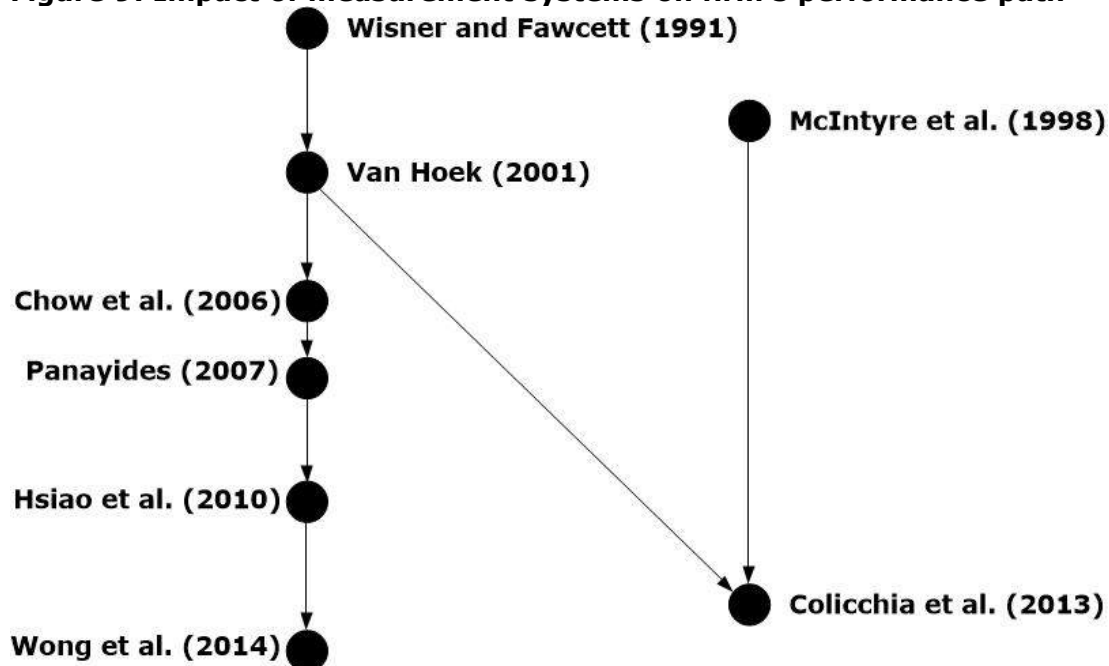
Source: The Authors

Reviewing supply chain measure and metrics
This research domain presents only one cluster with three articles that have the most citations. The first article named "Measuring Supply Chain Performance" by Beamon (1999) who proposed a supply chain performance measurement stream. This article was used as a reference for developing the performance measurement system by many practitioners and scholars such as Grimaldi & Rafele (2007), Van Der Laan et al. (2009), Barros et al. (2011), Forslund (2011), Gou et al. (2013), Jakhar & Barua (2014), Lee & Wu (2014) and SIMÃO et al. (2014).

The second most cited article entitled "A Framework for Supply Chain Performance Measurement" by Gunasekaran et al. (2004) who proposed a supply chain performance modelling/framework stream. This article was used as an important reference to asssess performance by scholars such as Seth et al. (2006), Banomyong and Supatn (2011), Barros et al. (2011), Forslund (2011), Bjorklund et al. (2012), Constăngioară (2014), Jakhar and Barua (2014), SIMÃO et al. (2014), Madhavan (2015), Loos and Rodriguez (2015) and Gong and Yan (2015).

The last seminal paper is entitled "Performance measurement systems design: a literature review and research agenda" by Neely et al. (1995) who proposed a performance measurement framework. This paper was cited by academics and practitioners such as Banomyong and Supatn (2011), Forslund (2011), Jothimani et al. (2014), Simao et al. (2014) and Gong and Yan (2015) in their development framework.

SUMMARY

This paper used the systematic method to review 38 articles from 28 journals and 2 databases. Subsequently, these 38 articles are classified into 2 main research domains based on Gopal and Thakkar (2012). The authors analyzed main path analysis (MPA) by following the guideline from Colicchia and Strozzi (2012) and used citation network as a key to link each article and conducted by Pajek software 4.01 (De Nooye et al., 2005) in each research domain.

The analysis shows that there are six research streams in the enhancing supply chain performance domain and three seminal papers in the supply chain measures and metrics domain. This review also observed gaps in research areas related to each paths. The first path describe that many performance dimensions are taken into account. This is the same as in the fourth path which investigate the use of common measurement metrics in an attempt to determine which one(s) are most useful for measuring performance but not including the environmental and social perspectives. Hence, future research efforts in both these paths should aim to better understand how to measure environmental and social practices.

The second path is a reflection on how quality management programs can be implemented effectively through performance measurement. The third path describe how diagnostic and assessment of logistics and supply chain performance can be done. However, there is a lack of benchmarking research to identify best practices. The fifth path describes various dimensions of performance but the measurement methods are restricted to single-firm case studies. The last path of enhancing supply chain performance domain is limited on how to utilise integrated measures that can highlight the contribution of corporate goals such as Economic Value Added. Finally, the three seminal papers by Beamon (1999), Gunasekaran et al. (2004) and Neely et al. (1995) must be referred to when reviewing supply chain measure and metrics.

The limitation of this systematic review is based on the restricted scope of material used as the focus has been exclusively on published research papers in academic journals. This narrow scope does not provide insights into the possible direction of each path that may be found in white papers or even conference papers.

REFERENCES

Can be furnished upon request

HOSPITAL-SUPPLIER INTEGRATION AND HOSPITAL PERFORMANCE: EVIDENCE FROM THE SAUDI ARABIAN HEALTHCARE SYSTEM

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ABSTRACT
One of the priorities of the healthcare sector is to minimise costs and to enhance the quality of service provided. The integration between hospitals and suppliers is a major factor associated with the cost of managing and operating the relevant supply chains. Quantifying the relationship between the measures of hospital-supplier integration and hospital performance can provide useful insights to minimise costs and improve the quality of service. There are limited studies which have undertaken such research into the hospital-supplier integration and hospital performance in the context of Saudi Arabia. A quantitative survey of the senior management of Saudi Arabian hospitals was undertaken to collect data about measures of hospital-supplier integration and hospital performance. The survey was designed based on an extensive review of relevant literature, and included measures of hospital-supplier integration and hospital performance, namely, logistics integration, information technology integration, information sharing, and trust; and quality, speed, cost and flexibility, respectively. The results of a confirmatory factor analysis (CFA) analysis found logistics integration and trust to be positively and significantly associated with hospital performance. Out of these, trust had a stronger association with hospital performance compared to logistics integration. This information can be utilised by healthcare managers in Saudi Arabia to improve hospital performance by optimising the above-mentioned measure of hospital-supplier integration.

1. INTRODUCTION
A major theme in the healthcare literature is the simultaneous reduction of cost of service and improvement of the quality of patient care (Glaser and Salzberg 2011, OECD 2012). Soaring expenses, some driven by clinicians associated with hospitals, have urged decision makers to find new methods to improve the operational efficiency. Kowalski (2009) studied hospital supplies and materials over a period of time and reported that supplies and materials have contributed to 45% of the operational budget of a hospital. Not only is the cost high, but also there is an escalated trend in these expenses (DeJohn 2009). Studying the integration between organisations and their suppliers has been a major area of research in different industries (see for example Lee and Padmanabhan (1997); Liu, Zhang et al. (2005); Kim (2009))) and this highlights the importance of conducting such a research. The literature is rich in studies in the area of organisation-supplier integration in different industries like manufacturing and retail (Schonberger 2007). This has led to extensive knowledge in this area, and found a vast array of management practices. However, the application of this in healthcare is limited. Even with these studies, researchers have only covered limited number of factors that affect this integration (Chen, Preston et al. 2013); and there has been a lack of studies which look into all these factors and their impact on hospital performance.

In this research, we have identified trust, logistics integration, information sharing, and information technology as measures of hospital-supplier integration, and have investigated the effect of these measures on hospital performance. The relationship has been tested in the context of Saudi Arabia. Healthcare spending is increasing, influenced by a number of factors, including the increased demand of health services, healthcare reform initiatives, and the changes in lifestyles and its consequences (OECD 2012). For example, the annual growth in health spending in Organisation for Economic Co-

operation and Development (OECD) countries in real terms between 2000 and 2009 was 4.1% compared to Gross Domestic Product (GDP) growth of only 1.5%. Even after the financial crisis around the world, healthcare spending has not declined in a number of large economies (OECD 2013). Furthermore, the expenditure on health purchases in Saudi Arabia has been increasing in the last five years (MoH 2013). This covers the expenditure on operational cost (beds, purchasing, medications, equipment, and other operations) in the healthcare delivery. This expenditure increased approximately 269% between 2007 and 2013. This presents a need to control the cost and reduce waste without compromising the quality of healthcare outcomes in Saudi Arabia and in the world in general.

This second section of this paper starts off by providing some information about supply chain integration in general, and then moves on to the a review of literature relating to hospital-supplier integration, hospital performance and the development of a conceptual framework. The third section of this paper summarizes the methods employed for this study. This is followed by a summary of the findings in the fourth section and a discussion of the findings in the fifth section. Finally, some concluding comments are offered in the sixth and last section.

2. HOSPITAL-SUPPLIER INTEGRATION

Supply chain integration may be defined as the close coordination and alignment between the various stakeholders associated with the supply chain. Compared to companies which have traditional supply chains, companies with integrated supply chains have a better chance of survival (Stevens, 1989). Some of the advantages of integrated supply chains include minimising inventory and general supply chain associated costs, and providing better customer service. Hospital-supplier integration can be considered as a subset of general supply chain integration. Whilst there are similarities between the two there are some specific aspects associated with hospital-supplier integration.

Hospital-supplier integration can be defined as the extent to which the business processes between a hospital and its key suppliers are strategically coupled and unified as a whole (Chen, Preston et al. 2013). The literature in this area is quite rich with studies that assign positive impacts to this integration on the overall performance of a hospital. Due to the complexity of the healthcare industry, one cannot find a widely agreed definition of hospital performance in the literature. In this research, we use four measurements for hospital performance, namely quality (order fulfilment process); speed (length and efficiency of the order fulfilment process and cycle time); cost of order fulfilment; and flexibility of order fulfilment (Hult, Ketchen et al. 2006).

Logistics integration can be defined as well-coordinated flow of materials from suppliers which allow firms to have a smooth operations process (Frohlich & Westbrook, 2001). Such coordination produces a seamless connection between firms and suppliers in such a way that the boundary of activities between the two parties is getting blurred (Gregory et al., 1998; Stock, Greis, & Kasarda, 2000). Some of the research on the impact of logistics integration on hospital-supplier integration shows that logistics integration allows companies and their supply chain partners to act as a single entity which can result in improved performance throughout the chain (Gregory et al., 1998). Through logistics integration, firms can have the potential benefits of vertical integration (quality, dependability, planning and control, and lower costs) without having it in the physical sense (La Londe & Masters, 1994); and have positive impact on customer satisfaction, lead time, reducing cost, reducing risks, improving sales, distribution, customer service and service levels (Nooteboom, 1992; Reddi et al., 1993; Seidmann, & Sundararajan, 1997; Liu, Zhang, & Hu, 2005; Kim, 2009). Therefore, it is hypothesised that logistics integration will have a positive association with hospital performance (see hypothesis 1 below).

There has been a wide agreement that information technology (IT) integration between hospitals and their suppliers has direct and indirect impacts on hospital-supplier integration and on the overall performance of supply chain. Some of the research on the impact of IT integration on hospital-supplier integration shows that IT implementation has no direct impact on supply chain performance, but it indirectly enhances it by its positive impact on supply chain integration (Li, Yang, Sun, & Sohal, 2009). Other studies show that there is a positive and direct relationship between integrated information technologies and supply chain integration, supply chain integration and customer service, and customer service and firm performance (Vickery, Jayaram, Droge, & Calantone, 2003). Therefore, it is hypothesised that IT integration will have a positive association with hospital performance (see hypothesis 2 below).

Dyer and Singh (Dyer, Cho, & Chu, 1998) define inter-organizational information sharing between hospitals and their key suppliers as the extent to which the hospital shares information about transaction in the business to generate 'specialized knowledge'. Information and knowledge sharing between hospitals and their suppliers play a key role in gaining competitive success (Klein, 2007). Research on the impact of information sharing on hospital-supplier integration shows that the collaborative planning activities can be enhanced by maintaining direct and frequent information sharing between a hospital and its key suppliers, in areas such as inventory monitoring, ordering, and production scheduling (Gavirneni, Kapuscinski, & Tayur, 1999). It is evident that without the willingness to share needed information between supply chain partners, large investments in IT could fail to produce expected benefits (Fawcett, Osterhaus, Magnan, Brau, & McCarter, 2006). Therefore, it is hypothesised that information sharing will have a positive association with hospital performance (see hypothesis 3 below).

The required information sharing between hospitals and their suppliers is a risky practice, as giving outsiders access to information about the internal activities of a hospital needs to be treated carefully. Studies on the impact of trust on hospital-supplier integration show that trust has a positive impact on hospital-supplier integration (Colquitt et al., 2007), it helps speed up the knowledge transfer between firms and their suppliers (Squire, Cousins, & Brown, 2009), and improves the quality of the information sharing practices between hospitals and their suppliers improves (Moorman at al., 1992). Therefore, it is hypothesised that trust will have a positive association with hospital performance (see hypothesis 4 below).

Using the literature review discussed earlier, we suggest a conceptual framework to study the relationship between the measures of hospital-supplier integration and hospital performance. The framework is shown in Figure 1. It is hypothesized that logistics integration, IT integration, information sharing, and trust between hospitals and their suppliers will be positively and significantly associated with hospital performance. These hypotheses are summarised in the Table 1.

Hypotheses
H1: Logistics integration is positively associated with hospital performance
H2: Information technology is positively associated with hospital performance
H3: Information sharing is positively associated with hospital performance
H4: Trust is positively associated with hospital performance

Table 1. Hypothesized relationship between supplier-hospital integration and hospital performance
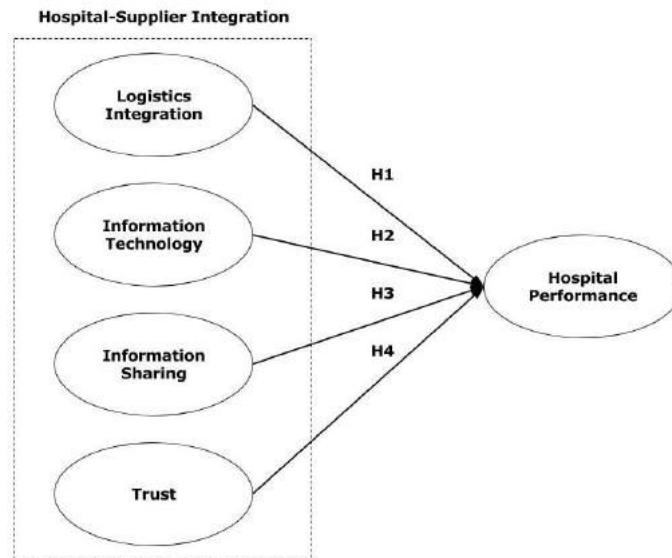
Figure 1. Relationship between measures of hospital-supplier integration and hospital performance

3. METHODS

This section describes the methods employed for this research.

3.1. Sample

The research employed a quantitative research approach based mainly on a field survey. A survey was designed to capture all relevant aspects of logistics integration, IT integration, information sharing and trust in a healthcare setting and based on a rigorous literature review. As on 2014, there were 259 public, 137 private and 39 other government sector hospitals, totalling 435 in Saudi Arabia. From every hospital, five types of managers were considered for survey participation including procurement executives, logistics and supply chain managers, medical services managers, chief executive office (only for small hospitals) and quality management director. Thus, the total sample size available for the survey was 2,175. Potential survey participants were targeted through online and traditional mail channels.

3.2. Confirmatory Factor Analysis (CFA) and Model-Fit Criteria

In this research, we investigated the relationship between the variables through a CFA. CFA was considered a more appropriate technique to theoretically validate the questionnaire, and gain insights into the nature of the subscales, and data-model fit.

A wide variety of model-fit indices are available. The goodness-of-fit measure, the chi-square test statistic, is used for testing the significance of the model. The chi-square (χ^2) test statistic is used for hypothesis testing to assess the appropriateness of data to a model. Significance or non-significance of the chi-square (χ^2) is a basis to conclude whether the model is supported by sample data or not. According to Hu & Bentler (1995), the chi-square (χ^2) test statistic has some limitation such as dependency to sample size and hence the test results are not reliable. So, numerous other descriptive fit indices have also been developed. The non-centrality parameter (NCP) is calculated as (χ^2/df). It has an expected value of NCP < 5 to indicate perfect fit (Marsh & Hocevar, 1985). A third criterion is that the root-mean-square error of approximation (RMSEA) must be smaller than the acceptable level of model fit. If the value of RMSEA is <0.08, the data and the model are matched (Brown & Cudeck, 1993). Furthermore, the goodness-of-fit index (GFI), the adjusted goodness-of-fit index (AGFI), the comparative

fit index (CFI), the normed fit index (NFI), and the Tucker-Lewis index (TLI) are fitness indices which have to be higher than acceptable level of 0.90 for concluding that the data fits the model (Joreskog & Sorbom, 1984). When the model fitness criteria are not within the acceptable level, the interpretation is that it is a misspecification. For the misspecified model, some model modifications might allow achievement of a better sample data. Following the individuals CFA models, a full CFA model was developed to test the main hypothesis for this study. Significances and the directions of the hypothesised relationships were calculated and assessed on the basis of the strength and significance of the parameters in the structural model.

4. ANALYSIS & RESULTS

4.1. Sample Profile

A final sample size of n = 498 was obtained from the survey. This indicated a response rate of 23%. A vast majority of the participants were males (n=460, 92.4%). The largest groups of participants had a Bachelor degree (n=194, 39%). This was followed by people with a post-graduate or a Master's degree (n=129, 25.9%), and people with a Doctorate degree (n=109, 21.9%). It should be noted that a large proportion of participants have higher education degrees (e.g. Post-graduate/Masters or more). Almost one-fifth of the participants each held the position of a procurement executive, logistics and supply chain manger, medical services manager, chief executive officer, or a quality management director. A vast majority of the participants had more than 11 years of experience (n=444, 89.1%). Amongst these, the largest group had between 16-20 years of experience (n=182, 36.5%), this was followed by people with more than 20 years of experience (n=137, 27.5%), and people with between 11-15 years of experience (n=125, 25.1%). These results indicate that the sample was characterised by participants who have extensive experience. Almost a quarter each of the participants indicated to have been 11-15 years of experience in healthcare (n=137, 27.5%), between 16-20 years of experience in healthcare (n=118, 23.7%), and 6-10 years of experience in healthcare (n=116, 23.3%). The other major group are people with more than 20 years of experience in healthcare (n=90, 18.1%). Almost half each of the participants are associated with public hospitals (n=251, 50.4%) and private hospitals (n=247, 49.6%). There was an almost equal representation of hospitals of different sizes in the sample.

4.2. Confirmatory Factor Analysis (CFA)

The results from the CFA of logistics integration, information technology, information sharing, trust and hospital-performance subscales are summarised in Table 2. In all the instances, modifications were made to the preliminary fit to achieve a final fitted model. These were either in the form of allowing loadings to vary or by dropping low correlation items from the model. In all the models shown in Table 2 below, the final model as a χ^2/df value of less than 5, an RMSEA of less than 0.08 and GFI, GAFI, CFI, NFI and TLI values all greater than 0.90. Therefore, these models meet the model-fit criteria described previously.

Initial Model	Final Model
Logistics Integration	
χ²=13.19 (p=0.001), χ²/df=6.96, RMSEA=0.11, GFI=0.99, AGFI=0.93, CFI=0.99, NFI=0.99, TLI=0.96	χ²=1.93 (p=0.17), χ²/df=1.93, RMSEA=0.04, GFI=1, AGFI=0.98, CFI=1, NFI=1, TLI=0.99
Information Technology	
χ²=61.19 (p<0.001), χ²/df=12.24, RMSEA=0.15, GFI=0.96, AGFI=0.87, CFI=0.96, NFI=0.96, TLI=0.93	χ²=7.58 (p=0.056), χ²/df=2.53, RMSEA=0.06, GFI=0.99, AGFI=0.97, CFI=1, NFI=1, TLI=0.99
Information Sharing	

Initial Model	*Final Model*
χ^2=62.59 (p<0.001), χ^2/df=6.96, RMSEA=0.12, GFI=0.96, AGFI=0.91, CFI=0.96, NFI=0.96, TLI=0.94	χ^2=8.16 (p=0.148), χ^2/df=1.63, RMSEA=0.04, GFI=1, AGFI=0.98,CFI=1, NFI=0.99, TLI=0.99

Trust

χ^2=136.78 (p<0.001), χ^2/df=27.36, RMSEA=0.23, GFI=0.9, AGFI=0.71, CFI=0.89, NFI=0.88, TLI=0.77	χ^2=0.1 (p=0.752), χ^2/df=0.1, RMSEA=<0.001, GFI=1, AGFI=1, CFI=1, NFI=1, TLI=1

Hospital-Performance

Initial Model	Final Model

χ^2=1522.79 (p<0.001), χ^2/df=28.2, RMSEA=0.23, GFI=0.61, AGFI=0.44, CFI=0.79, NFI=0.78, TLI=0.74

χ^2=6.52 (p=0.162), χ^2/df=1.63, RMSEA=0.04, GFI=1, AGFI=0.98, CFI=1, NFI=1, TLI=1

Table 2. Estimated standardised coefficients for the preliminary and final fit for logistics integration, information technology, information sharing, trust and hospital-performance subscales

The final fitted full CFA model is shown in the Figure 2. The model has a significant the chi-square statistic at $\chi^2(273) = 1109.66$ (p<0.001). The χ^2/df value of NCP is 4.07, which is below 5. The GFI, CFI, NFI, and TLI are 0.85, 0.92, 0.90, 0.91 respectively. RMSEA value (0.08) is within the recommended level. These results indicate that the final fitted full CFA model and the actual matrices are the same.

Table 3 shows the strengths and significance of the structural paths. The results indicate that logistics integration and trust aspects of hospital-supplier integration are significantly and positively associated with hospital-performance. Trust was found to have a relatively stronger relationship with hospital performance compared to logistics integration. However, information technology and information sharing aspects of hospital-supplier integration have not been found to be significantly associated with hospital-performance. Table 3 shows the results obtained corresponding to the hypotheses mentioned previously.
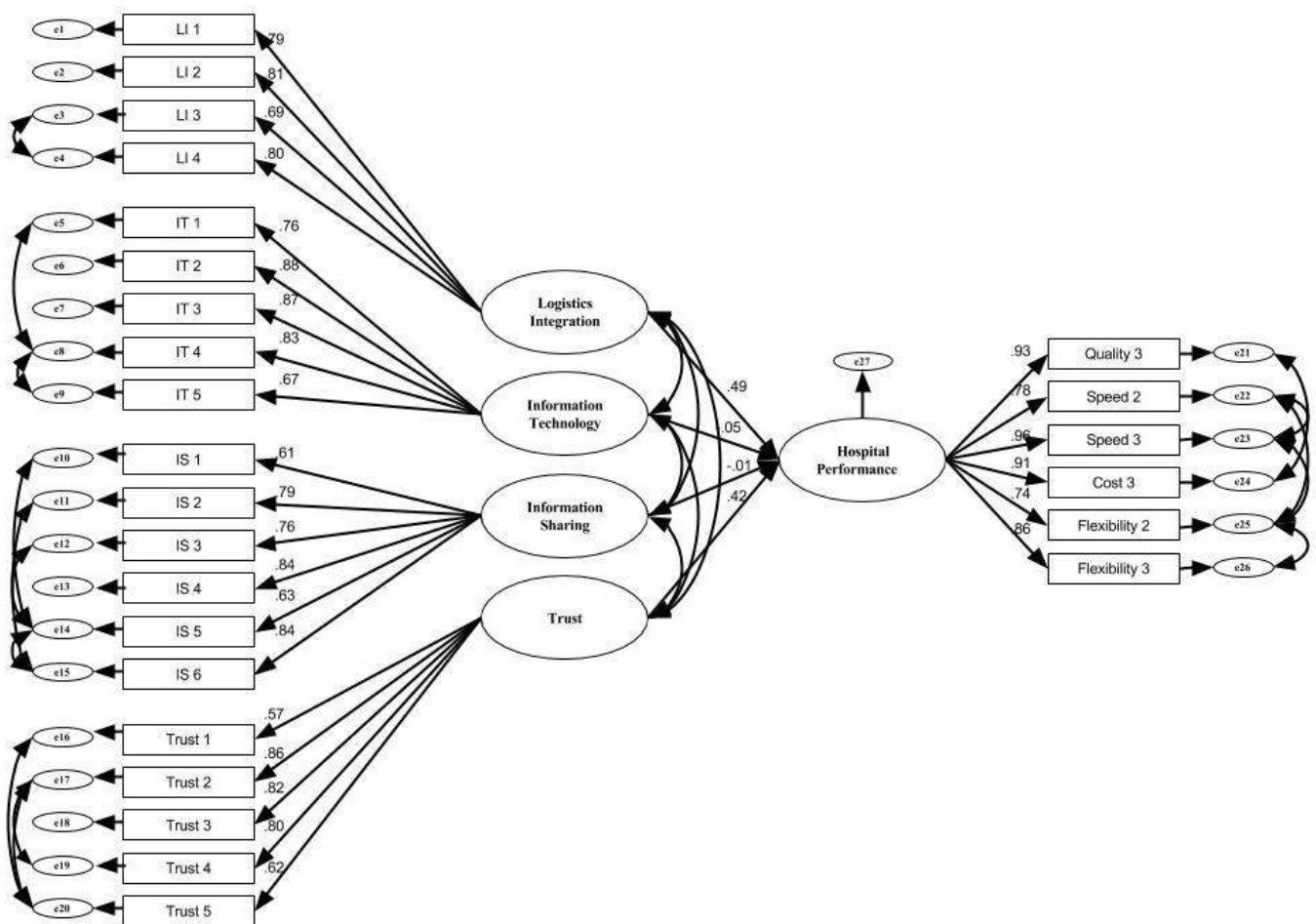
χ^2 (273)=1109.66 (p<.001), χ^2/df=4.07, RMSEA=0.08, GFI=0.85, CFI=0.92, NFI=0.90, TLI=0.91

Figure 2. Final full fitted CFA model

Hypotheses	Estimate	S.E	p-value	Support
H1: Logistics integration is positively associated with hospital performance	1.18	0.24	***	Supported
H2: Information technology is positively associated with hospital performance	0.13	0.15	0.395	Not supported
H3: Information sharing is positively associated with hospital performance	0.02	0.14	0.866	Not supported
H4: Trust is positively associated with hospital performance	1.57	0.26	***	Supported

Significant at level p <0.001

Table 3. Results from the hypothesis testing

5. DISCUSSION

It was hypothesised that there would be a positive and significant relationship between the four identified measures of hospital-supplier integration, namely, logistics integration, information technology, information sharing and trust, and hospital performance. However, only the relationship between logistics integration and trust, and hospital performance was found to be positive and significant. The other two hypothesised relationship were not significant.

As mentioned in the review of the literature relating to logistics integration previously, good coordination between the hospital and the supplier is positively associated with a number of aspects of hospital performance including lead time, cost minimisation, and improving customer service. The trust aspect of hospital-supplier integration can also be viewed from the same perspective. There has to be sufficient high level of trust between hospitals and their suppliers to be able to deliver optimal hospital performance and customer service for key stakeholders. One can argue that if there is a positive and significant relationship between trust and hospital performance, then the same could be expected for information sharing and hospital performance. This is because trust and information sharing are closely related concepts. The lack of a positive and significant relationship between information sharing and hospital performance could be explained by two factors: culture and strategic reasons. It is possible that the culture of information sharing between organisations in Saudi Arabia is not as advanced as in more developed countries. Also, there may be reluctance on part of the suppliers to share information with hospitals due to reasons of giving away strategically important information which may work against them. For example, too much information sharing might give away the details of pricing of products and services by the suppliers which can be used against them by the hospitals (e.g. as a bargaining chip). It should be noted that Saudi Arabia is a developing country and it may not have a very developed and robust IT infrastructure and/or acceptance that enables advanced levels of IT integration between different organisations. Fandy (2000) reviewed the relationship between information technology, trust and social change in Saudi Arabia. He found that due to the traditional state control of information media in Saudi Arabia, more reliance in placed on oral and unofficial means of communication as opposed to IT system driven communications. Almarshad (2013) researched the implementation of organisational factors in IT department in Saudi Arabian hospitals as a part of his doctoral research. He found that the following factors negatively affect IT project implemenation and performnace in Saudi Arabian hospitals: lack of management support, lack of training and knowledge amongst IT department,

lack of IT improvement, lack of IT planning, unclear IT department objectives, IT professionals' turnover, lack of ambition amongst IT employees, and lack of sharing knowledge. These factors could explain why IT integration was not significant to hospital performance for our sample as it might be perceived as a less reliable means of information exchange. It is also possible that the lack of IT integration between hospitals and suppliers could also act as a constraint for information sharing, which will be the subject of further analyses in future to capture any possible justification of the current results.

It is possible that there are differences between the responses of the participants by their gender, education levels, departmental affiliations, experience, and type of hospital (public or private) they are associated with. The focus of this study was to test the proposed framework on the entire sample in totality. Future studies can be pursued to test the framework by using various participant characteristics.

6. CONCLUSION

This study has made an important contribution to the literature related to healthcare supply chains. Through a review of literature - logistics integration, information technology, information sharing and trust were found to be measures of hospital-supplier integration which might have a significant impact on hospital performance. The relationship between the subscale item scores and respective latent variables was confirmed using a CFA. Subsequently, a full CFA model was fit to the data to validate the conceptual framework developed for this research. The results from the analysis found that out of logistics integration, information technology, information sharing and trust, only logistics integration and trust aspects of hospital-supplier integration are positively and significantly associated with hospital performance. Trust was found to be more strongly associated with hospital performance compared to logistics integration. These findings can be used to optimise the costs associated with healthcare supply chains.

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A STUDY ON THE ATTRACTIVENESS INDEX OF CHINA (SHANGHAI) PILOT FREE TRADE ZONE

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Abstract
Purpose of this paper:
In the last three decades, China is the major contributor to the Asian economic development by manufacturing large amounts of consumer goods. With the rapid growth in labour cost, the expectation on the enforcement of more strict environmental regulations, and the insourcing policy in the EU and the USA, Chinese government has decided to include the logistics businesses as one of her eight core national industries in the 12th five years development plan during 2011~2015. Logistics industry, a major enabler of internet commerce economics, is once again listed as a core industry for China's 13th national five-year development plan. Free trade zone is an innovative logistics operation model in China since July 2013 and is perceived to be one of the key successful factors for future economic growth in China. Many favourable incentives are provided to businesses that will set up their headquarters in the free trade zone. However the attractiveness of these incentives to its potential customers has not been studied thus far. This research intends to investigate critical factors influencing the successfulness of a free trade zone and provide suggestions to improve the degree of attractiveness of the trade zone to its regulators.

Design/methodology/approach:
Questionnaires are sent to the top 100 financial companies, the top 500 companies in the service industry and the top 1000 manufacturing companies in Taiwan to understand their perception on the degree of importance and the degree of performance of the major incentives promoted by the China (Shanghai)Pilot Free Trade Zones (CSPFTZ), and their intention to set up their offices in the CSPFTZ. The posted questionnaires are returned between Jan./2015 to Oct./2015, 129 copies of questionnaires are returned and 90 of them are fully completed to be valid for this research analysis. The importance-performance analysis (IPA) technique and the binary logistical regression technique are used to analyze the critical successful factors that attract the companies to set up their offices in the CSPFTZ.

Findings:
It is found 46.51% of the respondents either intends to or have already set up their offices in a free trade zone. The 27 sub-attractiveness indices can be grouped into the following 7 dimensions: government-related, strategy-related, service-related, facility-related, labour-related, operation-related, and market-related dimensions.The research results indicate the following 8 sub-attractiveness indices are perceived to have higher degree of importance and lower degree of performance: Favourable trade strategy, convenient custom clearance practices, healthy fiscal policy, innovative service contents, strong FTZ's promise fulfilment ability, relaxing FTZ investment regulations, relaxing regulations on accesses to raw material in the FTZ, and the removing government agenciescorruption. In addition to the IPA matrix, this study employs Binary Logistic Regression technique to analyze the impact of the 27 possible sub-attractiveness indices on these respondents' decisions to set up their offices in the Shanghai FTz. The amount of logistics Transport cost, flexible custom clearance procedure, and theNegative List of Commodities("the List of Commodities subject to import restriction")are found to significantly influence manufacturers' willingness to move to the FTZ or not(Table 1).With these 27

independent variables, the classification table indicates the proposed binary logistics regression equation has a 77.8% correction prediction rate (Table 2).

Value:
CSPFTZ is officially operated and launched in July 2013 and has attracted 12,000 companies to register and set up their offices inside the CSPFTZ within one year after its launch. Many countries have also ambitiously launched their FTZ. According to the authors' knowledge, the major successful factors for a modern FTZ (such as the one in Shanghai) have not been studied before. This is the first research to indicate factors that are required to invest more resources to effectively improve a FTZ's overall attractiveness to its users. Governments plan to set up their FTZ can use this research findings to allocate their limited resources to improve their performance on these three key attractive sub-indices.

Table 2 Predicted PercentageCorrect

ClassificationTable[a]

	Observed		Predicted		
			1.		Percentage
			0	1	Correct
Step 1	1.	0	59	6	90.8
		1	14	11	44.0
	Overall Percentate				77.8

a. The cut value is .500

Source: this research

Table 1 Binary Logistics Regression Result

Variables in the Equation

		B	S.E,	Wals	df	Sig.	Exp(B)	95% C.I. for EXP(B)	
								Lower	Upper
Step 1[a]	politics	-.005	.586	.000	1	.993	.995	.315	3.138
	diplomatics	-.475	.676	.492	1	.483	.622	.165	2.342
	Corruption	-.396	.622	.405	1	.525	.673	.199	2.278
	Terrorism	.811	.527	2.374	1	.123	2.251	.802	6.318
	EconomiesofScale	1.106	1.147	.928	1	.335	3.021	.319	28.635
	Competitiveness	.947	.941	1.013	1	.314	2.579	.408	16.308
	LandArea	-.773	.723	1.142	1	.285	.462	.112	1.906
	RawMaterial	-.235	.737	.102	1	.750	.790	.186	3.354
	ICTfacilities	-.019	.802	.001	1	.981	.981	.204	4.724
	LogisticsTransportCost	-2.172	.850	6.529	1	.011	.114	.022	.603
	LabourCost	.114	.817	.020	1	.889	1.121	.226	5.563
	EnvironmentLaw	.114	.798	.020	1	.887	1.120	.235	5.349
	ResearchAndDevelopment	-.490	.757	.419	1	.517	.613	.139	2.700
	MarketSize	-.661	.684	.932	1	.334	.517	.135	1.975
	MarketOpeness	-.264	.675	.153	1	.695	.768	.204	2.884
	InflationGDP	1.334	.949	1.978	1	.160	3.797	.592	24.375
	ManufacturingSkill	.612	.763	.643	1	.423	1.844	.413	8.221
	TradeFacility	.545	.759	.516	1	.472	1.725	.390	7.628
	LoanRegulation	-.661	.665	.988	1	.320	.516	.140	1.901
	GovernmentReform	-.254	.735	.120	1	.730	.776	.184	3.277
	CustomPractice	1.770	.931	3.619	1	.057	5.872	.948	36.380
	NegativeListOfCommodities	-2.396	.981	5.960	1	.015	.091	.013	.624

CrossBorderLoan	-.067	.749	.008	1	.928	.935	.216	4.054
FreeExchangeRMB	.753	.663	1.290	1	.256	2.123	.579	7.778
SOEtoJV	.807	.896	.813	1	.367	2.242	.388	12.967
FriendlyFTZRegulation	-.065	.768	.007	1	.932	.937	.208	4.219
PublicEPlatform	-.271	.972	.078	1	.780	.763	.114	5.123
Constant	-.257	2.913	.008	1	.930	.774		

a. Variable entered on step 1: politics, diplomatics, Corruption, Terrorism, EconomiesofScale, Competitiveness, LandArea, RawMaterial, ICTfacilities, LogisticsTransport, LabourCost, EnvironmentLaw, ResearchAndDevelopment, MarketSize, MarketOpeness, InflationGDP, ManufacturingSkill, TradeFacility, LoanRegulation, GovernmentReform, CustomPractice, NegativeList, CrossBorderLoan, FreeExchangeRMB, SOEtoJV, FriendlyFTZRegulation, PublicEPlatform.

Research limitations/implications (if applicable):
Response rate is very low and the respondents are mostly manufacturing companies and service companies with their own operating offices in Taiwan. Even many respondents are global company with their regional head office based in Taiwan,this research still needs more diversified responses outside the country to enable the research findings to be generalized and to be applicable to other FTZs outside China.

Practical implications (if applicable):
Mainland China government has launched many innovative foreign exchange and monetary policies in the China (Shanghai) Pilot Free Trade Zones (CSPFTZ) to attract the global companies to move into CSPFTZ. However, the respondents of this research perceive both the higher the logistics transport cost and the more the cargoes in the negative list of commodity will significantly decrease their willingness to move into the CSPFTZ. The degree of friendly custom practice has a positive impact on the global companies' willingness to move into the CSPFTZ. These attractiveness sub-indices are similar to those sub-indices used by most of the free trade zones in the 1970s to attract foreign manufacturers. The after-survey interviews with several respondents indicate innovative foreign exchange and monetary policies are usually not fully understood by these interviewees even if these policies might be useful to these interviewees. A good policy is useless in terms of their attractiveness to customers unless the potential customers can fully understand these policies. Thus CSPFTZ should ask their market department to actively approach the potential customers to clarify these foreign exchange and monetary policy.

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EVOLUTION OF LOGISTICS RESEARCH –ANALYSIS ON ISL CONTENT

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ABSTRACT

Purpose of this paper:
International Symposium on Logistics (ISL) is a well-known logistics conference that contributes to the international scientific community's discussion. ISL is one of the oldest conferences in its field the themes addressed by the conference are considered to have an impact to the general scientific discussion especially in the fields of logistics and supply chain management. Although there are some analyses done on the community and literature impact of ISL, the precise impact if ISL in terms of themes and topics is still in its infancy. Therefore, the purpose of this paper is to systematically analyze the themes of the textual context in the conference and how those have developed over the years, and how those relate to the general scientific discussion in logistics.

Design/methodology/approach:
The study utilizes integrative literature review approach to systematically analyze the textual content of the previous ISL proceedings. The chosen approach allows to evaluate and interpret all available research relevant to a particular topic of interest of a discipline. A detailed textual analysis is conducted in order to present the discussed themes over the years. The ISL specific results are compared to a dominant scientific literature indexes, namely Web of Science, to illustrate how ISL aligns to the wider scientific discussion. The bibliometric analysis is done by using qualitative data analysis softwares with word statistics.

Findings
The main contribution of the paper is in providing a detailed analysis of the ISL content-wise. The results reveal how the conference themes and topics are aligned with the overall global scientific trends. The outcome of the analysis identifies and analyses the advancements and lacks of ISL compared to the global trend in the field.

Value:
The chosen approach allows statistical as well as network overview of results through which the role of the ISL can be analyzed in the larger scientific discussion context. The systematic literature analysis allows to assess and compare the value and topicality of

global trends of scientific publishing regarding the field of logistics which can be considered useful for the participants, the organizers as well as for the larger scientific community.

Keywords: ISL; content; scientometrics; Web of Sciences, abstract

INTRODUCTION

International Symposium on Logistics (ISL) is well-known and one of the oldest conferences in the fields of logistics and supply chain management. In all scientific conference proceedings as an important knowledge source have been recognized especially in the fast-evolving research domains where "time-to-market" is essential (Montesi and Mackenzie, 2008; Lisée, et al. 2008). Due globalization, E-commerce will continue to increase its influence over the logistics and supply chain industry. Therefore, we argue that there is a rising need to understand how researchers are keeping up with the latest trends in the fields of logistics and supply chain management such as "sustainable logistics", "omni-channel logistics", "cloud services", "distribution network evolution" and "autonomous trucks" (Banker et al., 2016).

Conference proceedings and journal articles can be considered as complimentary communication channels (González-Albo and Bordons, 2011; Butler and Visser 2006; Godin, 1998). However, conference publications can provide novel information, which otherwise could be difficult to include other publications (Drott, 1995) since proceedings are usually only partially extended into journal publications (Miguel-Dasit et al., 2006; Kho and Brouwers, 2009; Aleixandre-Benavent, 2009; Glanzel et al. 2006). As a result it is suggested that ISL-conference proceedings can demonstrate an ability to innovate and propose new ideas (Montesi and Mackenzie, 2008) a years before they appear in the top tier logistics and supply chain management journals. By definition scientific research is grounded on previous knowledge, which is continuously evolving over time. Therefore it is vital to understand the structure and evolution of specific scientific domain such as logistics and supply chain management. Therefore, the purpose of this paper is to systematically analyze the themes of the textual context in the ISL conferences and how those have developed over the years, and how those relate to the general scientific discussion in logistics and supply chain management.

This paper is structured as follows: First we will introduce the theoretical background of the study, namely the scientometrics research approach. Thereafter the research process applied and data collection will be introduced. Next, the results of the study analysis will be presented and finally concluding discussion about the implications of the results will be described.

THEORETICAL BACKGROUND: SCIENTOMETRICS AS A RESEARCH METHOD

In this study we follow scientometrics research approach, which can be defined as the quantitative study of science and technology (Van Raan, 1998), focusing on texts (documents) as empirical units of analysis (Leydesdorff, & Milojević 2012). As in many times in scientific literature, similar and overlapping terms also for scientometrics (Larivière et al. 2012) have been proposed including bibliometrics (Pritchard, 1969) and informetrics (Nacke, 1979), which history have been documented by Hood and Wilson (2001). A comprehensive framework for classifying various types and combinations of scientometrics studies was recently proposed by Santonen and Conn (2015a). In Figure 1 we have illustrated their framework in which the cube is divided into 3x2x3 cells in which the three axis are representing following viewpoints:

- Horizontal axis: Popularity vs. Importance vs. Network dimensions
- Vertical axis: Actor vs. Content dimensions
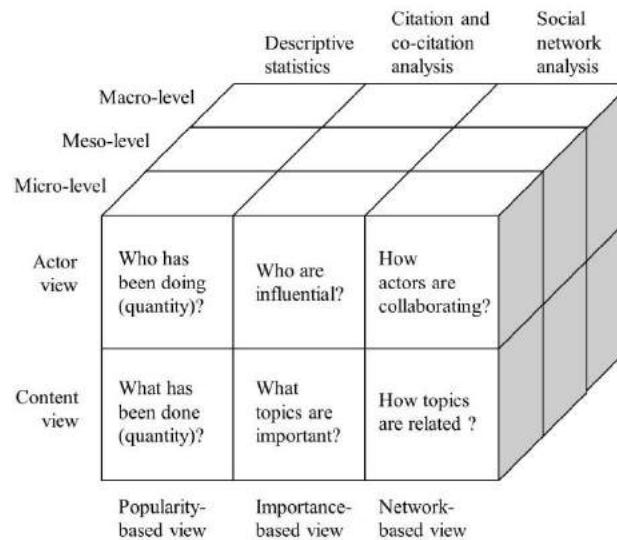- Depth axis: Micro vs. Meso vs. Macro dimensions

Figure 1. A comprehensive framework for classifying scientometrics studies (Santonen and Conn, 2015a)

Popularity-based studies (Choi et al, 2011) are typically analyzing frequency of people, keywords or other related meta-terms, which have been derived from the context of the research publication (e.g. Santonen and Conn, 2015a, Santonen and Conn, 2015b). *Social network analysis-based studies* (Borgatti et al., 1992) are instead focusing on the relationships via publications, which most typically are based on co-authorship (e.g. Santonen and Ritala, 2014) or keywords (Santonen and Conn, 2016). *Citation and co-citation studies* on the other hand focuses on the importance and impact of the people or topics by evaluating how much (popularity approach) or by whom (network approach) the particular study is cited (Pilkington and Meredith, 2009). The greater the amount of citations is, the more influential and important the study is. All of the above research viewpoints can be applied at the micro-level (e.g. individual authors or keywords) or the meso-level (e.g. universities that the authors represent) or at the macro-level (e.g. countries) (Gupta and Bhattacharya, 2004). Finally each of these research approaches can also be evaluated from temporal point like the study by Santonen et. al (2016) who evaluated the evolution of radical innovation both from popularity and social network analysis point of view. Prior scientometrics studies in the in the fields of logistics and supply chain management conferences have focused only on author viewpoints (Vilko et al. 2015), instead of identifying contextual research topics via keywords.

RESEARCH PROCESS AND DATA COLLECTION

By following a comprehensive scientometrics framework by Santonen and Conn (2015a), this study is grounded on "popularity-based" research approach (Choi et al, 2011). The study systematically analyzes and compares the textual content frequencies between the ISL (The International Symposium of Logistics) conference proceedings and peer-reviewed logistics and supply chain management journal papers as identified in Web of Science™ in order to reveal the possible similarities and differences between conference and journal publications. The years between 2004 and 2015 were selected for the analysis as those would reflect the content in the past decade or so. The main research questions can be summarized as following:

> RQ1: What are the most popular research topics in ISL conference and in logistics and supply chain management focused peer-reviewed journals?

> RQ2: How the research topics are evolving over time and are there any differences between conference proceedings and journal papers?

The research was done in four consequent step and Table 1 illustrates the research process carried out in this study.

Table 1. Research process

	1. GATHERING THE DATA	2. TRANSFORMING THE DATA FOR THE ANALYSES	3. SCIENTOMETRIC ANALYSIS OF CONTENTS	4. COMPARATIVE ANALYSIS OF RESULTS
ISL	Gathering abstracts from archives	Lexical processing of abstract texts	Cumulative and yearly word frequency analyses to top words	Analyzing the similarities and differences in results for propositions
WoS	Searching data from core collection data base	Downloading ja processing topic words from WoS data base		

First, the research began by gathering the text data from 2004 to 2015 to be used for the analysis. In ISL the abstracts were selected as the primary data source as those were considered to reflect the most relevant content in the conference papers. For comparison of the results and to give light of the ISL content to the larger scientific discussion Web of Science™ Core Collection (later WoS) database was used. WoS provides an access to the world's leading citation databases which covers over 12,000 of the highest impact journals worldwide, and over 150,000 conference proceedings. The search in the WoS was carried out be using keywords "logistic*" and "supply chain*" and the search was refined to include the topics (includes titles, abstracts and keywords) in the research area "transportation" which in total revealed 2358 papers. Due to the vastness of the data the research area limitations made for the WoS comparison data were considered necessary, and the authors acknowledge the limitations it derives which are discussed in conclusion section.

The second step of the research process was to transform the textual data to format in which the analysis could be carried out. A preliminary review and processing to the textual content of the abstracts from the ISL proceedings and the topics from the WoS was carried out. The body text from the ISL abstracts was isolated using lexical MAXQDA software and thereafter the text was cleaned using R programming. "Logistics" or "supply" or "chain" or "management" words were removed although they were clearly the most popular but did not provide any value since the referred to the main theme of ISL. Furthermore all common words, which did not have any thematic value were also removed. The WoS texts words received similar cleaning process as the foregoing. Then from both ISL and WoS datasets the top 50 words were selected for further analysis.

The third step was the popularity-based scientometric text analysis. In order to compare and assess the evolution of the ISL and WoS research topics, we used the cumulative and yearly frequencies of the top 50 words, which were transformed into relative percentage shares in order to enable comparison. For this relative frequency analysis, Excel and Wordstat softwares were utilized and various illustrations were drawn to visualize the evolution over time.

Finally in the fourth step, the results between the ISL and WoS datasets were compared in order to reveal possible similarities and/or differences, although the comparison between the abstract texts (ISL) and the topics (WoS) was considered to hold some limitations in terms of comparability.

RESULTS AND ANALYSIS

The analysis of the scientometric results is discussed from two perspectives, namely from the ISL's thematic evolution perspective, and from the impact it has had to the more general scientific discussion (WoS), in both cumulatively and yearly. From the overall words of ISL around 30% were same as used in the WoS.

The textual analysis revealed that the top words used in the ISL and in the WoS had many similarities which was expected as the both were from the same field. The major differences were that the WoS had more widely used words in the top compared to the more sharper top of ISL. This illustrates how the WoS scientific discussion addresses higher amount of topics than the more focused and changing themes of the ISL. More precisely, since the beginning of the researched time span (2004) words *industry* and *performance* appear almost every year in top 50 words of ISL abstracts. Other words that rank high in ISL can be found from the figures 2 and 3 below. The most frequently used words of WoS, such as *regression, system, traffic, transportation,* seemed to be more related to transport processes and similar issues. Both of the figures illustrate the permanence and continuity of certain themes that have appeared the most in the last 12 years.
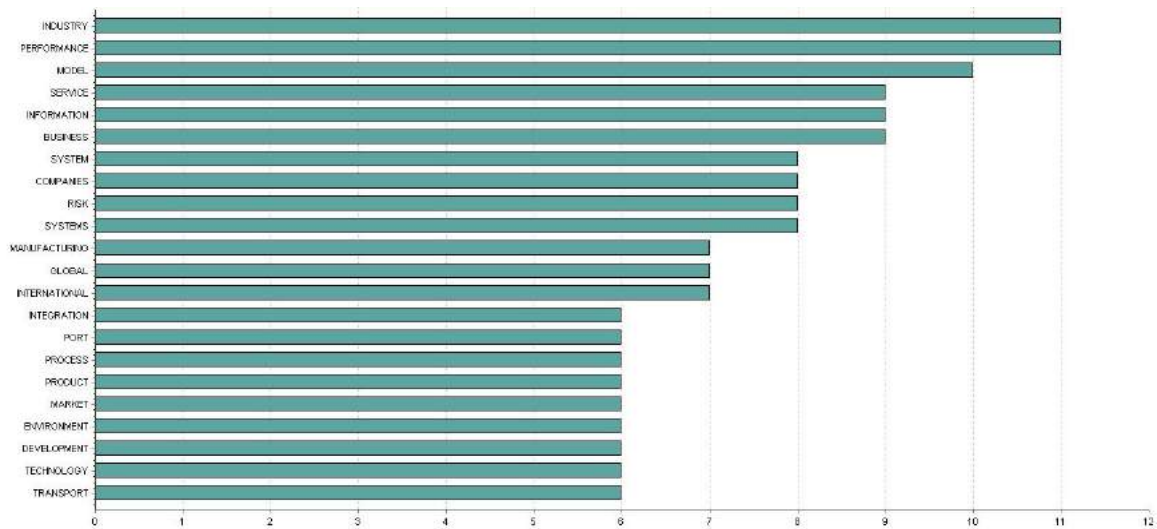

Figure 2. ISL most common words appearing between 2004 and 2015
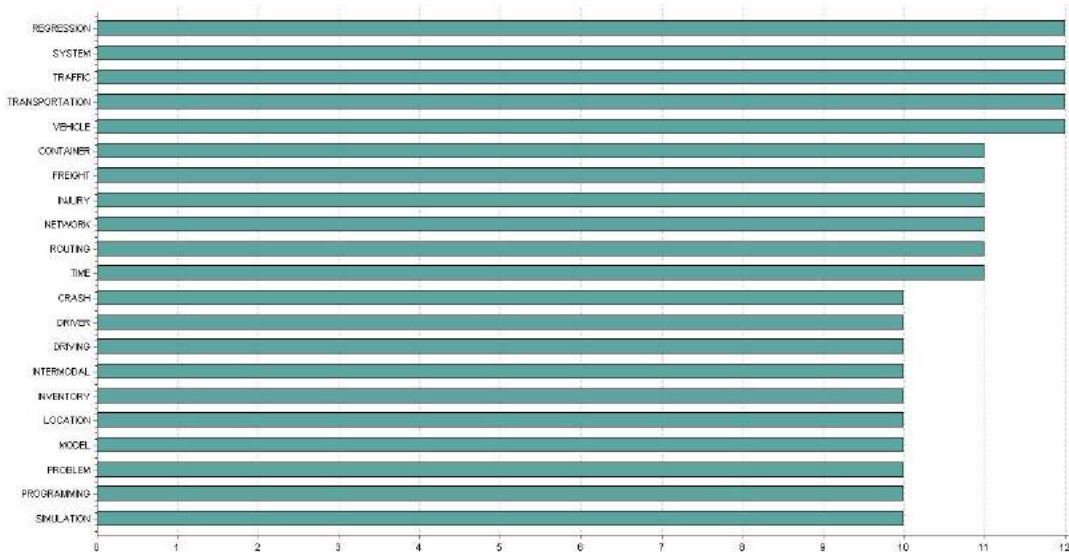

Figure 3. WoS most common words appearing between 2004 and 2015

When considering the yearly differences in popularity of the most frequently used keywords, the differences can be noticed from the Figure 4 below (due to illustrative purposes only the top 10). As can be noticed the popularity differences vary somewhat over the years which can be considered natural as the conference call for paper themes have varied as well. It is surprising how the same themes however seem to appear periodically over the time.
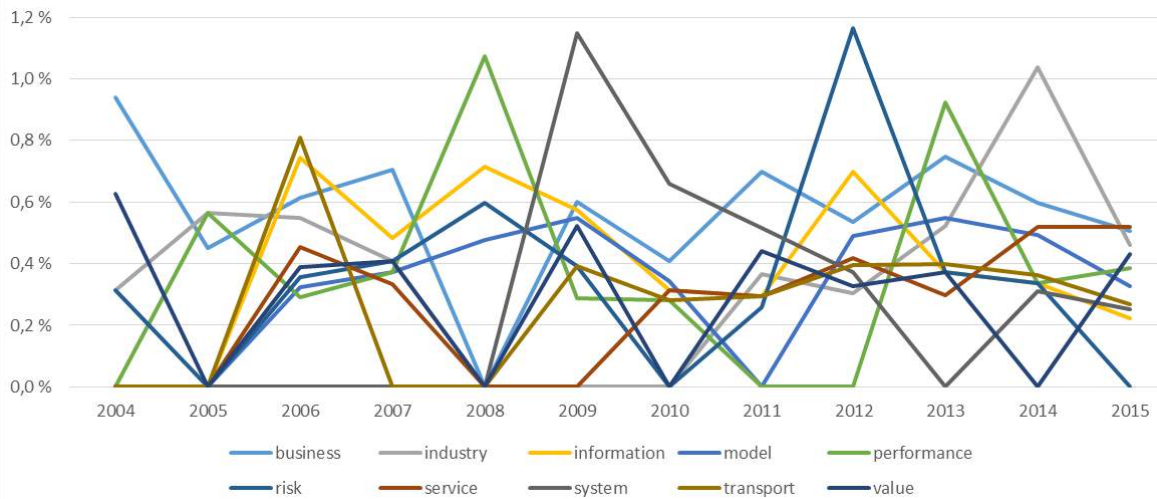
Figure 4. ISL Yearly top 10 frequencies

Comparison of the yearly frequencies with the same themes of WoS illustrates the differences of a particular conference with changes of popularity and the more general scientific publishing where the popularity of themes is bit more stable in the long run. Although, the Figure 5 also shows how the themes have yearly variation in WoS as well, like in years 2006, 2007 and 2008 for example.
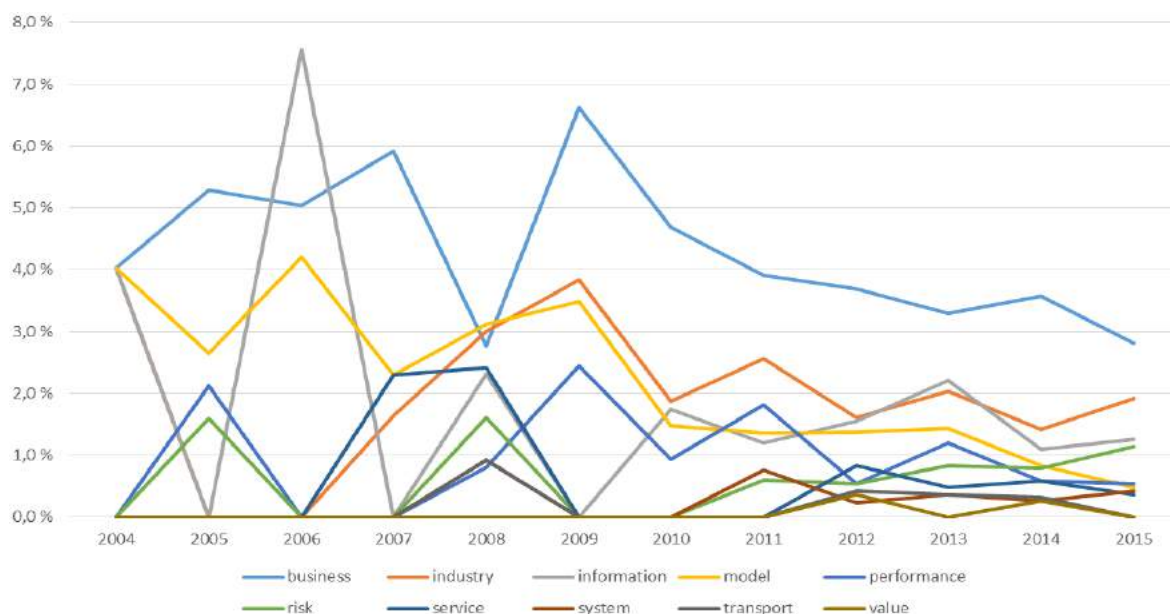
Figure 5. WoS Yearly top 10 frequencies

The cumulative frequencies illustrate the evolution of the top 10 themes over time considering of the overall past publication history from 2004 to a particular year. As can be noticed from the Figure 6 below, the cumulative frequencies of ISL are quite stable overall especially in later years when the first years annual variation has lesser impact on the result. This could be seen as quite typical scientific progress, since science by definition builds on previous knowledge, which evolves over time, refines and develops knowledge

and serves as a foundation for further research. The most popular theme here is the *performance*, which has continued as one the most relevant theme of the conference over the studied period. Other themes such as risk have steadily increased in their cumulative importance since 2005.
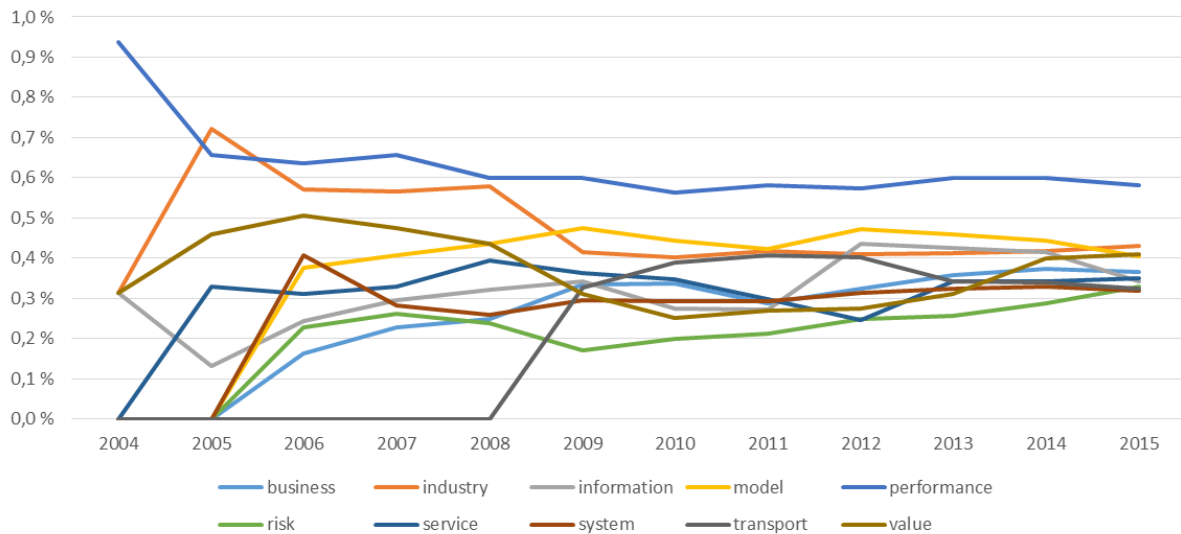
Figure 6. ISL Cumulative frequencies

The cumulative frequencies of the selected WoS comparison data have much more variation in the themes than the ISL themes. Considering that in the case of yearly frequencies the situation was opposite could refer to the yearly changes in publication volumes. For example when looking at *performance* it can be seen how the popularity of the word has been stable over the years after its relatively high popularity of 2004 in ISL, while in the yearly comparison data the popularity of the word has experienced higher variation. This seems to be the case with both ISL and WoS for *performance* it can be noticed how in both cases. Indeed, one of the strengths of the cumulative analysis is the fact that it better illustrates in the longer run to which direction the themes are developing.
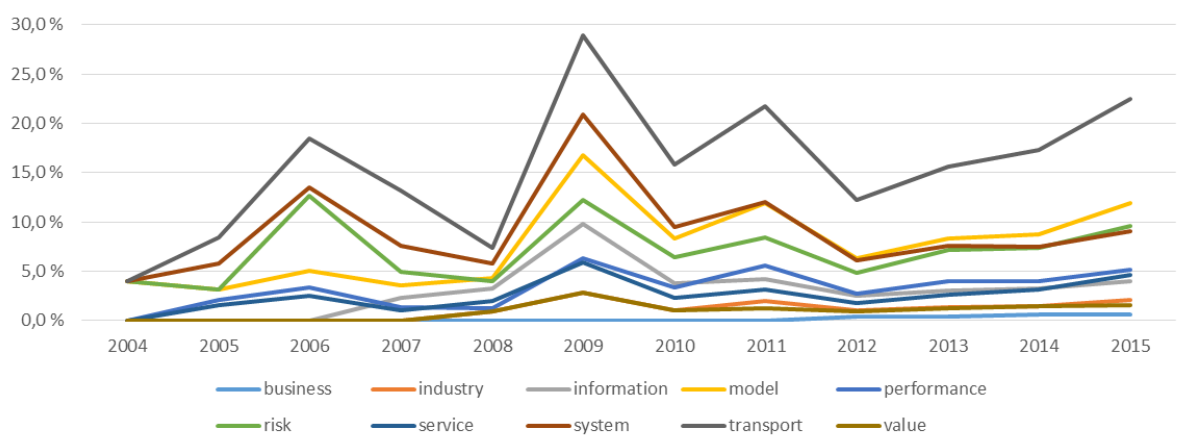
Figure 7. WoS cumulative frequencies

When conducting a pair-wise comparison of the different words, it can be noticed how the frequencies of the themes appear first stronger in the ISL while one to three years after that gain popularity in the WoS results. This illustrates how ISL as a conference in the same field acts as a starting platform or a discussion forum for new scientific themes. The

CONCLUSION

Academic conferences can have strong influence on the scientific and practical development of different fields. In logistics, ISL has been one of the oldest conferences and has made a significant impact to the scientific discussion over more than two decades. ISL have been known to play a part as a scientific discussion forum about the latest trends and developments, however the themes and their relevance to the general scholarly discussion in the field has not been understood where lies the core of our study.

Our study contributes to the understanding of scientific research both in logistics field, as well as in the specific context of ISL (International Symposium of Logistics). The unique data set spanning from 2004 until 2015 gives us the opportunity to study the most relevant themes in ISL and their longitudinal development over the years. This provides us several contributions that are related to themes evolution in a scientific conference, as well as their relation to the general scientific discussion in other forums; both of which that have been pointed as important research gaps (e.g. Santonen & Conn, 2015b). Scientometric approach applied in our research was considered useful as it allowed a meta-level thematic developments and impact to be examined. There are several interesting results that emerge from our study.

First, The most relevant keywords found from ISL had strong connection with the keywords of WoS. While the thematical evolution of the ISL and WoS were somewhat different and the ISL was clearly more concentrated on certain themes than the WoS, the popularity noticed for few keywords over the years illustrates the continuity of certain themes over the years.

Second, the results of this study show that even though there were great yearly differences in the popularity of the top keywords of ISL the cumulative examination can illustrate the longitudinal evolution. This implies that even though ISL as a conference has changing calls for papers (themes) every year, the scientific development in ISL is still incremental in the long run.

Finally, the meta-level examination of the ISL content over time helps to understand the role of ISL in the logistics field scientific development. Discovering the thematic core and its development in ISL allows to better understand what kind of topics are relevant and related.

The study has several limitations that should be taken into account when interpreting the results. The use of abstracts in the analysis opposes some limitations on the representability of the results. While the abstracts typically capture the essence of the paper some relevant words might be undiscovered compared to the full paper with keywords and title. Furthermore, the comparative data used from the WoS (Web of Science) database included the title and keywords in addition to the abstract which does not make the data sets fully comparable. Further runs for the ISL should be done with the title and keywords included. Moreover, the WoS database does not cover the whole scientific discussion in logistics and can be considered limited for that purpose. This applies to the filtering made for the data as well. Therefore, other databases should be included in the analysis to confirm the results. Also, the use of single keyword analysis involves severe limitations and relevant concepts involving more than one word can be missed. Therefore, further analysis should be conducted by taking into account the two and three word concepts. Finally, the used software holds some limitations with the linguistic capabilities of taking account stemming etc. which should taking into account.

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Section 13: Education and training

POSSIBILITIES AND CHALLENGES IN CONVEYING SUPPLY CHAIN RISK MANAGEMENT SKILLS IN HIGHER EDUCATION INSTITUTIONS

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Abstract

Supply chain risk management gains more and more importance in daily operation of supply chains as well as in educational context. However, so far practical results show that there are some operational problems in addressing supply chain risks. Thus in order to overcome the problem, one aspect would be to look at how SCRM is taught and if the educational offer really addresses the required competence development, or if different educational methods should be used. This paper gives an overview of the needs and the offers and identify some challenges in delivering the right competences.

Introduction

Risk Management (RM) is a topic with increasing interest. Within higher educational institutions (HE) risk management has been taught for several decades within different disciplines like law, finance, medicine and engineering (Sage, 2015; Nissen, 2010). Examples of not appropriate risk management have been reported in several articles, also related to supply chain (Ho et al.,2015) and thus the interest in Supply Chain Risk Management (SCRM) education has intensified (Baalsrud Hauge, 2014). There are several reasons for the lack of good risk management practices: lack of motivation and knowledge, the susceptibility to cognitive biases, reluctance in investment on education, the focus on short term revenue and difficulties in measuring the impact of RM (Macelino-Sabada et al., 2014; Lindegaard, 2011; Negus, 2010; Falkner and Hiebel, 2015; Ellegaard, 2008; Sukumar, 2011; Ho, 2015; Gao, 2013). Furthermore, the complexity and dynamics of supply chains facing unexpected events, both within and outside an organisation (Clark, 2011; Ho, 2015) makes good SCRM even more difficult (Manuj and Sahin, 2011; Ho, 2015, Peck, 2005). Consequently, many managers are under-informed about the risks that may arise (Pettit et al., 2010). Jüttner (2005, p.139) found that "while faced with new challenges of what appears to be an increasingly 'uncertain' environment, practitioners have little guidance on their SCRM approaches", thus making it difficult to apply theoretical frameworks and methods into daily operations.

In line with Jüttner (2005), Gao (2013) argued that knowledge about risk management is often informal, which implicitly often means that there is also a lack of knowledge on suitable RM methods (Jüttner, 2005; Pettit, 2010), whereas Falkner and Hiebel (2015) argued that there is a reluctance to invest in corporate training. However, Huo et al. (2015) shows the relevance of employees' skills for supply chain integration is of high relevance, thus it is a concern that specifically

SMEs are so reluctant in investing in education and training among their employees. The findings of Ho (2015) showing a discrepancy between the usage of analytical and empirical methods reported in the literature may further support the assumption that there is a competence gap on SCRM in organisations. In addition, RM is often based on past experience and thus prone to human error, miscalculation of probabilities, or simply irrational decision making (Thomas, 2011; Barnes, 1984).

Thus, in order to understand why practitioners face difficulties in SCRM it is necessary to understand if this arises from a gap in the educational offering. In order to answer this, we need to look into what RM competences managers need, and then to identify how SCRM is currently taught. Hence our research aims to address this gap and provide some insight on how the gap between practice and teaching can be reduced. The research question that guided our research was: "Is the teaching methods and offers used for teaching SCRM supporting future managers possibilities to handle unexpected events in the supply chain".

Approach

For the research design, a mixed method approach was used (Teddlie and Tashak-kori, 2006), in combination with action research, involving teachers and students at an early stage. The reason for selecting this approach is that it gives the opportunity to analyse the research questions from different perspectives.

The research methodology involves literature reviews and examination of courses. In order to identify the competences needed for SCRM, a literature review was carried out. Papers included in the review were retrieved from online journal academic libraries with a focus on resilience, supply chain risk management, enterprise risk management, and risk assessment. Also entrepreneurial practice is very important. For this purpose, additional to the literature review, a web search on relevant news and blog contributions, and speeches on trade fair were carried out.

An important issue in order to reduce the miss-management of supply chain risks, is to make sure that a teacher can use the most efficient way of mediating the required competences. Also this were answered by carrying out a literature review. A third step, was to investigate how SCRM is currently taught. Finally, we looked at how topics related to risk management in supply chains are taught today. Also, a questionnaire (N=56) was used in order to get a view of what practitioners and educators identify as relevant teaching methods. Most of those answering the questionnaires where either lectures or high-level managers. In order to cover middle management and those carrying out the daily work in a collaboration, 10 project managers working in large scale complex projects were interviewed and also asked to complete the questionnaire.

Required competences based on literature review

How to manage risks in the best way in a given situation (i.e. take the opportunities, but reduce the threats), and be able to act on unexpected events are still challenging (Ho et al, 2015; Gao, 2013; Pettit et al, 2010; Sage, 2015). In order to improve managers' capabilities to handle this, it is necessary to know which competences are required (Nissen et al., 2010; Baalsrud Hauge, 2014).

This requires knowledge and technical skills on Risks and RM methods and their application, but also conceptual skills like strategic thinking, planning as well as leadership, communication skills (Hardy, 2014; Nissen et al., 2010; Jüttner, 2005). Furthermore, decision-making related to risks in dynamic systems calls for dynamic decision making, which is a stream of decisions closely depending on one another (Manuj and Sahin, 2008; Jüttner, 2005; Peck, 2005, Sage 2010, Ho, 2015; Hardy, 2013). Thus, SCRM common decision making also requires competences in information sharing, communication, team work, and collaboration, cooperation abilities to ensure efficiently execution across the supply chain.

Teaching methods

Typical risks for Supply Networks are related to collaboration, connectivity, information sharing, and communication, etc. (Peck, 2005; Pfohl, Gallus, and Köhler, 2008; Sheffi, 2005; Waters & Donald, 2007). The required skills found in the literature review do not only include technical skills and a need of knowledge, but also, among other, conceptual design, team, communication, decision-making skills. There has been much discussion within the engineering education domain on how to best support the students in process of developing such skills, since there are reported difficulties in delivering and developing knowledge in normal class room settings (Kerns et al., 2005; Cheville and Bunting, 2011; Davis et al, 2003). Thus, other teaching methods and tools are being explored that target more direct participation of students (O'Sullivan et al., 2011; Chryssolouris and Mavrikios, 2006, Baalsrud Hauge et al., 2012). Therefore, in analysing if the reason of insufficient RM is due to a gap in the educational offering, a desktop search on educational offering at undergraduate, post graduate, vocational and corporate training was carried out. However, related to the large numbers of corporate internal and courses provided upon request, the latter is not fully covered. As described in the methodology, we searched the online curricula for more than 150 universities, as well as asked for information, and more than 50 vocational educational training organisations and consultancies.

The intention of the analysis was to get an overview of the educational landscape in the field, as well as to identify the main foci for teaching and training in this area. A high level overview of the results is given in Table 1. In order to limit the number of courses to those relevant for this thesis, only courses related to risks and/or Supply Chain/Supply Network, as well as collaborative production were selected. In addition to higher educational institutions, Supply Chain and risk related topics are offered by several consultancies and professional training organisations.

There is a large variety of educational offerings (i.e. courses, workshops, seminars, presentations, etc.) on Supply Chain Management (SCM) and SCRM related courses available at universities and vocational training institutions. These range from one-day workshops to complete courses and master degrees. Most of the identified courses on risk management topics in the field of SCM were offered to post graduate students but in recent years, the number of courses targeting undergraduate students has been increasing.

The identified courses and offers were investigated according to the criteria of topics (risks, risk management, supply network, supply chain, risks (mostly based on the module description), teaching method (lectures, lectures and tutorial, workshop, simulation and games, others), duration (long term, short term, no. days etc.) and level (undergraduate, postgraduate, executive, management, etc.). The intention of the analysis was to get an overview of the educational landscape in the field, as well as to identify the main foci for teaching and training in this area. The analysis showed that lecturing is the primary teaching method for long-term courses at undergraduate and post-graduate level. The second most common method was lectures in combination with tutorials. Furthermore, the analysis showed that many institutions offer 1-2 day workshops, often based on case studies and problem based learning (cognitivism), or the use of business simulations (only a few) based on constructivism. These latter two involve active participation of the students. It also revealed that the more practice oriented the educational institution; the higher likelihood of active participation.

Most of the identified courses on risk management topics in the field of supply chain management were offered to post graduates.

Methods	Corporate Risk Management	Risk Management and Insurance	Supply Chain Management	International Supply Chain Management	Supply Chain Operations	Logistics and Supply Chain Management	Risk Management Decisions	Risk management /-controlling	Supply Chain Management in Practice	Design of High Performance Supply Chains	Supply Chain Planning and Control	Supply Chain Strategy and Performance Measurement	Risk Management Processes
Illustration based on actual occurring situations	x,e												
Illustration of individual behaviour within a certain market due to group	x,e												
Lectures on essential theories, logical coherences	x,e	x,c,e	x,c,e	d,e	x,c,e	x,c,e	c,e		x,e	x,d,e	x,d,e	x,e	x,c,e
Q&A	x,e												
Formulation of concrete research			x										
Literature research			x			x,c,e							
Case studies			x,c,e	d,e		x,c,e							
Business simulation		x,c,e	x,c,e										
Discussions			x,c,e	d,e	x,c,e								
Essays					x,c,e						x,d,e	x,d,e	
Presentation and homework			x	d,e									

x=postgraduate
c=pre-graduate
e=Europe
d=management program, MBA

Fig. 1 Overview on how specific topics are taught

The analysis of how classes on SCRM are offered in HE compared with the skills the literature mentions being necessary to have, showed a significant gap at HE, but less on seminars and training courses offered as vocational training. However, much of the literature is focusing on the financial aspects or intra-organisational risk management. Thus, in order to get more detailed answers on what practitioners and teachers perceive as suitable teaching methods, as well as to get a deeper insight in exactly which skills the industry expects related to SCRM, we conducted a survey with 56 respondents, described in the next section.

Results of questionnaire on risk management skills and teaching methods.

In order to get more detailed information on industrial needs related to SCRM and teachers' perspective, a survey approach was used based on a questionnaire that was distributed at different conferences and via emails to industrialists and lecturers. The questionnaire covered their perceptions on the needed skills and knowledge for RM in enterprise networks, as well as on how they see the different methods for conveying these competences. The second research phase involved interviews with a small number of project managers working on large scale collaboration projects. These where selected because they according to the German law are obligated to carry out a risk management process for their companies. However, their duties to deliver the overall project goals also require them to work very closely with the other companies, thus often experiencing the challenge of RM for own company and project.

The questionnaire, that was pre-tested on a small group of researchers, comprises of five sections. Section A covered administrative information (position, number of employees in organisation, year of experience etc.). Section B (12 questions) was related to RM within his/her organisation and the personal experience of the respondent in dealing with risks in the company and in an enterprise network. Section C covered various aspects of risks in enterprise networks related to collaboration (cultural and communication (10 questions), strategic risks (5 questions), human resources (5 questions) and innovation risks (5 questions). These areas were selected based on the theoretical analysis of risk in enterprise networks. Section D covered the educational needs for risk management for engineering students (12 questions). All together there were 51 questions. For each section there was one open question and the rest were mostly multiple choice ones using a Likert scale. The reason for the selection of multiple choice questions was the need to obtain quantitative answers, to make statements of the relevance of specific terms identified in the analysis. An open question was added to each section so that the person completing the questionnaire could add further information. Some of the results can be seen in table 2.

The questionnaire respondents expect that future employees should have skills on risk management (89.3%), know how to reduce risks as well as how to identify risks (73.2%). The respondents expect that future employees should have skills on risk management (89,3%), on how to reduce risks as well as how to identify risks (73,2%). The results of the questionnaire on mediation methods show that on average the respondents are sceptical of the sufficiency of only having theoretical classes (50%), but that they do expect that classes will give the students an understanding of risks (28,6%).

All engineering candidates should get a basic knowledge of a standard risks management process				
Not at all				Very much so
0.0	0.0	5.4	37.5	51.8
It is important that engineering students learn about the different steps in the risk management process in more detail				
True				Not true
1.8	5.4	12.5	46.4	28.6
It is important that the candidate knows various methods of risk assessment				
Not at all				Very much so
1.8	10.7	23.2	35.7	23.2
The candidate should know different types of risks. How they may occur and how they can be detected				
Not at all				Very much so
0.0	1.8	19.6	41.1	32.1
It is important that the candidate knows how to reduce risks				
Not at all				Very much
1.8	1.8	10.7	44.6	35.7
The candidates do not need to know anything about risk management, they will learn what they need while performing there				
Strongly disagree				Fully agree
41.1	32.1	12.5	3.6	3.6
Do you agree upon that it is sufficient to read a book on risk management to understand how to apply risk management methods				
Strongly disagree				Fully agree
26.8	41.1	16.1	8.9	1.8
To what extent do you think it is possible to read a book on risk management to get an understanding of risk management in an enterprise network				
Not possible				Very well Possible
5.4	32.1	39.3	12.5	5.4
Do you agree upon that it is sufficient to join a theoretical class on risk management to understand how to apply risk management				
Strongly disagree				Fully agree
12.5	37.5	23.2	21.4	0.0
To what extent do you think it is possible to join a theoretical class on risk management to get an understanding of risks in an enterprise				
Not possible				Very well possible
5.4	17.9	35.7	26.8	1.8

Table 2: Survey results

Discussion and conclusion

Regarding the need of which competencies needed for successfully carrying out SCRM, shows that in addition to technical skills on RM methods and on risk behaviour, skills like communication, decision-making, planning and assessment are required. The literature also shows that specifically the latter competences are difficult to teach by using traditional lectures. However, the analysis of the educational offers shows that this is the main teaching form.

The analysis of course content showed that there are several offers supporting this objective, but the analysis also revealed that most of the offers used classical teaching methods such as lecturing instead of methods fostering active participation. Vocational training centres used more experiential learning methods, whereas the universities used classical lecturing as the primary teaching method, or lectures in combination with tutorials. The usage of lectures as the main teaching form is a contradiction to the preferences of the teaching method based on the analysis of the questionnaires, as the results of the questionnaire on mediation methods show that on average the respondents are sceptical of the sufficiency of only having theoretical classes (50%), but that they do expect that classes will give the students an understanding of risks in Supply Chains (28.6 %). The identified mismatch between offered teaching methods and preferred teaching methods show may explain the challenge among actioners to carry out risk management efficiently. Also the unwillingness of companies to invest in training on this subject among their employees as well as their short term goals increases this challenge. The study also show that there are educational offers based on active participation. These can be used as a supplement to curricula without needing to change them.

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INTEGRATING ENTREPRENEURSHIP INTO SUPPLY CHAIN MANAGEMENT CURRICULUM TO EXPAND STUDENTS' ENTREPRENEURIAL MINDSET

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Abstract
Purpose:
Integrating innovation and entrepreneurship into curriculum is a noticeable trend in America's higher education and producing entrepreneurial graduates is becoming a mission for many institutions. Supply chain management and entrepreneurship classes are usually taught in separate classrooms, and yet the knowledge and skillsets pertinent to these two subjects are inseparable and indispensable when it comes to planning and launching new business ventures. Thus, understanding the intersection of these two subjects and developing effective pedagogical methods are valuable for expanding the respective curriculum and for enhancing students' entrepreneurial perspective. This paper is built on two fundamental principles: (1) students' entrepreneurial mindset (EM) is viewed as an important learning outcome by current higher-education institutions; and (2) the EM framework, defined by Kern Entrepreneurial Education Network (KEEN), is adopted as a basis for measuring students' entrepreneurial behaviour. The major goal of this article is to explore teaching methods and classroom exercises that can integrate some aspects of entrepreneurship into supply chain management curriculum and to share the experiences and lessons learned from my own experiments.

Design/Methodology/Approach:
This conceptual paper is a result of two efforts. The first is a comprehensive literature review of two areas: one is the components of a complete entrepreneurship ecosystem in higher-ed setting and representative university practices; and the other is the three attributes of EM defined by KEEN through three C's: curiosity, connection, and creating values. The second effort is experimental in nature and describes a course project based on a real start-up and several in-class exercises/assignments I have designed and implemented in my undergraduate global logistics class to engage students in active learning while simultaneously strengthening their three EM characteristics.

Findings:
The review results and my experiments are presented and areas for future improvement are discussed, while some initial student feedback is also included. In addition, possible ways for integrating the fundamental elements of supply chain management and entrepreneurship into respective courses are proposed. It is found that active learning is an effective pathway for cultivating students' entrepreneurial mindset.

Value:
The value and originality of the paper are revealed by at least two perspectives. The first is that it provides a useful means and complements a university-wide endeavour for enhancing students' entrepreneurial behaviour. The other is that it is one of the first pedagogical efforts to integrate interrelated elements of supply chain management and entrepreneurship into each other's course, which adds a new flavour and dimension to each subject. The paper will be of interest to educators and practitioners in both fields.

INTRODUCTION

There has been a big buzz on college entrepreneurship lately in the U.S., and starting businesses is becoming increasingly popular among college students. As a result, innovation and entrepreneurship (I&E) are one of the keywords frequently cited in classrooms and education related media, and fusing I&E into regular curriculum is considered a new trend in higher-education institutions.

Kern Family Foundation, headquartered in Waukesha, Wisconsin and famous for its goal to empower the next-generation Americans to lead flourishing lives, has identified "instilling entrepreneurial mindset" as one of its four philanthropic focuses. One of its sponsored programs, the Kern Entrepreneurial Engineering Network (KEEN), is a national partnership of universities with a shared vision to revolutionize education, which is to graduate engineers with an entrepreneurial mindset so they can create personal, economic, and societal value through a lifetime of meaningful work.

Supply chain management and entrepreneurship classes are usually taught separately in business classrooms, and yet the knowledge and skillsets pertinent to these two subjects are inseparable and indispensable when it comes to planning and launching new business ventures. Thus, it is valuable to understand the intersection of these two subjects so as to expand the respective curriculum and to offer students more exposure to the essence of entrepreneurship.

The goal of this paper is thus fourfold: (1) to summarize the key components of a university-based entrepreneurship ecosystem; (2) to review what entrepreneurial mindset means in the context of higher education and how to cultivate that through active learning; (3) to describe my experiments in my supply chain and logistics courses to expand students' entrepreneurial mindset. The details of some of these projects and how they are linked with the class materials are provided; and (4) to explore the intersection between supply chain management and entrepreneurship and the associated implications for respective course content expansion.

ENTREPRENEURSHIP ON HIGHER-ED CAMPUS

Many campuses around the U.S. are developing opportunities and providing resources to help students become innovative and entrepreneurial, as well as to keep them on campus to finish their education. These activities range from a university-level strategic initiative to a programmatic offering in a Business School such as a minor in Entrepreneurship. For example, campuses with big names and ample resources, such as Harvard, Michigan and Penn State, are able to provide funding, physical space and advisory services to students that have business ideas.

One may think that comprehensive universities with strong engineering programs are usually active in entrepreneurship, but as a matter of fact, small schools with much less programmatic offerings, and even liberal arts colleges, have also followed the trend and taken steps to build an entrepreneurial campus. Taking three universities in Pennsylvania as examples, Villanova, Bucknell and Ursinus, we see that regardless of the size, prestige, or nature of a university, each campus can always find a suitable way to facilitate their community members to pursue their business ideas.

Extensive case studies indicate that, to foster students' entrepreneurial spirit and sustain their interest and pursuit, it is important to build a university-based entrepreneurship ecosystem (UBEE) for unified strength and long-lasting impact. Evidently, such a UBEE must be established in a top-down fashion, meaning that the buy-in of senior leaders is crucial, followed by faculty champions and various physical, intellectual, and financial resources.

Rice, et al. (2014) conducted a comprehensive case study of six universities worldwide that have evolved over a minimum of two decades: three located in the United States; and one each in Latin America, Europe and Asia. The study has identified nine essential components of a UBEE shown in Figure 1 that enable each of the six universities to achieve a sustainable and impactful entrepreneurship ecosystem. Additionally, the authors have noticed that although a remarkable convergence with respect to the common elements exists, there is significant variability in the strength and importance of the various elements of each of the six ecosystems. The findings of this study provide a possible roadmap for any higher-education institution to develop towards an entrepreneurial campus.
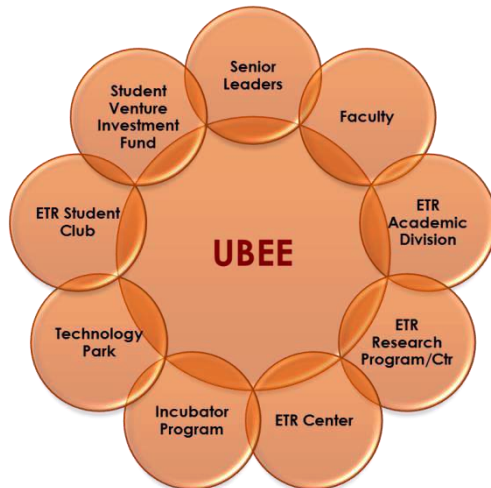

Figure 1: The Nine Essential Components of UBEE (Rice, Fetters and Greene 2014)

ENTREPRENEURIAL MINDSET AND TEACHING

Perhaps Kern Engineering Education Network (KEEN) is the most important advocate and supporter of entrepreneurial mindset learning (EML)[1]. By working with faculty leaders of universities, KEEN believes that EML should be an important element students need to acquire while they are on campus and can be taught and learned in classrooms. In particular, KEEN defines with major characteristics of entrepreneurial mindset that all start with the letter, "C", as shown below:

(1) <u>Curiosity:</u> (i) Demonstrate constant curiosity about our changing world; and (ii) Explore a contrarian view of accepted solutions.
(2) <u>Connections:</u> (i) Integrate info from many sources to gain insight; and (ii) Assess and manage risk
(3) <u>Creating Value:</u> (i) Identify unexpected opportunities to create extraordinary value; and (ii) Persist through and learn from failure.

The importance and value of instilling EML into education can be best described by Kriewall and Mekemson (2010). From an educational perspective, the essential question to EML becomes "how to do and achieve it in each classroom?" A set of key pedagogical methods, collectively called "Active Learning", is proven effective and powerful in EML. Active Learning is a process whereby students engage in activities, such as reading, writing, discussion, or problem solving that promote analysis, synthesis, and evaluation of class content. A

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[1] http://engineeringunleashed.com/keen/em101

comprehensive workshop by Bonwell offers a range of classroom activities that make in-class learning and teaching enjoyable and engaging. A brief classification of these pedagogical methods is given in Figure 2.
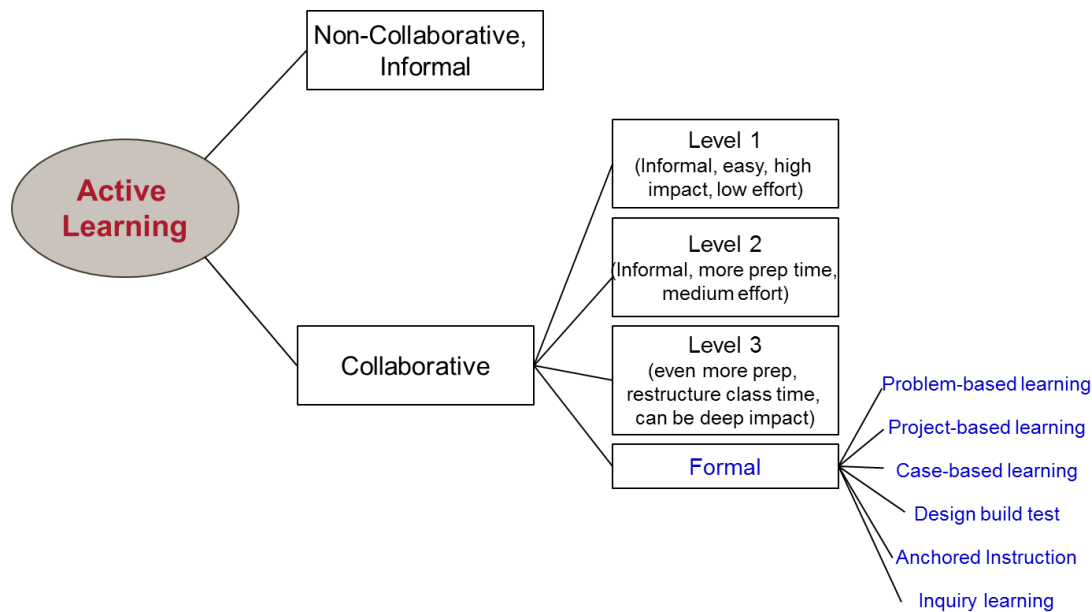

Figure 2: A Classification of Teaching Methods for Active-Learning

MY EXPERIMENTS IN SUPPY CHAIN MANAGEMENT COURSES

Course Project based on Real Startup

The intersection between supply chain management and entrepreneurship can be pursued through course projects based on real start-ups' practice and operations. I have collaborated with a real start-up and designed a project based on the company's plans for commercializing its latest patent in the field of organic chemistry. The project was implemented in my graduate supply chain class and undergraduate global logistics class, both in the fall of 2014, to enable students to experience how to design supply chain and logistics channels for bringing new products and technologies to potential global markets.

The start-up is called Organic Technologies Corp (OTC), LLC, based off in Milwaukee, Wisconsin. Their newest patented technology is a fine particle separation process through using an innovative combination of physical and chemical forces to accomplish the desired outcomes in a low-energy, ambient temperature, no-emission, and economically attractive fashion. Based on this patent, OTC was seeking to create two business ventures by commercializing this technology, as explained below.

The first one is associated with a set of cleaning products, called "Tongo". These easy-to-use products cleanse and dissolve mold and grease, and remove their odor quickly by only a few quick sprays of chemical liquids to the surface. Although these products look similar to current cleaning merchandise available in the market, they are not only environmentally friendly, but also removes odor and changes the surface wastes to non-harmful residuals after the chemical separation process. The products and associated manufacturing processes are already developed and ready for mass production and distribution to any potential markets. OTC was interested in establishing sales markets in China and Europe

with Switzerland and Norway as the starting points, in addition to the U.S. The student teams in my classes acted as consultants to help examine the feasibility and develop a detailed expansion proposal. Each team must gather, analyse and summarize the findings in a two-phase process and present key findings and recommendations.

The second venture aims to address an enormous environmental challenge of Red Mud storage and disposal, which presents one of the aluminum industry's most important problems. Red Mud is composed of a mixture of solid and metallic oxide-bearing impurities and is produced in the process of refining bauxite into alumina.The red color is caused by the oxidized iron that makes up to 60% of the mass of the red mud. Red Mud cannot be disposed of easily. In most countries where Red Mud is produced, it is pumped into holding ponds. Red Mud is toxic in either a wet or dry form and can destroy plant and animal life for multiple square miles upon a breach of holding ponds. These waste ponds represent a huge potential liability for the aluminum makers and presently have no positive economic value to these manufacturers. The new technology developed by OTC can effectively convert the Red Mud by neutralizing the material into valuable raw materials required for steel and aluminum manufacturing, while yielding valuable recovered metals and organically rich top soil, using a low energy, environmentally friendly or "green" process. With over 3 billion metric tons of Red Mud in sites around the world, this venture not only has enormous business potential and value, but also can make huge impacts in many dimensions. The biggest challenge of this business venture, though, is that a processing facility that can handle the Red Mud transformation process at a rate of millions of metric tons per year must be built. Aside from the processing capacity issue and significant capital investment, the facility location is a non-trivial question, as it obviously impacts inbound and outbound logistics costs and process design. OTC was considering building the facility in four countries – Guinea, Hungary, India, and Jamaica, and was also hoping that a standard venture establishment process will be developed through this study so that the process can be replicated to other countries of interest in the future. Four project teams, namely RM-Guinea, RM-Hungary, RM-India, and RM-Jamaica, were formed and each was expected to come up with detailed suggestions and associated rationales.

All the student teams working on the two ventures were required to follow a two-stage process as explained in Table 1. The research roadmap is divided into two steps to not only enable students to complete the research in a step-by-step fashion, but also follow the sequence of the subject topics covered in the class, allowing the students to apply immediately what was learned in the classroom to related project issues.

Table 1: Two-stage Research Process for the Course Project

Tongo Products	Red Mud Plant
Phase 1: Market Assessment • Macro-market evaluation • Profile of the household chemical industry • Country-specific regulations and policies • Import restrictions and IP laws • Analysis of sales market and competition	Phase 1: Market Assessment • Macro-market evaluation • Profile of current state of Red Mud in the country • Country-specific regulations and standards for constructing chemical plants • Existing efforts or plans for treating the Red Mud

• Case studies and best practices		• Sales markets for the recovered metals	

Phase 2: Market Establishment
• Doing business in the selected country
• Transportation infrastructure
• Design of distribution and sales channels
• Market entry
    • Finding partners
    • Source/Produce/Sell
• Risk mitigation and contingency plans
	Phase 2: Facility Location and Logistics Network
	• Location decision factors
	• Obtaining construction permit and potential barriers
	• Transportation infrastructure around the selected site and design of distribution and sales channels
	• Risk mitigation and contingency plans

This exercise helps students become aware of the interrelationship between supply chain management and entrepreneurship, as well as gain a deeper understanding the role of supply chain/logistics in launching and managing a new business venture. Some of the "pros" of such a course project include (1) an authentic case exposing a real-world scenario to the students, as supposed to a hypothetical case; (2) a specific product, technology and market drawing more attention and interest from the student learners; (3) a great exercise for tying theories and concepts with a real-world practice and giving students a hands-on opportunity; and (4) enabling students to "discover" the important role logistics/supply chain plays in starting new businesses. The major "con" of this exercise is the lack of economic/financial data for modeling and in-depth analysis of logistics network planning and design alternatives. My future plan for improving this exercise includes collaborating with our TAN (Tech Advisors Network) to help the new business startups to develop their initial supply chains in order to make their ventures successful.

In-class Active Learning Activities

In the fall of 2015, I designed a series of active-learning activities ranging from simple Level-1 to more sophisticated Formal exercises for my undergraduate "Global Logistics" class. A summary of these activities are reported in Table 2, which also indicates the level of sophistication. At the end of the course, I conducted a survey to gauge students' assessment of the engaging level of each activity, and the average scores (on a 5-point scale) are shown in the last column of Table 1. It's a bit interesting to notice that simple activities can also induce high level of student engagement and participation, as seen in the last two exercises on the list.

Table 2: Active-Learning Exercises in My Undergraduate Logistics Class

#	In-class Activities, Exercises and Assignments	Activity Learning Method	Average
1	Supply chain performance analysis of Walmart & Nordstrom	Formulate Share Listen Create	3.36
2	Acronyms used for market classification: how many do you know?	Think-Pair-Share	3.80
3	Market entry strategies used by 20 companies	Quick Thinks – Level 2	3.56

4	Global market selection for WorcesMed	Jigsaw; Gallery Walk	4.19
5	Logistics network design options and company examples	Quick Thinks – Level 1	3.60
6	Decision-tree and discounted cash flow analysis for Trip Logistics	Formulate Share Listen Create	3.42
7	Sales & Ops Planning case competition: Mintendo Game Girls	Cooperative Base Pairs; Problem–based Learning	3.96
8	Internet-based beer games	Problem-based Learning; Design Build Test	4.67
9	Group case study of postponement at Penang Electronics	Case-based Learning	3.77
10	Warehousing and packaging video clips and discussions	Quick Thinks – Level 1 & 2	4.56
11	Sustainability at WPI and SCM information technology trivia	Quick Thinks – Level 1	4.04

My personal favorite, which also takes the longest time for me to prepare and manage, is No. 4 – *Global Market Selection for WorcesMed*, and class rated this exercise 4.19/5.00 (5 = highest) in terms of the engaging level. In this exercise, the students are assumed members of the Global Logistic Division of WorcesMed, Inc., a developer and manufacturer of medical devices headquartered in Worcester Massachusetts. The Board of Directors of the company has come to the division stating that they have selected five countries (Australia, Brazil, China, Chile, and Germany) and for future market expansion and need the students' advice on choosing one country. A brief description of how the exercise was designed and implemented is given below.

- Objectives: Gain a deeper understanding of global market assessment process, develop the ability to collect data for important indicators, and practice relevant comparison techniques.

- Deployment and staging schedule
  - Step 1: Expert groups' study (5 groups with each studying one country and collecting related data and facts; outside class work)
  - Step 2: Expert groups meet to update on progress (in class – 50 minutes)
  - Step 3: Advisory groups meet (6 groups with each group consisting one member from the expert group), discuss and make a recommendation by debriefing the entire class and designing a poster; each expert group submits the country assessment report. Each group is provided with color markers and a poster paper for creating the poster (in class – 110 mins)

- Deliverables and student assessment
  - Participation (10 points): Expert Group Meetings, Advisory Group Meeting, and Final Debriefing and Voting (jigsaw)
  - Expert group report on assigned country (25 points) (written report + 3-min pitch)
  - Advisory group work on poster design (6 points)
  - Poster design quality (9 points; Gallery Walk)

INTEGRATION OF ENTREPRENEURSHIP AND SUPPLY CHAIN MANAGEMENT

The intersection between entrepreneurship and supply chain management actually can be explored easily in a straightforward manner from at least two perspectives. The first

perspective is illustrated in Figure 3, which shows the linkage between the essential elements of supply chain planning and the critical components of a business plan/model. In each respective class, the one-to-one relationship can be discussed conceptually and using real company examples, which will definitely reinforce students' understanding of how the two subjects are interrelated and dependent upon each other.
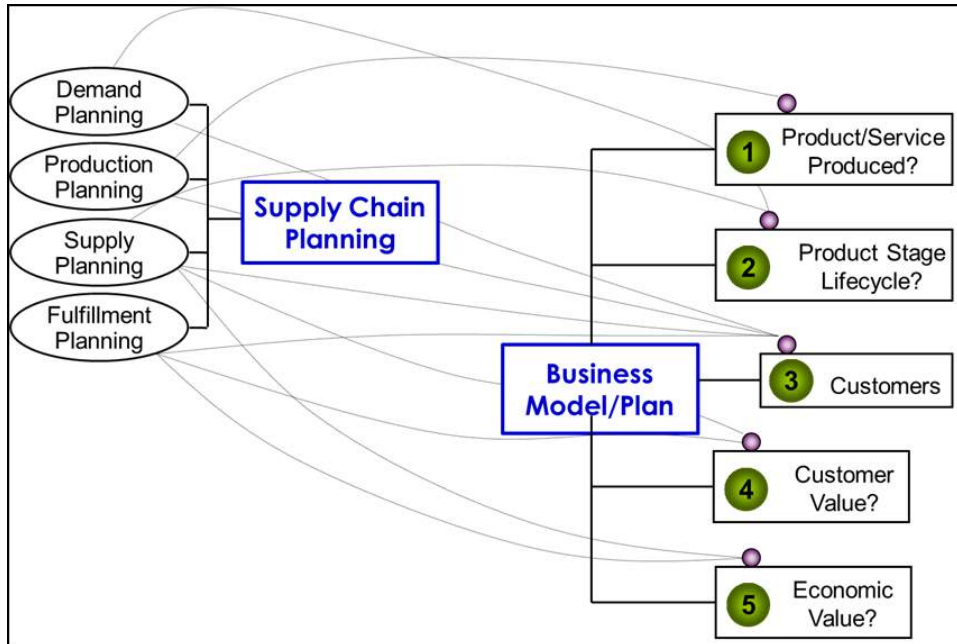
Figure 3: Supply Chain Planning and Business Plan

The second perspective is revealed by the possibility of injecting supply chain related concepts into specific topics in an entrepreneurship class. For example, in an undergraduate class at WPI called "Assessing Entrepreneurial Opportunities", there are at least two topics that suggest augmented discussions by including supply chain/logistics elements: (1) In *Topic 3 - macro-market analysis: is this a good market*? Concepts of logistics, logistics infrastructure, and cultural impacts of a selected market can be included; and (2) In *Topic 10 – building strategy maps*: supply chain concept, supply chain strategy, and strategic planning can be integrated into the discussion.

CONCLUDING REMARKS

This paper reviews what entrepreneurial spirit and mindset mean in the context of higher education and stresses the importance of active learning as a pedagogical guideline for cultivating students' entrepreneurial mindset. Furthermore, this paper presents some specific active-learning methods such as course projects and various in-class activities in my supply chain and logistics classes to demonstrate how to engage students in the learning process, to stimulate their interest and curiosity, to develop their capacities to make connections, and to expand their thinking about creating values and making impacts. From a teaching perspective, this paper also explores how the two subjects, namely supply chain management and entrepreneurship, can be taught jointly in respective classes to enrich students' learning and knowledge pertinent to entrepreneurship.

The value and originality of the paper are revealed by at least two perspectives. The first is that it provides a useful means and complements a university-wide endeavour for enhancing students' entrepreneurial behaviour. The other is that it is one of the first pedagogical efforts to integrate interrelated elements of supply chain management and entrepreneurship into each other's course, which adds a new flavour and dimension to each subject. The paper will be of interest to educators and practitioners in both fields.

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MODERATED MEDIATION ANALYSIS OF ACADEMIC IMPACT OF SUPPLY CHAIN MANAGEMENT SCHOLARS

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Abstract

This paper applies social capital theory to develop a theoretical model for the antecedents of the research impact of supply chain management scholars. From a database of 450 supply chain management scholars from various universities collected from ResearchGate and economic data from the World Bank, an analysis of the mediating role of the scholars' social capital suggest that social capital theory has a strong explanatory power on the relationship between research skill and academic impact. Further, an examination of the boundary effect of the country level factor suggests that this mechanism is economic development dependent.

Keywords: Academic Impact, Social capital, Supply chain management, Moderated mediation effect

Introduction

Scholars usually obtain peer recognition and funding opportunities by sharing their research outcomes. The most popular and common form of knowledge sharing is to share their publications via academic social websites. Such websites are useful for research related activities because of the ease of making new connections with peers (Yu, Wu, Alhalabi, Kao, & Wu, 2016).

ResearchGate, a social platform founded in 2008 by Madisch, is the largest online scholar community for knowledge sharing. ResearchGate seeks to transform the way researchers do research (Thelwall & Kousha, 2015) as researchers can now disseminate their ideas and share their publications freely to facilitate collaboration with other researchers globally. The domain of supply chain management is a large and rapidly growing area within ResearchGate. Thus, a study of the supply chain management scholar's academic impact globally can provide an international view about supply chain management.

However, whether a supply chain management scholar's research has impact may be influenced by country-level contextual factors (Haunschild, Bornmann, & Leydesdorff, 2015). Government investments, including policy and monetary instruments, research system building vary hugely. The investment and development that increase the efficiency of the research system in high economic development countries have a critical influence on a supply chain management scholar's academic impact (Varsakelis, 2006). Therefore, it is important to examine the boundary effect of economic development.

Overall, this study makes three contributions. First, this research extends previous studies that focused on scholarly impact. This paper explores the mechanism of the relationship between research skill and scholarly impact by testing the mediation effect of a scholar's social capital. Second, this study examines the boundary effect of this mediation process by specifically using a country-level moderator of economic development to determine if there exist any country-level variation. Third, the data of 450 supply chain management scholars from various universities collected from various datasets such as ResearchGate and the World Bank provide rich and robust empirical foundation for our analysis.

Theory and hypotheses

1. Social capital theory

Social capital theory has received increased attention in the literature and has been studied at multiple levels: individual (Raider & Burt, 1996), organizational (Nahapiet & Ghoshal, 1998), and societal (Dasgupta & Serageldin, 2001). Social capital has multiple definitions, interpretations, and uses. In this paper, we focus on the individual level and define social capital to be the collective value of all social networks and the inclinations that arise from these networks to do things for each other (Liu, Gan, & Zhang, 2015). Put simply, social capital emphasizes on the benefits from the trust, reciprocity, information, and cooperation associated with social networks. For an individual, social capital contains both interpersonal relationships and the resources from the social network (Burt, 1992). We focus on the interpersonal relationships an SCM scholar has. Social capital theory suggests that individuals are capable of achieving results from interpersonal relationships (McFadyen & Cannella, 2004). High social capital is reflected by both the direct and indirect ties individuals maintain with others, such as how many colleagues follow one scholar's research in ResearchGate. Researchers have positioned social capital as being needed for understanding knowledge creation (Nahapiet & Ghoshal, 1998), which directly influences the academic impact of researchers. Researchers are now able to access and leverage resources embedded in social networks through their interactions. The strength of social relations indicates how well a researcher knows his/her exchange partners. However, explicit knowledge is modifiable; it can be easily transferred from one person to another, frequently without much interpersonal interaction (Tsai, 2001). Scholars can easily find and follow other scholars they are interested in, and read and download their publications through ResearchGate. When a scholar has more followers, his/her research will have a higher chance to be known by other research partners. Scholars have applied social capital in the theoretical and empirical studies of scholarly performance. For instance, McFadyen and Cannella (2004) found that social capital affords the opportunity for scholarly interactions and has positive relationships with knowledge creation and scholarly output.

2. Research skill and social capital

In the modern academic environment, researchers are more likely to cooperate internationally. International cooperation makes their study more convincing and global. Researchers are more likely to cooperate with other scholars who have various research skills. Collaboration can deliver an increased diversity of resources, skills, knowledge, and viewpoints. Studies have shown that scholars tend to collaborate with others who can help them in terms of methodology or theory building. Pinto et al. (2010) have examined 3,116 articles published in seven logistics journal from 1987 to 2007. They conclude that scholars in the logistics area value co-authored research. The results show that co-authorship and the frequency of citations are significantly related. This leads us to posit that cross-disciplinary and international collaboration are a conduit for providing knowledge, and they facilitate ongoing knowledge exchange for developing a better understanding of this area. Research skill is a scholar's human capital, which refers to the knowledge and abilities fit for change in action and economic growth. Research human capital is the skills and knowledge that are valuable for a specific research area or method (Dakhli & De Clercq, 2004).

Research skill can be developed through formal training and education aimed at updating and renewing one's capabilities in order to do well in research collaboration (Dakhli & De Clercq, 2004). Accordingly, research skills can strengthen one's ability to have better social capital in research. Dasgupta and Serageldin (2001), in reviewing of social capital, concurred with Coleman (1990) and emphasized the importance of research skill for developing social capital. As for ResearchGate, some evidence suggest that supply chain management scholars who have more research skills may have more followers. For example, a supply chain management scholar from ResearchGate (scholar A) has 27 research skills and there are 57 scholars following his personal page. In contrast, scholar B with 5 skills has only 7 followers. Thus, a scholar with more skills may have more social capital. We propose the following

hypothesis:

H1: A scholar's research skill is positively related to his/her social capital.

3. Social capital and academic impact

Scholars, whose social capital is high, have a higher academic impact. McFadyen and Cannella (2004) found that when individuals seek partners to exchange information and knowledge, these individuals will be influenced by their partners. The number of followers, as a proxy of social capital, explains how research skill influences academic impact. On ResearchGate, scholars with a large number of followers have a higher academic impact than those with a low social capital. This is because scholars with a high social capital will influence other scholars who view their work by following their personal pages. These followers can know the recent activities including the publications and topics of the scholars they follow. This suggests that scholars who have more followers have more academic impact. Hence, we posit that:

H2: A scholar's social capital is positively related to the scholar's academic impact.

4. Mediating role of social capital between research skill and academic impact

The above hypotheses suggest that research skill has an influence on a scholar's social capital which may in turn have a positive effect on academic impact. Therefore, a scholar's academic impact is directly influenced by the scholar's research skill through social capital. Research skill is the human capital of a researcher. Kilkenny, Nalbarte, and Besser (1999) proposed a human capital model for performance, which suggests that high performance results from human capital. In addition, they found out that all measures of social capital exert an effect on individual performance. Moreover, Boxman, De Graaf, and Flap (1991) report a direct effect of social capital on individual performance. Social capital adds to, rather than replace, human capital in explaining individual performance. As such, we propose a mediating model to explain the relationship for research skill, social capital and academic impact. Thus, we have:

H3: A scholar's social capital mediates the relationship between research skill and academic impact.

5. Moderating role of economic development

The strength of a country's research and high education system depends on the level of economic development (Varsakelis, 2006). Countries with higher economic development usually invest more resources into their research and higher education systems than countries with lower economic development. According to Abbott and Doucouliagos (2003), in most developed countries with a better developed research and higher education system, universities are largely funded by public sector agencies, such as the Department of Employment, Education and Training. In a developed country, the public universities are autonomous bodies established under legislation and a well developed system provides scholars with more opportunities to disseminate their work. As such, the results can be better shared and the academic impact is greater. Thus, a better managed research system can support academic impact.

Figure 1 summarizes the theoretical model for this study. To explain the relationships among economic development, research skill, and academic impact, we propose the following hypotheses:

H4: Economic development moderates the relationship between social capital and academic impact.
H5: Economic development moderates the mediation effect of research skill on academic impact.

Method

1.   Measures

Our study focuses on the active researchers found in ResearchGate, namely those who interact with their peers and respond through this medium. We identify only supply chain management researchers. Thus, 450 members with a ResearchGate score of greater than 3.0 were selected. This score was selected as 90 percent of the overall ResearchGate members have a ResearchGate score of greater than 3.0, which indicates our sample is representative. The data of research skill, social capital and academic impacts are coded from ResearchGate. *Research skill* is measured by the number of research skills a scholar has. *Social capital* is measured by the number of followers a scholar has. A large number of followers indicates a scholar with a high social capital. *Academic impact* is measured by a scholar's impact points, which are computed based on the total impact factor of the journal articles that researchers from a university have authored. All data before 10 January, 2016 were coded. *Economic development* is measured from the World Bank by the Gross Domestic Product of the researcher's base country. Two variables are controlled: the scholar's number of research topics and country culture. We control for the number of research topics because the more topics a scholar focuses on, the more research skills possessed, which may distort the results. Country culture is controlled because scholars in high power distance countries may have more followers e.g. the US. Scholars in high power distance countries tend to accept power distribution inequalities in organizations (Clugston, Howell, & Dorfman, 2000). People tend to follow the websites of scholars with stronger research skills,. We measure the power distance culture using the data from the World Values Survey maintained by Hofstede (http://geert-hofstede.com/china.html).

2.   Analysis strategy

For the mediation tests, we followed MacKinnon, Lockwood, Hoffman, West, and Sheets (2002) and K. Preacher and Hayes (2004). Bootstrap analysis was used to avoid the problems associated with non-Normal data. For the moderation test, an interaction term was created and its significance was tested (Aiken, West, & Reno, 1991). The moderated mediation or the 'conditional indirect effect' (K.J. Preacher, Rucker, & Hayes, 2007) indicating the contingent nature of the mediation effect, depends on the moderator(s). Based on Edwards and Lambert (2007)'s procedure, we test our model by integrating the moderated regression analysis and path analysis to simultaneously analyze moderation and mediation. Hayes (2012)'s PROCESS model ver 2.15, an add-on in SPSS, was applied to conduct the analysis. Potential multicollinearity was avoided by centering the variables and expressing the interaction terms as a product of the centered scores of the component variables. In addition, Monte Carlo Simulation bootstrap method is applied to calculate the difference of mediation effects between high and low economic development countries (Kristopher J Preacher & Selig, 2012).

Results

Table 1 reports on the descriptive statistics: mean, standard deviation, and bivariate correlations among the studied variables. The results show that social capital is positively correlated to research skill (r=0.44, p<.01) and academic impact (r=0.53, p<.01) respectively.

INSERT TABLE 1 ABOUT HERE

Figure 3 summarizes the statistical model. Multicollinearity was avoided by centering the variables

and expressing the interaction terms as a product of the centered scores of the component variables. Control variables were included in all the regressions unless specified otherwise. Hayes (2012) PROCESS model ver. 2.15 was used for the path analysis.

INSERT FIGURE 2 ABOUT HERE

Hypothesis 1 proposed that research skill is positively related to social capital. The results in Table 2 suggest a positive and significant direct effect of research skill on social capital (β=0.32, p<.001). Hypothesis 2 proposed that social capital is positively related to academic impact. The results suggest that a positive and significant direct effect of social capital on academic impact (β=0.66, p<.001). Thus, Hypotheses H1 and H2 are supported. For the mediation hypothesis H3, the indirect effect is statistically different from zero, as evidenced by a 95% bias-corrected bootstrap confidence interval that contains zero (β=0.23; CI [0.10; 0.44]; α=.05). The results suggest a mediation effect exists, supporting hypothesis H3. For the moderation analysis H4, economic development positively moderates the relationship between social capital and academic impact (β=0.26, p<.01), as shown in Figure 3. The effect of social capital on academic impact is high for countries with high economic development, and vice versa, as shown in Table 2.

INSERT FIGURE 3 ABOUT HERE

Hypothesis 5 proposed the moderated mediation effect of research skill on academic impact (through social capital) at high and low levels of economic development. To assess this indirect effect, we used the maximum likelihood estimate regression with 5,000 data draws. The results suggested the indirect effect of research skill on academic impact (through social capital) between the low and high economic development groups is significant (estimate = .10; CI [0.05; 0.24]; α=.05) based on R language tool. Thus, hypothesis H5 is supported. Figure 4 summarizes the results.

INSERT FIGURE 4 ABOUT HERE

Discussion and conclusion

This paper seeks to fill the gap in explaining the relationship between research skill and their academic impact. Using data from ResearchGate and the World Bank, we found that social capital theory can explain the relationship between research skill and academic impact. Further, the economic development of a country moderated this relationship and the mediation effect of social capital. Given these findings, our study provides several implications for theory and practice, and some avenues for future research.

1. Theoretical implications

This research offers two theoretical implications. First, this paper examined the relationship between research skill and academic impact by testing the mediation effect of social capital. The results indicated research skill influences social capital, which in turn influences academic impact. The supply chain management scholar with more research skills has more followers. More followers indicate that the publications will have a higher chance to be cited. The ideas and results from researchers with higher social capital skill will be more widespread and accepted. Second, the results indicated the mediation effect is stronger for countries with higher economic development. A supply chain management scholar has a higher research impact if he/she works in a country with high economic development. This is

because the research system there is more developed. A scholar's output can be better disseminated, evaluated and recognized. Likewise, in countries with low levels of economic development, the research system is not as developed, a valuable publication from a scholar may be undervalued and unrewarded.

2. Practical implications

Our findings may also be of interest to other scholars who want to enhance their research impact. The results imply that supply chain management scholars can reap the benefits of their social capital. Specifically, the results indicate that scholars can enhance their academic impact by increasing their social capital. In addition, a strong correlation between altmetrics and bibliometrics indicates that the researchers who have greater academic impact can usually enjoy better social impact among researchers sharing similar research interests (Yu et al., 2016). In addition, the investment on research skill development is important for increasing social capital, which in turn will enhance a scholar's academic impact. Scholars can also move to countries with better economic development to increase their academic impact albeit with much difficulty as many factors can hinder the move from their home country to another country e.g. family, religion, culture, and personal preference (Gawlewicz, 2014).

3. Limitations and future research

This study has three limitations. First, the findings from this study are from a specific research area. This limits the generalizability of the study. Future research could replicate the theoretical model in other fields, such as biomedical research and chemical research, and other knowledge-intensive industries. Second, the data collected from ResearchGate and the World Bank is cross-sectional in nature. Further studies could collect longitudinal data and thus provide a general and objective view on this study. Third, this paper only studied the effect of social capital at the individual level. Further research can study the impact from an institutional level, for example, how university reputation may influence social capital.

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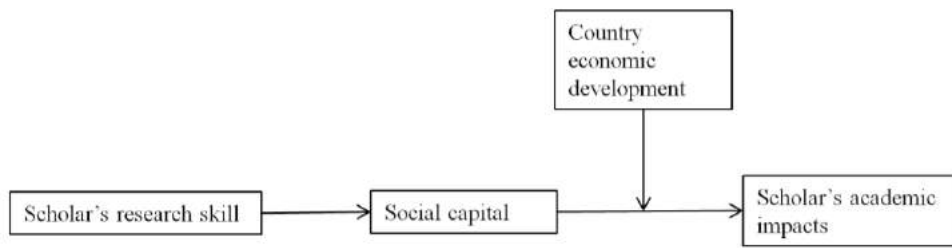
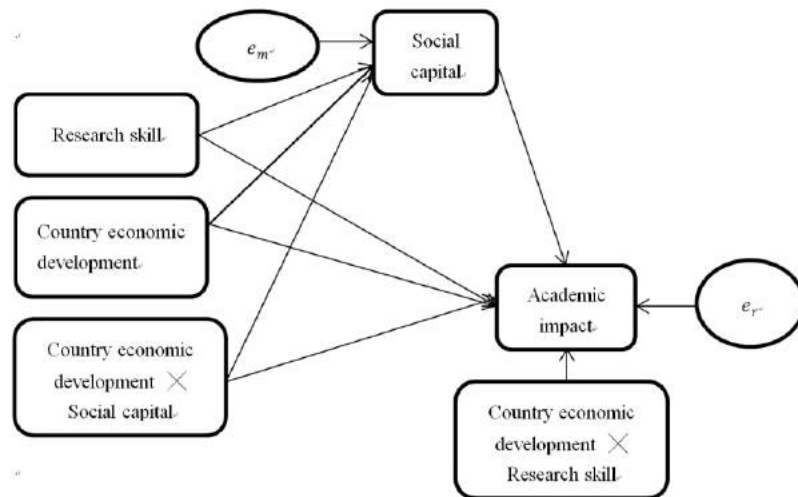**Figure 1. Theoretical model**

Figure 2. Statistical model

Figure 3. Interaction between social capital and economic development on academic impact
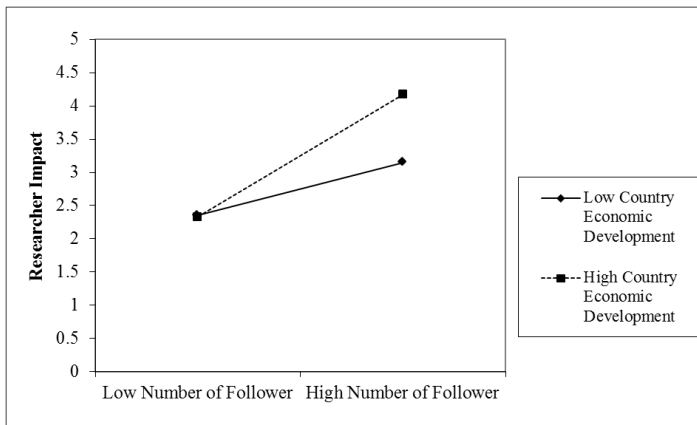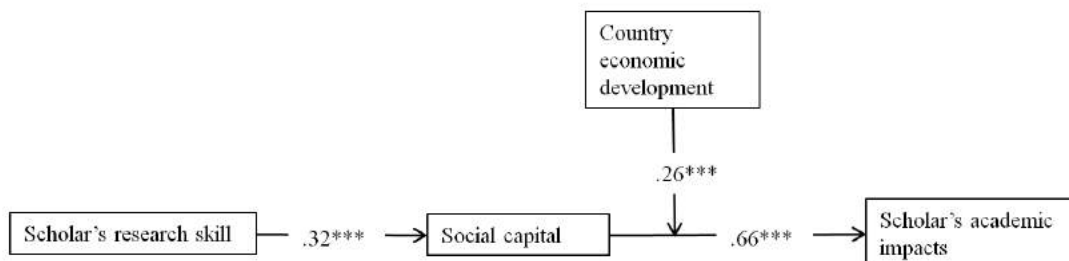

Figure 4. Summary of results

INVESTIGATING LOGISTICS SKILLS GAPS AND THEIR IMPACT ON THE SUPPLY CHAIN: A REVIEW OF THE SOUTHERN AFRICAN SITUATION

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Abstract
PURPOSE:
Southern Africa relies on trade to generate wealth to fund its economic and social development. Successful trade is dependent upon efficient and effective supply chains that must be supported by sound logistics management. It is therefore important to understand the current levels of skills required to operate those supply chains and deliver serviceability able to capture and sustain global business. This research endeavours to understand the skills required for South African and Namibian supply chains, identify those that are available and thereby recognise any skills gaps. It then seeks to ascertain the impact of any gaps on supply chain development in southern Africa and suggest a route to addressing them.

DESIGN/METHODOLOGY/APPROACH:
This research takes a critical realist approach using purposeful sampling of logistics industry stakeholders from South Africa and Namibia. The main instruments used were surveys evolved from previous research from Heyns and Luke (2013), based in South Africa. The surveys were designed to determine skills requirements and availability in the region, which enabled an understanding of skills gaps and their impact.

FINDINGS:
The investigation determined shortages in the South African and Namibian logistics industries, showing the similarities and differences between the two countries. Comparing the data sets enabled the researchers to understand the possible causes of the differences and make tentative extrapolations concerning the skills situation across southern Africa.

LIMITATIONS:
The main limitations concern the sample size, especially in Namibia, and the fact that the investigation to date has only covered two of the southern African countries, over different time periods. The limitations should be addressed by extending the survey laterally to include a greater number of Namibian stakeholders and encompass neighbouring (SADC) countries such as Botswana and Mozambique. It would also be desirable to extend the study longitudinally to investigate on-going changes and trends.

RESEARCH IMPLICATIONS:
The research output will increase the academic knowledge in this important area by creating awareness of the magnitude of the problem, thus laying the foundation for further academic investigation into the issue. It will also provide important information for

government and policy makers to consider in terms of future education and training interventions for the logistics sector.

ORIGINALITY:
Originality is derived from the fact that previous research on skills gaps in southern Africa's developing countries is limited.

INTRODUCTION

The research underpinning this paper concerns South Africa (SA) and Namibia. Both countries are members of the Southern African Development Community (SADC), an inter-governmental organisation which aims to further socio-economic cooperation and integration among 15 southern African states, of which SA is by far the larger and dominates the economy and therefore the logistics of the region. SA is the second largest economy in Africa, with the gross domestic product (GDP)(purchasing power parity) for 2014 being approximately US$707bn, ranking it 30th in the world (Central Intelligence Agency, 2016). In contrast, Namibia's GDP in 2014 was US$12bn. SA's total foreign trade by value (combined imports and exports) for 2014 was approximately US$ 127bn, which represents trade with over 220 countries (South African Revenue Services, 2016). Over recent years most of SA's major trading partners have sustained or increased trade with SA. This trend is expected to continue as the economic growth for SA for 2016 and 2017 is 0.7% and 1.8% respectively (International Monetary Fund, 2016). Some of the better performing countries in the region, i.e. Namibia and Botswana, as with most of the countries in the Southern African Development Community (SADC), are heavily reliant on SA, with 66% and 75% respectively of their goods imported from SA (Trading Economics, 2016) and there are therefore many synergies between their economies.

SADC synergies and challenges are influenced by SA, that is seen as the gateway to the region. According to the IMF, the real GDP growth estimate for SADC in 2016 is 3.1% (International Monetary Fund, 2015). Over the period 2003 – 2013 the region's economies grew by an average of 4.7% annually (South African Institute of International Affairs, 2015). This growth has seen other countries in the region have similar gateway aspirations i.e. Namibia, Mozambique and Tanzania (Werikhe & Jin, 2015).

The SADC region has massive potential, as is evidenced by its economic growth rates over the past ten years. SAIIA (2015) asserts that, although the average annual growth rate of 4.7% seems impressive, especially when compared to the equivalent of 2% in the European Union, it lags far behind areas such as ASEAN, with its 7.4% equivalent, implying that there is a clear potential for increased growth. "SADC region has an immense growth potential associated to natural resources availability. Investment opportunities arise in mining, agriculture, manufacturing, financial services, ICT, tourism and infrastructural development. Yet, the region performance continued to fall short of its potential ...." (Banco Nacional de Angola, 2012).

Oscar (2001) stated that international trade and economic growth were two undividable branches of economics. However for a country to succeed in external markets, it must have a well-organized and effective logistics industry that provides high standards of customer service (Hoekman, 2014). Another of the key issues underlying the relative lack of development of the SADC potential is the limited intra-regional trade, which accounts for between 10% and 12% of Africa's total trade. This appears very low when compared to approximately 40% in North America, 60% in Western Europe (Tafirenyika, 2014), 52% in Asia and 27% in Latin America (The Economist, 2013).

There are many reasons for SADC not reaching its full potential, including several obstacles to trade e.g. delays, complex documentation requirements, skills shortages and unpredictable border procedures, which all contribute to high costs and relatively low levels of trade in the region (Heyns & Luke, 2012). Hasse (2013) states that "Africa's economic development and ability to compete internationally depend on removing these roadblocks."

One of the most critical "roadblocks" is relative lack of appropriate levels of logistics competence in the region. In the World Bank's Logistics Performance Index for 2014, South Africa ranks as 34rd in the world, down from a high of 23rd in 2012. Comparing this to South Africa's major trading partners (China, Germany, U.S.A., Japan, India, Saudi Arabia and the United Kingdom), indicates some similarities with China, ranked at 28th, however there are few logistics synergies between South Africa and most of its major trading partners. Although Saudi Arabia is ranked 49th and India is 54th, in general, most of the trading partners are ranked considerably higher, i.e. with Germany 1st, U.S.A. 9th, Japan 10th and the United Kingdom 4th (The World Bank, 2015), indicating a mismatch between logistics competencies and a likely inability to trade on equal terms. The LPI confirms SA as dominating in SADC, however logistics improvements have been noted amongst other SADC countries. Namibia moved from 153rd to 93rd between 2010 and 2014, and Botswana from 135th to 120th. Some countries' performance has weakened with Mauritius down from 82nd to 115th and Mozambique ranked the lowest at 147th, down from 115th. There is still a big disparity between SA and the rest of the region on most index evaluating factors, however logistics competence and capabilities remains a problem for all. Trade within the region is thus severely hampered by logistics skills shortages.

The Global Competitiveness Report (World Economic Forum, 2015) indicates further skills issues, with SADC countries ranging from a ranking of 50 (Seychelles) through 116 (Namibia) to 120 (South Africa) and 130 (Maurtitius) when tested on the quality of the higher education system (which measures how well the education system meets the needs of a competitive economy). The region's major trading partners' rankings range from 15 (United Kingdom) to 67 (India), again indicating a mismatch in skills levels.

The above rankings, in terms of the Logistics Performance Index, as well as the Global Competitiveness Report, clearly indicate that skills are an issue within the region. The World Economic Forum's Outlook on the Logistics & Supply Chain Industry 2012 report indicates that skills shortages are key risks within the industry (WEF, 2012). As the world wide skills shortage becomes more severe, many countries experience difficulties in retaining their available talent. Many countries, including the United Kingdom and Australia, recognise their skills scarcities and have adjusted immigration plans to attract people with the appropriate skills sets (Migration expert, 2012). For developing countries it therefore becomes increasingly difficult to retain their existing talent.

Logistics skills in particular are hampering the ability to trade both within the region as well as with other countries and regions. "Africa's share of world trade is tiny—only 3% in 2009, according to the United Nations Conference on Trade and Development." (Hasse, 2013). It thus becomes critical to identify the logistics skills requirements in southern Africa, so that shortages can be addressed to the benefit of trade in and with the region.

RESEARCH METHODOLOGY
The purpose of this article is to obtain a better understanding of the current logistics skills shortages in southern Africa and to provide an indication of the skills required to develop effective supply chains in the region. Based on earlier research by Heyns and Luke (2012, 2014), which focussed on the supply chain skills requirements in the South African economy, a comparative research methodology was followed to ascertain the logistics and supply chain related skills requirements in Namibia. An initial exploratory study was conducted in Namibia to investigate if any synergies exist between the two neighbouring countries. Literature (Kisperska-Moron, 2010) suggests that a general shortage of educated and skilled supply chain managers exists worldwide and this research attempts to explore the critical skills required to enhance the competitiveness of supply chains in southern Africa.

Based on a review of various international studies (Heyns & Luke, 2012), a preliminary list of 66 skills areas were identified as important to logistics and supply chain managers. A panel of academics and industry experts in these fields deliberated the initial list and subsequently reduced it to a set of 38 which they perceive to be critical to industry. This

panel further grouped these as follows: (1) general management, (2) behavioural/interpersonal skills, (3) logistics awareness, (4) logistics analytical, (5) logistics information technology, and (6) environmental awareness.

To acquire a better understanding of the existing logistics skills requirements in South Africa, data from surveys conducted at two Annual SAPICS conferences (Association for Operations Management in Southern Africa), in 2011 and 2012 was used. The methodology used was convenience sampling. In both surveys the respondents were asked to rate, on a scale of 1 (to no extent) to 4 (to a large extent), the importance of the various skills and skills groups in the recruitment process for logistics and supply chain employees in South Africa. The analysis of the skill requirements are based on the survey results of 204 and 200 respondents in 2011 and 2012 respectively.

To acquire an initial understanding of the existing logistics skills requirements in Namibia, an exploratory survey was conducted at the 7th Annual Logistics and Transport Workshop at the Namibian University of Science and Technology (NUST) in 2015. The survey required respondents to rate the level of importance of the various skills and skills in Namibia. The analysis of the skill requirements are based on the survey results of 33 respondents. Although the number of respondents could be viewed as a limitation of the study, the researchers are of the opinion that the specialised nature of the sampling pool was capable of eliciting a relatively representative view of the opinions of Namibian practitioners. A further limitation could be regarded as the differing timescales of the surveys, however the Namibian survey was intended to be exploratory, with the aim of extending the research into the SADC region into the future.

RESEARCH RESULTS
Both surveys covered various industrial sectors and the profiles are depicted in Figure 1.
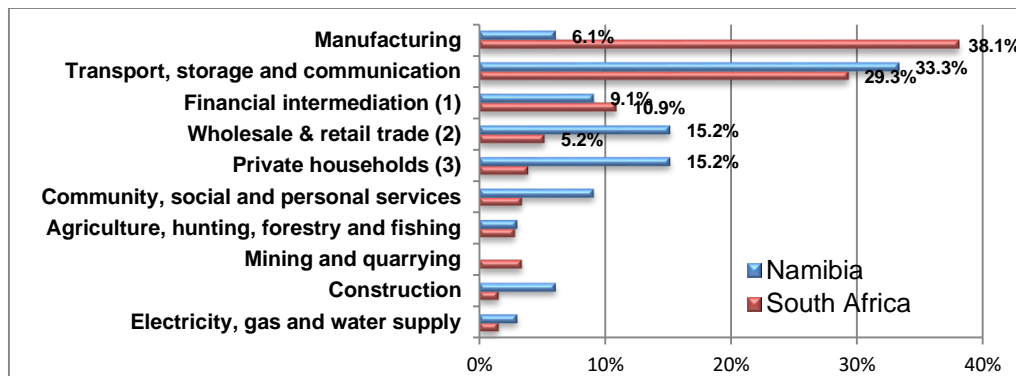
(1) Financial intermediation, insurance, real estate and business services
(2) Wholesale & retail trade; motor vehicles/cycle repair, personal & household goods; hotels & restaurants
(3) Private households, exterritorial organisations, representatives of foreign governments and other activities not adequately defined

Figure 1: Industries represented by respondents

The surveys used a four-point Likert-type scale. In terms of mean importance, respondents from South Africa ranked the skills group 'Logistics Awareness', as the most important, followed by 'General Management' and 'Logistics Analytical'. Respondents from Namibia ranked the skills group 'General Management', as the most important, followed by 'Logistics Analytical' and 'Behavioural / Interpersonal skills'. The low rating of logistics awareness is evident from Savage, et al. (2013) who illustrate the lack of understanding of logistics found within the Namibian industry. Both respondent groups rated 'Logistics IT' and 'Environmental awareness' the least important skills groups.

Table 1: Mean rating of proposed skills group

Skills Group	South Africa		Namibia	
	Mean	**Rank**	**Mean**	**Rank**
Logistics Awareness (e.g. see "big picture", total cost concept)	3.58	1	3.54	4
General Management (e.g. plan, organise, control)	3.52	2	3.72	1
Logistics Analytical (e.g. demand forecasting, transport & warehouse management, quantitative analysis)	3.46	3	3.62	2
Behavioural / Interpersonal skills (e.g. time & diversity management, people & social skills)	3.46	4	3.62	3
Logistics IT (e.g. software knowledge, computer skills)	3.17	5	3.48	5
Environmental awareness (e.g. reverse and "green" logistics)	3.00	6	3.38	6

The South African respondents were requested to indicate their agreement with a list of 38 (2011) and 30 (2012) skills regarded as important when recruiting employees. The ranking of the skills in terms of the perceived importance was established by calculating the mean of the various skills items. Table 2 depicts the descriptive statistical results of these results.

For the South African practitioners the most important logistics and supply chain-related skills are 'Customer focus' followed closely by 'Ability to plan and prioritise' and 'Business ethics'. The ten highest ranked skills comprise mostly 'softer' (i.e. Business/Interpersonal = 5) and very broad management skills (i.e. General Management = 3). 'Customer focus' and the 'Ability to see the big picture' are the two most important logistics awareness (LA) skills that are viewed as essential by the respondents.

Table 2: Mean rating of required skills of logistics managers (South Africa)

RANK	SKILLS ITEM	SKILLS GROUP	MEAN	RANK	SKILLS ITEM	SKILLS GROUP	MEAN
1	Customer focus	Logistics Awareness	3.64	20	Spreadsheet abilities	Logistics IT	3.23
2	Ability to plan and prioritise	General Management	3.62	21	Motivation skills	Behavioural / Interpersonal	3.22
3	Business ethics	Behavioural / Interpersonal	3.62	22	Negotiating skill	Behavioural / Interpersonal	3.21
4	Ability to see big picture	Logistics Awareness	3.57	23	Quality management	Logistics Awareness	3.19
5	Team work	Behavioural / Interpersonal	3.56	24	Transport and related regulation knowledge (1)	Logistics Awareness	3.17
6	Problem solving	Behavioural / Interpersonal	3.55	25	Supply chain design	Logistics Analytical	3.17
7	Ability to think outside the box	Behavioural / Interpersonal	3.51	26	Transport management	Logistics Analytical	3.15
8	Communication skills	Behavioural / Interpersonal	3.48	27	Procurement / Purchasing management	Logistics Analytical	3.13
9	Business process improvement	General Management	3.47	28	Project management (3)	General Management	3.13
10	Decision making	General Management	3.47	29	Networking skill (3)	Behavioural / Interpersonal	3.13
11	Time management (3)	Behavioural / Interpersonal	3.38	30	Quantitative and/or statistical skills	Logistics Analytical	3.09
12	Inventory management	Logistics Analytical	3.34	31	Conflict management (3)	Behavioural / Interpersonal	3.07
13	Leadership	General Management	3.33	32	IT skills / software knowledge	Logistics IT	3.01
14	Cross-functional coordination skills	Behavioural / Interpersonal	3.31	33	Reverse logistics	Logistics Awareness	3.00
15	Change management	Behavioural / Interpersonal	3.29	34	Order processing (3)	Logistics Analytical	2.93
16	Warehousing / Materials Handling manage	Logistics Analytical	3.28	35	Knowledge of environmental issues	Environmental Awareness	2.86
17	Supply chain cost knowledge	Logistics Analytical	3.28	36	Facility location / Network design (3)	Logistics Analytical	2.81
18	Knowledge of the industry	Logistics Awareness	3.24	37	Data mining (3)	Logistics IT	2.79
19	Demand forecasting	Logistics Analytical	3.23	38	ISO 14000 standards (2)	Environmental Awareness	2.71

(1) "*Laws and regulation*" in 2012 survey

(2) "*Green logistics/ environmental issues*" in 2012 survey

(3) Only in 2011 survey

The Namibian respondents were requested to indicate their agreement with a list of 38. Table 3 depicts the descriptive statistical results of these results. The most important logistics and supply chain-related skills are 'Team work' followed by 'Business ethics' and 'Customer Focus'. The ten highest ranked skills, similar to the South African results, also comprise mostly 'softer' (i.e. Business/Interpersonal = 6) and broad management skills (i.e. General Management = 3). 'Customer focus', an important logistics awareness (LA) skill, also features relatively highly.

Table 3: Mean rating of required skills of logistics managers (Namibia)

RANK	SKILLS ITEM	SKILLS GROUP	MEAN	RANK	SKILLS ITEM	SKILLS GROUP	MEAN
1	Team work	Behavioural / Interpersonal	3.84	20	Project management	General Management	3.40
2	Business ethics	Behavioural / Interpersonal	3.72	21	Supply chain design	Logistics Analytical	3.40
3	Customer focus	Logistics Awareness	3.72	22	Warehousing / Materials Handling management	Logistics Analytical	3.40
4	Time management	Behavioural / Interpersonal	3.71	23	Networking skills	Behavioural / Interpersonal	3.39
5	Ability to think outside the box	Behavioural / Interpersonal	3.68	24	Conflict Management	Behavioural / Interpersonal	3.36
6	Problem solving	Behavioural / Interpersonal	3.68	25	Motivation skills	Behavioural / Interpersonal	3.36
7	Communication skills - wirtten and oral	Behavioural / Interpersonal	3.67	26	Quality management	Logistics Awareness	3.36
8	Ability to plan and priortise	General Management	3.64	27	Cross-functional coordination skills	Behavioural / Interpersonal	3.32
9	Demand forecasting	Logistics Analytical	3.61	28	Reverse logistics	Logistics Awareness	3.32
10	Transport & related regulation knowledge	Logistics Awareness	3.60	29	Change management	Behavioural / Interpersonal	3.29
11	Ability to see big picture	Logistics Awareness	3.56	30	Order processing	Logistics Analytical	3.28
12	Decesion making	Logistics IT	3.56	31	Facility location / Network design	Logistics Analytical	3.24
13	Negotiations skills	Behavioural / Interpersonal	3.52	32	Procurement / Purchasing management	Logistics Analytical	3.24
14	Business process improvement	General Management	3.50	33	Quantitative and/or statistical skills	Logistics Analytical	3.21
15	Transport management	Logistics Analytical	3.48	34	Spreadsheet abilities	Logistics IT	3.21
16	Inventory Management	Logistics Analytical	3.44	35	Data mining	Logistics IT	3.20
17	Knowledge of industry	Environmental Awareness	3.44	36	Knowledge of environmental issues	Environmental Awareness	3.17
18	Supply chain cost knowledge	Logistics Analytical	3.42	37	ISO 14000 standards	Environmental Awareness	3.00
19	Leadership	General Management	3.40	38	IT skills / software knowledge	Logistics IT	3.00

When comparing the top ranked skills from the South Africa and Namibia surveys, it is noticeable that, albeit in a different order, seven skills are present in both top ten (when comparing the top 20, 16 skills are present in both). Most are soft skills. Similarities are also noticeable between the least important skills, as seven skills are found on both lists. For the Namibian practitioners the majority of the ten least important skills are related to logistics analytical skills followed by environmental awareness and logistics information technology related skills.

The majority of South African practitioners (63%) suggested that it was relatively easy to fill operational level positions. Similarly only 33% of the Namibian practitioners indicated that they have difficulties in filling operational level positions. It seems that tactical level positions are slightly easier to fill in Namibia with only 52% of respondents indicated difficulties in filling tactical level positions, as opposed to 65% of South African practitioners. A significant difference is evident when it comes to filling strategic level positions. It appears that South African practitioners find it much more challenging to fill these positions with 65% indicating difficulties, compared to only 40% of Namibian practitioners. Figure 2 shows that industry is struggling to attract people with the right skills and qualifications, particularly at tactical and strategic levels.
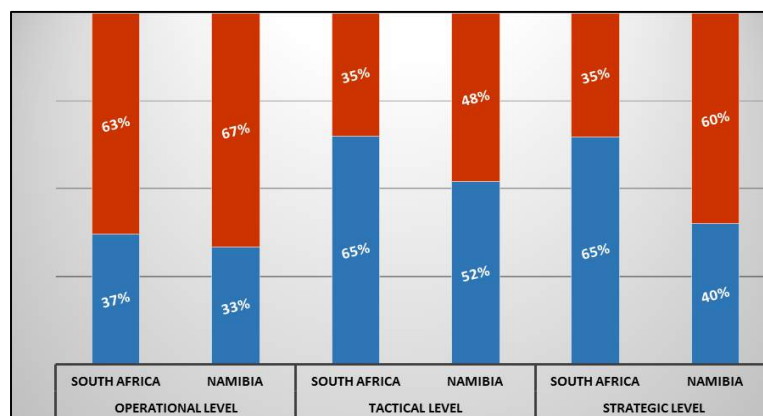
Figure 2: Difficulty of filling positions at various employment levels

Respondents were also requested to indicate which job functions are the most difficult to fill with suitable employees for operational, tactical and strategic level positions. Tables 4 and 5 provide lists of the ten most challenging job functions to fill for each of the management levels as indicated by South African and Namibian practitioners respectively.

Table 4: Positions most difficult to fill (South Africa)

Rank	Operational level	Tactical level	Strategic level
1	Managers (incl. distribution, ops, logistics, commercial)	Managers (incl. inventory, logistics, ops, project, transport, warehouse)	General managers
2	Controllers & supervisors	Planners (incl. transport, supply)	SC Managers
3	Drivers (Truck)	Demand planners	Executive & Directors
4	Planners (Demand)	Business analysts	Planners
5	Clerks	Procurement staff	SC Strategist/consultant
6	IT SC Specialist	Planner (Inv & prod)	Business analyst/researchers
7	Procurement staff	Controllers & supervisors	Logistics managers
8	Stores/Warehouse staff	Supply chain strategist	Procurement managers
9	Logistic staff	Consultants	Operational managers
10	Buyers	SC IT Specialists	Specialist managers

Table 5: Positions most difficult to fill (Namibia)

Rank	Operational level	Tactical level	Strategic level
1	Drivers	Inventory Managers	Supply Chain Managers
2	Cerks	Transport Managers	General Managers
3	Transport Planners	Logistics Planners	Researchers
4	Organizational Leaders	Organizational Leader	Fleet Managers
5	Operations researchers	Logistics Officers	Procurement Managers
6	Logistics Managers	Asset Manager	IT Managers
7	Inventory Controllers	Contract Manager	Logistics Planners
8	Warehouse supervisors	Demand forecaster	Statisticans
9	Buyers	Quality & Safety supervisors	Operations Managers
10	Mechanics	Project planners	Asset Managers

As the global economy is reliant on effective logistics and supply chain management, it is evident from the above that the development of supply chain skills in southern Africa is critical to the success of its trade with its global partner countries.

CONCLUSION

The findings from this research strongly imply that there are significant logistics skills shortages in the supply chain industries of both South Africa and Namibia. Given the quality of the higher education system, as measured by the Global Competitiveness Report, it is unlikely that skill levels will improve enough, in the near future, to allow the achievement of efficiencies that global supply chains demand. Such skill deficiencies are likely to inhibit the enhancement of the supply chains into value chains. Therefore, it can be seen that the skills gaps are acting as barriers to the development of supply chains and therefore of trade in and with the region.

On a more detailed level there are a number of similarities and differences between South Africa and Namibia that may be significant. For example, the samples from both countries show that at an operational level it is proving to be difficult to fill relatively low-skilled jobs such as clerks and drivers. This indicates that part of the problem, at least, is not simply the need for logistics education, but that training for these jobs seems to be being frustrated by the poor level of general education (e.g. literacy and numeracy), which is prevalent across both countries. At the other end of the skills spectrum, it appears that strategic level positions are harder to fill in South Africa than in Namibia and that these types of jobs are becoming more challenging to fill. Whilst it is clear that demand is outstripping supply, there are a number of possible reasons behind this. Firstly, it could simply be a worsening ability of the logistics education system to replace managers that have retired or moved on. Alternatively, the difficulty may be a function of increasing need for strategic supply chain thinking rather than a decline in the number of skilled personnel. This, in turn, reflects the growth in the industry and its maturity. This interpretation would also explain the perceived difference between South Africa and Namibia as the Namibian industry is less mature and does not seem to be expanding as rapidly.

Skill shortages are not however unique to Africa rather, currently, there seems to be an issue throughout the supply chain world; e.g. although almost 10% of the working population of the UK is engaged in supply chain activity, the sector has an acute recruitment predicament that extends well beyond lorry drivers (Kelly, 2015). According

to Beimel, vice-president at DHL Global Forwarding: "Supply chain managers are retiring faster than they can be replaced. There simply are not enough young people to backfill the pipeline" (Kelly, 2015). Further, Kisperska-Moron (2010) suggests that a different skills set will be required in the future as excellence is required from the beginning of operations as there is no time to improve performance during its [the supply chain's] lifetime, which is believed to be no more than 5–7 years.

The findings also suggest that the levels of skills that both the Namibian and South African logistics industries are able to supply are unlikely to be commensurate with their visions and ambitions of enabling economic and social development through the benefits of membership of the 'global supply chain community'. Analysis has revealed that the problems besetting both countries' industries are similar and, at least to a substantial degree, due to human capital related issues, just as much as more concrete ones such as infrastructure limitations.

Although the data analysed is only from two of SADC's fifteen or Southern African Customs Union (SACU)'s five member states, it is reasonable to postulate that similar issues are likely to prevail across both communities and therefore across southern Africa as an whole. Although this would need confirmation by further research, it suggests that the achievement of effective supply chains is unlikely to be achieved in the near future. Without such competitiveness, companies and their host countries are not able to support the trade necessary to generate the wealth that is needed for development, particularly in emerging economies.

This research has enabled conclusions to be drawn, but inevitably there are a number of limitations that should be addressed by future research both to validate and enhance the conclusions. Notably, the research sample in the Namibian survey could be expanded in the future and the research could be replicated in other SADC/SACU countries. It is also intended that the South African survey be updated in 2016. A further avenue for research is the investigation of current competency levels of key supply chain skills.

Notwithstanding the potential further work, the research to date makes it clear that, if South Africa and Namibia want to achieve their potential within the global market, they must offer supply chains that are appropriate for the task. To do so, it is vital to address the skills shortage issues to overcome the barriers that have been identified. These skills shortages occur at all levels from the driver or warehouseman to managers, directors and government officials. Although this cannot guarantee immediate success, as improving human capital is inevitably a slow process, suitable programmes must be treated as a high priority. Such education must address cultural issues and human resource based skills as well as the more obvious functionally related ones. It is therefore recommended that the governments of Namibia and South Africa allocate resources to fully identify the logistics educational needs and address them as a matter of urgency.

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DEPLOYING SERIOUS GAMES FOR SUPPLY CHAIN MANAGEMENT: LESSONS LEARNED AND GOOD PRACTICES

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Abstract
While there is a certain consensus about the educational potential of SGs in higher education (HE), the deployment rate of SG in HE and their proper insertion in meaningful curricula are still quite low. Several engineering and business schools offer game based learning either as a supplementary to lecturers or as an integrated part of their curriculum. Most of the games are used in a workshop setting, and much of the learning outcome is achieved through the debriefing part of the workshop, i.e. not as an integrated part of the game. One reason is that many of the games do not offer stealth assessment, and thus need interpretation of a very well skilled facilitator. In additions games only used for one specific course are costly to develop, maintain and improve and in addition facilitated games put limitations on the class size and make it costly to integrate. This article report experience with using a COTS game within a specific curriculum.

Introduction

The Accreditation Board for Engineering and Technology (ABET) has defined 11 competencies that a post graduate should have at command when leaving engineering or business school. Such competencies are, amongst others, identifying and solving problems, applying advance engineering tools, communicating effectively as well as to be able to carry out teamwork [1]. The main focus of the HE institution should be to develop these competencies, but there are some studies showing that this is difficult by only using traditional teaching methods [2-4].
Game based learning, i.e. the use of serious games to support the learning process [5], has a long tradition as a teaching method [6] and is currently used at several business and engineering schools, either as an integrated part in the curriculum or as a supplement. Serious games can be defined as entertaining games with non-entertainment goals, used to educate, train and inform [7, 8, 9]. The main features of Game-based Learning (GBL) have been addressed by several authors [10-16], highlighting learner involvement through exploration, experimentation, competition and co-operation. Many of the SG currently in use at engineering schools are designed in-house and often used by those being actively involved in the development process. This process is mostly time consuming and costly since

changes are based on students' feedback and measurement of learning outcome [17]. Additionally, in the field of business and engineering education, serious games are mostly conducted used in a workshop setting [18], using either Kolb's experimental learning cycle [19] or Nonaka's SECI [20] model for the implementation of the game in a course.

Consequently, in a workshop setting most games are facilitated, i.e. the debriefing is not within the game, but outside the game [21], and the teacher or facilitator actively carry out the learning analytic based on observation as well as indicators delivered by a game. The learning outcome is therefore not only dependent on the game itself, but also on the facilitators' ability to carry out analysis using available information. The University of Bremen and Heriot-Watt university have used GBL for teaching their engineering students on topics like decision making in supply chain and production in distributed environments, specifically training the skills mentioned by ABET for decades, mostly in-house built games, but in this article we look at using an existing course and integrate that in a course. In addition, the University of XXXX has just started to use gamebased learning, and is now offering the same game to their students on a supply chain management course. Thus, in order to investigate the possibility further, a game, developed as an online game but also used for similar courses at a different university was selected and introduced into a game based course on supply chain decision making with good learning outcome (compare results [22, 23]).The article reports and discusses the results from a game, SHORTFALL, used in three different courses at different institutions.

1.1 Game-based learning in higher education

For students, the supply chain (SC) and its management are still mostly addressed primarily at a theoretical level. When they graduate from a SC-related discipline of a business school, most students will need to make decisions in variable environments, lacking the previous experience of anticipating their strategic impact on the other SC stakeholders in practical terms. Game-based learning (GBL) [**Error! Reference source not found.**, **Error! Reference source not found.**, **Error! Reference source not found.**] - in particular through Serious Games (SGs), including ad-hoc games designed for joining fun and instruction [**Error! Reference source not found.**, **Error! Reference source not found.**, **Error! Reference source not found.**] –have shown to be advantageous in delivering an otherwise difficult subject [**Error! Reference source not found.**, **Error! Reference source not found.**] fostering more direct student participation of the students [**Error! Reference source not found.**, **Error! Reference source not found.**, **Error! Reference source not found.**]. Such games also motivate children, contextualize teaching and/or offer opportunities to exercise and verify knowledge and skills.

Educational simulations enhanced with gaming features do enable learners to cope with real problems and authentic situations that are close to reality [**Error! Reference source not found.**, **Error! Reference source not found.**, **Error! Reference source not found.**]. For the subject on SCM it only requires that the bounded rationality of economic actors [**Error! Reference source not found.**] and the nonlinearities, time delays and feedback structures can be visualised without sacrificial performance [**Error! Reference source not found.**].

Although Semini [**Error! Reference source not found.**] pointed out that games are more suitable than simulations to teach decision making in SCs the deployment rate of SGs for SCM remains low. To a large extent because the facilitation is challenging as most games are not course specific requiring an experienced lecturer [**Error! Reference source not found.**]. This article intends to contribute in reducing the barrier of integration of existing games in the classes by reporting our

experience in using SGs within the education of engineers at different universities, namely: Herriot Watt (HWU, UK) and Bremen (UNIHB, Germany), while considering the role of the teacher and facilitators for the game.

1.2 Integration of serious games and curriculum adaption

The adoption of new learning/teaching tools always raises several questions regarding traditional techniques of classroom instruction. Some of those questions are related to how it will affect the way learners carry out educational tasks and how teachers might/must facilitate learning [**Error! Reference source not found.**]. Another important question that results from the integration of serious games in formal education is how it will affect the role of the trainee and the role of the teacher. As argued by Iverson [**Error! Reference source not found.**], serious games offer a paradigm shift in training as it changes the role of the trainee from passive to active and the role of the trainer changes from just delivering material to being a facilitator. The role of the teacher becomes central as the facilitator balances 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.

In order to guarantee an effective use of serious games for educational purposes, these questions need to be addressed, not simply from the nature of games but also how the game and its characteristics can be adopted and leveraged to enhance learning within the structural, organizational and cultural constraints of institutional education [**Error! Reference source not found.**]. In this regard, the integration of serious games requires teachers to take into account a variety of different elements (timing, contents, assessment, etc), in order to guarantee that (a) that the information being taught is indeed generalizable outside the context of the game and (b) that deeper, metacognitive gains are attained as a result of socially constructed game play [**Error! Reference source not found.**, **Error! Reference source not found.**, 24]. Even though most games used for teaching purposes within engineering and business schools are in-house developments, there are some propositions about which games can be used for SCM education [25, 26].

The most well-known SCM Game is the beer distribution game [**Error! Reference source not found.**]. A variant has been redesigned as an Internet based SC challenge Simulation game (ISCS) [**Error! Reference source not found.**]. Role-play mechanics is the mainstay of SCM gameplay dynamics whichever the variant. ISCS also includes a Management Information System (MIS) built in to support decision making allowing it to test SCM strategies in the game. ISCS has been used at postgraduate level in the University of Greenwich since its launch in 2005. The Lean Leap Logistics Game [**Error! Reference source not found.**] is another variation of the beer game more appropriate for application to a manufacturing process. It considers set up times, process reliability and capacity issues across multiple stages and constraints.

In terms of engineering the objectives are to provide students a detailed understanding of how to identify the pinch points for modern manufacturing SCs. In particular for e-manufacturing, where production planning and logistics are key learning topics, such games provide a more realistic alternative to classical teaching methods.

One main challenge for the integration of a serious game in a new environment is their adoptability. The next section therefore describes a game that can be used for supply chain management, followed by how it was integrated in three different curricula at two different universities.

The game

SHORTFALL [27] is a strategy game that incorporates implicit role-play mechanics and is structured over 10 rounds. Communication is key to success and the game is played in teams of three per computer, competing against other teams.

Each player manages their individual stake holding that make up a whole supply chain (3 factories, from transformation of raw material to production of cars). The aim is to achieve a benign manufacturing enterprise such that profits are maximized across all stakeholders. Players have to take decisions and select options, as seen in Figure 1.

The structure of the game is a repetitive loop of 10 rounds. In every round, the player is first informed about the status of the chain (which is expressed in five target dimensions: profit, green compliance, number of sold products, etc.) and about the external conditions (prices of material, parts and products). Although not explicit a turn-base mechanic regulates each player role such that each player set some numerical values (in particular the quantity of material to be purchased, of products to be sold or stored). Events may occur impacting the next period.

The player has to select between three options. These options have an environmental impact, and thus the player should apply any knowledge accrued in this field in order to select the optimum solution for green and sustainable production. To aid decision-making and to meet certain criteria, the player can access information related to costs and revenue, including waste as seen in Figure 1.

The difficulty level increases with the rounds since events become ever more difficult to deal with, forcing the player to reflect and think of more complex counter-actions to avoid losses and to fulfil the objective.

Fig. 1. Shortfall GUI- overview costs- materials

Educational setting

The integration of SHORTFALL varies both within an institution as well as from one institution to another. However, it can be clearly stated that traditional teaching methods are mostly used, and SGs remain as a niche tool either as a supplement to normal classes or as a GBL course for a specific module. The usage depends very much on the topic and the flexibility of the curriculum. In this article two different approaches are presented. In the first setting, SHORTFALL is used as an extension that parallels conventional teaching whilst being played regularly throughout the course. In the second setting it is used as a part of a GBL course, in which the students shall apply methods and knowledge acquired in earlier semesters at the university.

1.3 Heriot Watt University Engineering Manufacturing course

The context of SHORTFALL used in this investigation pertains to supplementing taught material on engineering manufacturing at Heriot-Watt University in the UK for final year mechanical engineering students. The course comprises theoretical understanding of manufacturing and technologies that influence its workflow. Within this course lies e-manufacturing. The aim was to provide students an alternative approach to classical teaching about the principles of manufacturing enterprises and the technologies employed therein. From the academic perspective, it was about how SHORTFALL could be used as an abstraction layer to broaden their knowledge and implementation strategy of manufacturing concepts and as a platform for engineering related information sharing. On completion of this course students are expected to demonstrate how various principles of manufacturing methods can be applied and its role in the modern engineering processes. To further establish the game's effect an exam question was designed to ascertain the learning outcomes.

The students formed teams of three and play three game sessions, with each session lasting 2 hours over a 12-week period. No corroboration between teams is allowed. UK students were largely un-facilitated other that the tutor explaining where to locate the game, which game scenario to be played and responding to simply "how-to" queries with regards to the game's interface. A reflective class was held after each game session.

In 2013 there were 17 groups of three while in 2014 a total of 9 groups of 3 were available in UK. After each session played, a team spends two weeks reflecting on how they performed, their strategy and how the taught material compares to real world scenarios, and how it aligns with the game. A reflection class was held after each game week for students to discuss the game in context with the taught material. Course lectures are scheduled such that incremental knowledge accrued would increase the relevance of game play. This was further supplemented with industrial visits where students have the opportunity to question industrialists on matters such as tradeoffs among economic and environmental policies that influence technology implemented or even which current strategies are used in industry to address environmental issues.

After the 12-week case-study, each team gave a short presentation on how they conducted their game sessions; each team member was graded on their understanding of manufacturing methods and the use of technologies therein. A System Usability Scale (SUS) report [**Error! Reference source not found.**], which is a well-established a tool used in usability engineering, was modified to establish the class perception on using SHORTFALL.

1.4 University of Bremen Course 1: Decision Making

At the University of Bremen SHORTFALL was used as an introduction to a game based course on decision making in distributed production and supply chain for 3rd Semester Master students studying production, industrial or systems engineering. The course aims to strengthen the capability of strategic thinking as well as to support the process of constructing new knowledge. On completion students are expected to be able to demonstrate how various methods for strategic decision making can be applied to support collaboration, reduce network risks and thus increase the resilience of the supply chain or production network. Furthermore, it is expected that they also experience how different technologies affect the production in different ways and how their decisions have an impact on the overall success as well as on the efficiency of the network.

The academic use of SHORTFALL was to investigate if the game could either replace or act as an extension to the games already in used. SHORTFALL was played by 18 Master students from the second year on Oct. 21, 2013. It was played directly after

a short introduction to the game, to the learning objective, a very brief introduction to the different production and supply chain strategies relevant for the SHORTFALL game (meant as a repetition). No detailed introduction to sustainable production was given. The students were divided in 6 groups sharing one PC with an allocated 4.5 hours for completing the whole game, which was far more than the lecturer would expect that the students needed. Initially it was planned to have a short debriefing after rounds 5 and 10, and not give additional information and help during game play, so that we could check if it might be possible to use the game unfacilitated, but due to the observation of the lecturer during game play, there were debriefing session after round 3, 7 and 10 and she also had to provide help during game play. The game play was facilitated by the teacher and much time was dedicated to the reflection and discussion phase after round 3, 7, and 10. In order to establish the game's effects, and to be able to compare the results with the exisiting results from Heriot-Watt, the student used the same questionnaire and had to deal with the same questions as the students at Heriot-Watt. A questionnaire with the 10 questions listed in section 4 was completed directly after the game play, and also added a reflection and documentation part to the lab protocols.

1.5 University of Bremen Course 2: Reengineering of Manufacturing Processes

This game based course deals with reengineering of manufacturing processes. It is aimed at applying methods on quality management, reengineering, project and change management within the context of production and manufacturing. During the course students apply different creative techniques and methods to solve different problems. The course has a blended learning concept, with a short introduction to the theory before the experiential learning experience takes place. The majority of students in this course are first semester industrial and production engineering Master students. These students have not yet selected a main topic within their master studies and have their undergraduate degree from different universities, however many of them come from industrial and production engineering at the university of Bremen.

In this course SHORTFALL was played by 19 master students in 1st Semester 2013. It served as an intersectional part between a game re-engineering (a physical game where the students have to produce mini elevating truck) and the management section dealing more with process quality and project management topics. The idea was to see if SHORTFALL would help the student in reflecting on what they learned and transfer this knowledge and the methodological approaches learned during the first part of the course in different settings. Before playing, a short introduction to the course was given including an overview of different production and supply chain strategies relevant to SHORTFALL was provided by the teacher who was also responsible for carrying out the reflection and discussion phases in between the game rounds. She was also available during game play for explaining the different manufacturing strategies and technological solutions during game play. The same questionnaires and lead question during game play was used.

3.2 University of Szczecin
In the academic year 2015/16 at the University of Szczecin, within the classes of the decision-making games in the logistics, Students first of all played the game Shortfall. One round game lasted 5 hours. In the game participated a total of 45 students, the game took place in 3 different dates. The students were playing the individual and group game.

Methodology

SHORTFALL was administered in a digital format where students access the game online. To ascertain the strengths and weaknesses of SHORTFALL as a supplement to classical teaching and purely as a game-based learning, the approach was to:

- Capture or collect usability data, such as scores, task completion time, error records, and subjective ratings;
- Analyse and interpret usability data to identify fitness of purpose;
- Critique and suggest solutions or improvements to mitigate problems.

It analyse the results achieved by the students as well as the experience of the teachers.

Findings:

The findings are based on the analysis of the results from three universities: The results from the two universities that have used serious games for teaching purposes for a long time, indicate that a teacher/facilitator with some experience using SHORTFALL is important and that the regular use of the game by continuous adaption with corresponding taught topics impacts on the students learning outcomes, since we have seen a steadily improvement of the reported learning outcome. The third university has less experience in using Serious Games, but long experience in teaching SCM. A comparison with the results from the third university, which used SHORTFALL for the first time, will help us to answer better to which portion the experience with the teaching method and the experience in teaching the topic (SCM and sustainable production) as well as the setting and integration influences the results. By comparing the results both across the institutions and with the results of previous years, it will be possible to understand better how SHORTFALL can be integrated in the curricula, the challenges and barriers and also how to overcome these.

Results

The results herein are in part to ascertain the long-term use of SHORTFALL either as supplementary teaching material or as a bespoke means to teach SCM and production strategies. For UNIHB, there are two fundamental reasons for using SHORTFALL; the first concerns decision making while the second is directed at managing re-engineering. Not too dissimilar, HWU uses the game as a means to associate how technologies influence the production strategies in a supply chain. This is closer aligned with UNIHB's use of the game for decision making meaning as it pertains to formulating SCM strategies.

It should be noted that the demograph of students and the teaching methods vary. However, the analysis for both institutions is associated to how a specific serious engineering game, such as SHORTFALL, can be adapted to a specific course. The post questionnaires [**Error! Reference source not found.**] provide more detailed answers than a simple yes/no or neither/nor. However, to quickly view the trend a 3-point Likert-type sale was adopted. These are summarised in Tables 1 and 2 which represent the HWU results of 2013 and 2014. Note the number of students on the course is shown in the column 'total'. This similar format was used at UNIHB (See Tables 3 and 4 on 2014 results).

Table 1: 2013 HWU use of SHORTFALL

Question no	Description	yes	no	neither/nor	total	yes (%)	no (%)	neither/nor (%)
1	Shortfall increased my knowledge of the automotive supply chain.	39	4	8	51	76%	8%	16%
2	Shortfall increased my knowledge of supply chain management.	36	11	4	51	71%	22%	8%
3	Shortfall increased my knowledge of manufacturing practices.	30	12	9	51	59%	24%	18%
4	Shortfall increased my knowledge of environmentally benign manufacturing practices.	27	10	14	51	53%	20%	27%
8	Playing Shortfall again would further increase my knowledge of environmentally benign automotive manufacturing.	34	7	10	51	67%	14%	20%
10	I would enjoy playing Shortfall in tandem with class lectures about environmentally benign manufacturing and/or supply chain management.	35	8	8	51	69%	16%	16%

Table 2: 2014 HWU use of SHORTFALL

Question no	Description	yes	no	neither/nor	total	yes (%)	no (%)	neither/nor (%)
1	Shortfall increased my knowledge of the automotive supply chain.	19	0	1	20	95%	0%	5%
2	Shortfall increased my knowledge of supply chain management.	20	0	0	20	100%	0%	0%
3	Shortfall increased my knowledge of manufacturing practices.	17	1	2	20	85%	5%	10%
4	Shortfall increased my knowledge of environmentally benign manufacturing practices.	12	3	5	20	60%	15%	25%
8	Playing Shortfall again would further increase my knowledge of environmentally benign automotive manufacturing.	13	2	5	20	65%	10%	25%
10	I would enjoy playing Shortfall in tandem with class lectures about environmentally benign manufacturing and/or supply chain management.	16	3	1	20	80%	15%	5%

Table 3: 2014 UNIHB use of SHORTFALL. Summative results of the post-questionnaire for the decision making course.

Question no.	Description	yes	no	neither/nor	total	yes (%)	no (%)	neither/nor (%)
1	Shortfall increased my knowledge of the automotive supply chain.	7	9	2	18	39%	50%	11%
2	Shortfall increased my knowledge of supply chain management.	12	5	1	18	67%	28%	6%
3	Shortfall increased my knowledge of manufacturing practices.	9	6	3	18	50%	33%	17%
4	Shortfall increased my knowledge of environmentally benign manufacturing practices.	12	3	3	18	67%	17%	17%
8	Playing Shortfall again would further increase my knowledge of environmentally benign automotive manufacturing.	9	7	2	18	50%	39%	11%
10	I would enjoy playing Shortfall in tandem with class lectures about environmentally benign manufacturing and/or supply chain management.	18	0	0	18	100%	0%	0%

Table 4: 2014 UNIHB2 use of SHORTFALL. Summative results of the post-questionnaire for the manufacturing and reengineering course.

Question no.	description	yes	no	neither/nor	total	yes (%)	no (%)	neither/nor (%)
1	Shortfall increased my knowledge of the automotive supply chain.	6	8	5	19	32%	42%	26%
2	Shortfall increased my knowledge of supply chain management.	13	5	1	19	68%	26%	5%
3	Shortfall increased my knowledge of manufacturing practices.	8	6	5	19	42%	32%	26%
4	Shortfall increased my knowledge of environmentally benign manufacturing practices.	11	6	2	19	58%	32%	11%
8	Playing Shortfall again would further increase my knowledge of environmentally benign automotive manufacturing.	4	13	2	19	21%	68%	11%
10	I would enjoy playing Shortfall in tandem with class lectures about environmentally benign manufacturing and/or supply chain management.	8	6	5	19	42%	32%	26%

The relevant questions of interest to HWU are related to strategic use of production technologies in a SCM are mainly Q3 and Q4. Most of the technological components and strategic decision making are related to Q3. Q4 focuses on implementing a benign SCM. The results indicate a positive experience of SHORTFALL in both years with regards to knowledge of manufacturing practices. With reference to creating a benign manufacturing enterprise there is minimal increase in the capacity (7%) of using the game. It is worth noting that HWU students are taught the fundamentals of engineering manufacturing from first year onwards. Thus, students are expected to build upon knowledge gained, hence the reasoning for minimal facilitation. Facilitation here refers to directing students to the website, how to operate the interface, and where to find information to enable them to construct a strategy. The lectures that parallel the game and the reflection classes allow students to have a deeper understanding of SCM and discuss how best to approach SCM bottle necks. The rationale is that students take a leading role in the pursuit of their own knowledge endeavours and the applied decision information mining during the gameplay.

Considering that 2014 has less than half of 2013 cohort, the trend remains that SHORTFALL is useful as a compliment to the taught material. What is interesting is that there is a more distinct perception of the game from the point of the students; there is a clear 'yes' and 'no' vote of confidence to the game.

For UNIHB courses on decision making in supply chain (Table 3) the most relevant questions are 1, 2, and 4. Judging from the results, half of the students did not feel that the game increased the knowledge on automotive supply chain. This has to be seen in the relation to the high involvement of the automotive industries in the education of the engineers offering several internship, company visits etc. during study. Q2 and Q4 (66.7%) indicate the opinion that shortfall did increase their knowledge of SCM and environmental benign of manufacturing. This is an important finding since SHORTFALL was only intended as a short repetition of the theoretical foundation prior to using downstream games for strategic decision making in supply chains. The post-questionnaire, with its more detailed answers as well as the feedback in the debriefing sessions, however did reveal that most students thought the availability of a facilitator and the use of debriefing sessions increased their understanding on how to assess the impact a decision may have on the result and the next steps required. In addition students lacking the expected level of knowledge reported that it was very important for their learning outcome to have a teacher explain the theory while playing.

For the course on manufacturing and re-engineering an UNIHB the most relevant questions are as for HWU, Q3 and Q4. Interestingly, even though the largest group of students indicated that they increased their knowledge of manufacturing practices, this question reveals a high number of students not knowing, such that the overall results is less positive. These results have to be verified with the next year's cohort, in order to see if an adaption of the theoretical foundation is necessary or not. 42% of the students would like to play SHORTFALL in combination with a class lecturer focussing on environmental or supply chain aspects; while 32% do not support this statement and 26% are uncertain.

The results of each game in the indication of the average, median and best results are presented in Table 1.

Table 5 Results of the Shortfall – Students of University of Szczecin

Indicator	measure	individual	group
Total Profits	average	89 697, 54	101 238,5
	best result (max)	140 192	138 509
	median	90 937,5	106 071,5
Greenscore	average	1392,58	1496,45

|			
	best result (max)	4334	2783
	Median	1205	1423
Total waste remove	Average	158,33	180
	best result (max)	504	468
	Median	143	157
Waste disposal expenses	average	14 452,8	16 899,64
	best result (max)	34 996	39 837
	median	13 450	14 944
Total cars sold	average	54	61
	best result (max)	86	86
	median	57	64
Waste Disposal Expenses / 1 unit	average	95,05	95,8
	best result (min)	62,9	85,12
	median	97,73	97,08

An important element of interpretation is strategy, which were taken by students, and which had an impact on the achievement of the final result.

Starting with an analysis of the individual results and relating them to those used by the students of the strategy should be noted that: adopting the strategy of the highest profit, eg. Student No. 34 had invested in the production technologies, which resulted in a reduction of production waste and also lowered the production costs, because due to the limited demand, it was the only opportunity to increase the profits. This strategy was also associated with the maximum met of the demand. Student No. 3 adopted a strategy of minimizing the environmental effects in the supply chain, binding by the greenscores. From the economic point of view this strategy has affected of the total profit in such a way, that failed to achieve the highest profit, but the profit place oneself well above average. It can be concluded that the investments were related to a greater extent with improving the waste management system and not to reduce production costs. Using this strategy, student No. 3 has reached the lowest unit cost associated with waste disposal. Student No. 25 adopted the disposal of waste strategy, without optimizing the entire waste management system and production, which led to a lot of waste production (sub-optimalisation strategy). It achieved the highest level of expenses associated with the waste disposal expenses, also one of the highest quantitative results related to the waste disposal.

Game Group was the second game, which should approach the students. They were played after the individual game, which means that students first have developed some strategies in the individual game that moved it on the group game. The second: the strategy of the game group could be modified, due to the fact join individual strategies and Students knowledge in each link of the supply chain. In turn has could lead to a situation, that in the group was a leader who, in a sense, impose his point of view for the other person. And the other team member adjust to those needs embodiments thereof. The lectures observations of leading that these groups achieved the best results.

Another conclusion which emerges from the observation of the game participants indicates that learning from each other. Often there was a situation, that the leader provide information and the possible consequences of the actions other participants in your group. Reflecting the results of selected students presents a Figure No. 1

**Figure 1 game results of the selected students**
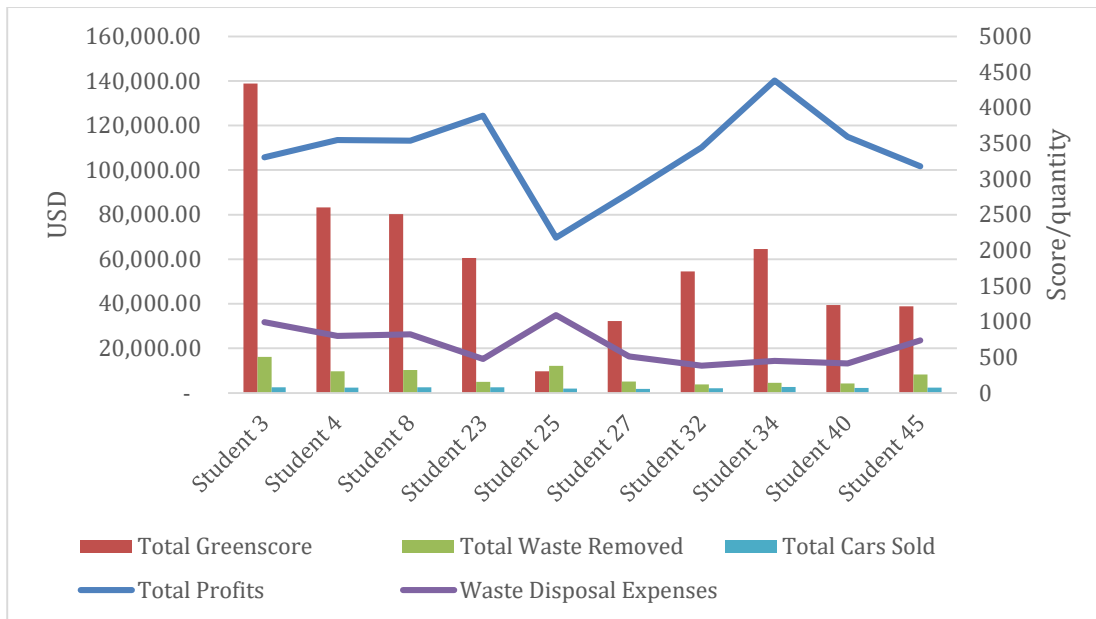
On the other hand, in the groups where not designated the leader of this group the results were much weaker. It can be interpreted as a make of decision on an individual basis. Without taking into account the clearly identified aim often were repeated the decisions of the individual results of the student. The results of these games indicate a wrong decisions, which from the point of view of the educational process indicates the immediate and easier to understand the mistakes and their consequences.

This means in consequence, that the games confront for the students the consequences of their decisions.

This is not only the theoretical knowledge, or a case study, but in the labour environment it is a reflection of the economic reality. This system indicates a greater involvement of the students, allows you to easily acquire the knowledge, and allows leading to easier, more illustrative explanation for the phenomena occurring in the supply chain. For example the depending on investment and production development of the variable unit costs.

Figure   2   Group   results
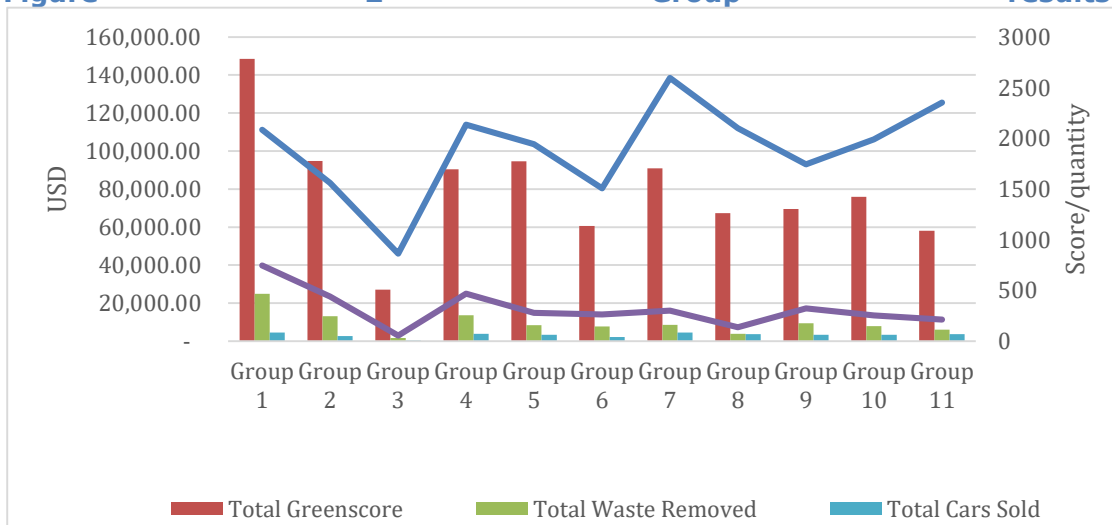
To test students' knowledge prior, for the game were conducted a pre-test of competence. After the game was carried out the same test again, to see, how the game influenced of the students' knowledge.

The test results of the competence tests carried out before and after the game allow to draw the following conclusions. There was a definite change in the selection of elected factors when making decisions on the core business (eg. what, where and how much to buy or sell). All students in the final test rejected the volume of supply (the game based on customer market), increased a number of responses concerning the possibility of a disruption of the supply chain (it is effect of the game, which occurred eg. random events eg. strikes). It has increased the importance of the investment costs, since such decisions were also taken in each round of the game. Reflected graphic of this situation presentes Figure nr 3.

Figure 3 selected factors which are taken into account in decision-making process on the core business
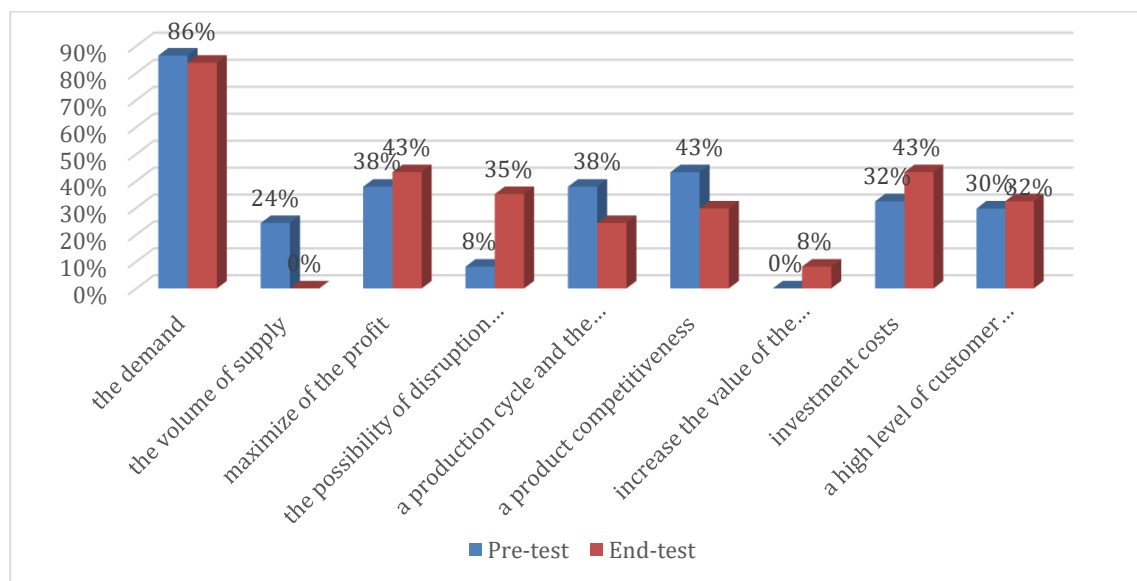
Referring to the strategic objectives of the supply chain, students definitely changed the approach to environmental innovation, almost 50% of them selected last factor in the first test, turned after the game on a more important factor in the hierarchy, but not the most important. Also increased the importance of reducing of the global logistics costs, while fell the importance of increasing of the flexibility of customer service, which was not part of the game.

Taking into account the specific elements for the design of the supply chain (to choose was 22 items), the biggest change after the game concerned by the transfer response of "no opinion" to others answers. This means, that the students knowledge were higher on the subject and support the hypothesis that the imperceptible effect of the game is to increase knowledge (figure 4).

Figure 4 Elements of the designing of the supply chain
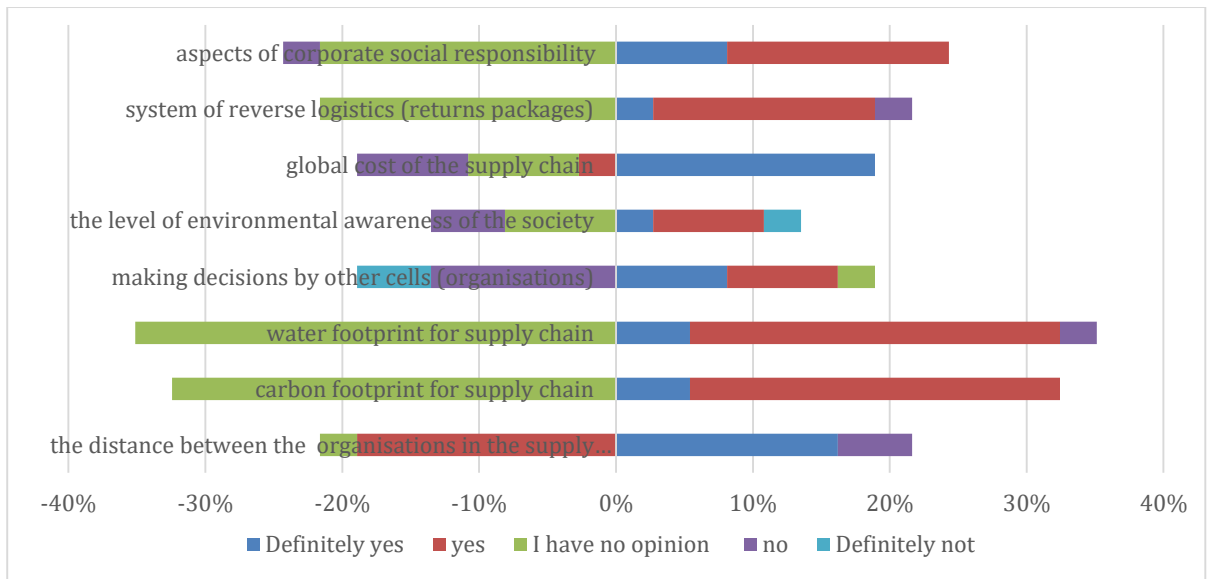
The ecological aspects in the functioning of the supply chain has become a more important element after playing the game, students indicating a preliminary test on a small importance of these aspects changed their minds, especially the increased number of responses "often", which means that they still prefer other aspects, however, ecology is beginning to play an increasingly the important role and meaning (Figure 5).

Figure 5 element of the Sustainable development in the supply chain (role in the designing of the supply chain)

	ecological	social	economic
Never	0%	0%	0%
Rarely	-5%	0%	-3%
Sometimes	-16%	11%	5%
Very Often	16%	-8%	-3%
Always	5%	-3%	0%

Indicating, what elements the greening of the processes Students take into account when designing the supply chain, after the game, it turned out, that the most important areas are greening of transportation and production. Quite surprising is the fact, that in the process of purchasing and warenhousing the effect was the opposite, that means, that students indicated this elements as less important processes in the greening of the supply chain (Figure 6)

Figure 6 Areas of greening in the designing of the supply chain

	supply (purchaisning)	manufacturing	distribution	transport	warehousing
Not Important	0%	0%	0%	0%	0%

Slightly Important	0%	-5%	0%	5%	8%
Moderately Important	14%	-5%	-11%	-8%	-14%
Important	-8%	-11%	5%	-24%	8%

2 Discussion

For the University of Bremen, the use of SHORTFALL in course 1 showed positive answers regarding Q1-4, Q8 and Q10, with low percentages uncertain (neither/nor). The results from course 2 indicates the same; however, the results are not as clear (lesser percentages) while the share of uncertain (neither/nor) answers increased. In both cases the teacher was the same, but the course domain and the knowledge of the students were different.

Questions 8 and 10 however displayed contrasting differences. While course 1(UNIHB) supports the statement, that playing shortfall again would increase their knowledge of environmentally benign automotive manufacturing, course 2 ((UNIHB2) contradicts this statement. Further, regarding Q10, course 1 fully supports that statement, while course 2 supports this with only 42% of the students and a high percentage of 26% uncertain (neither/nor). At HWU, where the game is played 3 times during the semester and with theoretical classes in parallel the first cohort shows similar results as the decision making course, and slightly better than the manufacturing course at UNIHB. For the cohort 2014, the results at HWU were much more positive than Bremen's. Since this was the second year it was played, it can be assumed that an adaption based on the experience of using SHORTFALL in 2013 has had a very positive influence. It needs however more long term use to see if this is also depending much on the group or only of a better integration in the curricula.

A main question that should be addressed is the role of the facilitator and teacher. In the case of HWU, the teacher gives the theoretical classes prior, with some facilitation during the first game play, but with no facilitation in the last. However, the facilitator is aware of what happens in the game, and use time on reflection with the students after game play. It is the same teacher that carried out the classes both in 2013 and 2014.

In the case of the UNIHB Course 1, the game was originally planned to be unfacilitated as a repetition. However, during gameplay it became obvious that this did not work, as the students where guessing instead of making sound choices based on prior knowledge of the subject. Thus, the approach of using the game unfacilitated had to be changed into playing the game with facilitator and reflecting phases were introduced after round 3, 7, and 10. The main reason for the change seems to be a result of a mismatch of needed as well as expected prior knowledge (based on taught topics in the BSc degree and first year of master) and actually available knowledge. The change in the use of facilitator had according to the feedback from the students and the observation from the teacher/facilitator, a positive impact on the game play, and the usefulness of SHORTFALL as a repetition of pervious gained knowledge, but this required for some group much facilitating during game play. For some groups, with a higher level of relevant knowledge, less facilitation was required. Almost all students reported that the several debriefings and reflection phases (outside the gameplay) supported the analysing and assement of the gameplay. .

UNIHB Course 2 was facilitated from the beginning since it was expected that some of the students would have too little knowledge on manufacturing practices due to a large number of students coming from industrial engineering, and also due to the experience collected in the first course. However, again contrary to the teacher at HWU who have had these students regularly over the past years, the teacher in

Bremen did not know the students, their learning style and their knowledge before. This can be directly seen in the results, that indicates that there is a need for more information on the topics either beforehand or inbuilt in the game play, and that if SHORTFALL should be used in future courses a better integration in the course is necessary. The results show in all experiments that the students find that the game improves their skills on SCM. In addition, the analysis of the HWU case where the game was played three times with additional theoretical classes, show that the more they are into the topic, the less facilitation was needed. Also the impression of the teacher at UNI HB underpins this, but in order to confirm the results, the experiment has to be repeated with a more proper experimental set-up. However, in one of the cases at UNI HB, the intention of using SHORTFALL was to use it for repetition of prior knowledge, unfacilitated this was only achieved for the groups having a high level of prior knowledge, and not for the all groups. Thus, it can be indicated that for this purpose, facilitation is necessary.

3 Conclusions and future work

Both the HWU and UNIHB results indicate that a teacher/facilitator with some experience using SHORTFALL is important and that the regular use of the game by continuous adaption with corresponding taught topics impacts on the students learning outcomes. None of the courses were expedited through use of RCT since this was, and will not be possible even in the future. However, by comparing the results both across the institutions and with the results of previous years, it will be possible to understand better how SHORTFALL can be integrated in the curricula, the challenges and barriers and also how to overcome these. So far only two universities took part in the experiments, but it is the intention to enlarge this group in order to identify patterns and to provide more general guidelines for integration of SG in the manufacturing education. Such long term measures will also improve the understanding of how different game mechanics influence the gameplay and the learning outcome [40]. It will also help to understand for which learning types, different types of adaption are necessary and to understand how to optimise the setting.

Conclusions

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SYSTEMATIC LITERATURE REVIEW OF SERIOUS GAMES AND SIMULATIONS ON URBAN TRANSPORT PLANNING

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ABSTRACT

This paper explores how serious games and simulations are reported used as visualization means and tools for supporting the understanding of urban transport planning for both students and practitioners. It presents the results of a systematic literature review. The first search term identified 4964 papers related to the topic, but based on additional selection criteria, 40 papers are considered as relevant publications. These consist of papers that review simulation and serious games as well as development of visualizations. These visualizations are clustered into some different purposes which indicated that simulations and serious games have possibility to be used in different purposes within urban transport planning.

INTRODUCTION

The increasing number of inhabitants in urban areas has amplified the transport demand. Based on Global Health Observatory (GHO) data [20] in 2014, 54% of total global population live in urban area and it continues to grow currently with approximately 1.84% per year. Consequently, in 2020 63.2% of global population live in cities. For European countries, cities is the home for more than 72% of total EU dwellers [6]. These statistics forces governments and local authorities to put more attention to urban transport planning. According to [10] multimodal transport planning has been induced as a new paradigm. This concept involves interaction between buses, trams, cars, trains, taxis, bicycles, as well as pedestrians and requires connectivity across the modes. This leads to a need for good visualizations to investigate cause and effect of congestions, accidents, for studying the effects of policies and designs to manage and regulate traffic, and to provide insights on urban development and planning [17, 18].

In addition, holistic mobility concepts for urban regions require that different stakeholders get together, interact and collaboratively develop suitable solutions, taking the need and the requirements of each stakeholder group into account. This results in growing needs of simulating large-scale complex traffic patterns, individual behaviour etc. at the scale of large cities, possible informed by real time sensor data and visualized in real time for decision support [13]. However, many traffic simulations provides highly complex, accurate models with high granularity for one mode, but do often not mirror the complexity and the high interaction and mutual dependencies of the real world needed for an holistic planning, thus their potential for use in a multimodal context is limited. Other approaches like participatory simulations and the use of serious games for this purpose exists, but often hardly known to a larger audience.

The objective of the paper is to analyse how serious games and simulations are currently used for supporting urban transport planning. The starting point for the consideration was an analytical review on transportation engineering instructional practices by [8] identifying tools (simulation, visualization, problem-based learning, and other types of active learning)

as teaching methods in transport engineering studies. Further underlying works were the early work on simulation games for urban planning by [11], that gives general overview of role playing simulation fulfilling the needs of urban planning as well as the work of [16], which is a review on simulation gaming in transportation and logistics. That review focus on commercial simulation and open source games, flight simulation and city building game. None of the reported games contributes to decision making in transport planning and planning processes.

So far a systematic overview of tools serious games and gamified simulations that can be used for planning mobility solutions in urban area was not found. Consequently, in order to become an overview of the field, a systematic literature review on simulations and serious games on urban transport planning were carried out. The main purpose was to identify if there are sufficient existing solutions providing interested stakeholders with enough information for making qualified decision on what to use or to identify a gap in existing tools able to visualize the complexity of multi urban transport planning and thus propose a research agenda on this topic.

This paper organize as follows: Section 2 covers the research methodology, whereas the results are presented in section 3. These results are discussed and our conclusion are covered in section 4.

RESAECH METHODOLOGY

We conducted a systematic literature review according to [15]. It was designed with the aim to collect, classify and analyse on tools like games and simulations that could be used for multi-modal urban transport planning. According to the review methodology described in [15] we established a review protocol development; data collection; selection criteria identification; data selection and analysis; results synthesis and evaluation conclusion.

Keywords

The keywords were obtained from the research topic and previous studies related to serious games for teaching purposes including empirical evidences [5, 4]. Only those related to this study were included. In addition, in our first search also research papers related to simulations and simulation games in transport engineering [8, 16] were considered. Due to the first phase of entries, we limited the search to only include serious games and simulation:

("serious games" OR simulation OR "simulation games" OR "game-based learning" OR "computer games" OR "online games")

To limit the search terms to papers which purpose for learning and education purposes, the keywords input as followed:

(teaching OR curriculum OR learning OR education OR training or skills OR motivation OR engagement)

For focusing on civil engineering, transport planning, and urban planning, we used keywords:

("transport" OR "traffic" OR "logistics" OR "transport planning" OR "traffic planning" OR "urban planning" OR "multimodal planning" OR "multimodal mobility")

Databases

The databases used originate from University of Bremen catalogs and online databases identified relevant to computer science, education, and urban transport planning. The explored databases presented in Table 1.

Selection Criteria

In selecting relevant publications, we determined 3 criteria: firstly, the papers should be related to serious games or simulations used as tools for teaching and learning as well as design or develop a new simulations for teaching and learning purposes. Secondly, related to transport engineering, transport planning, traffic planning, transport studies, urban planning, multimodal planning, multi-modal mobility. Third, the time period for selecting papers for literature was January 2005 – January 2016 (present).

Some papers appear in different databases, and a specific game or simulation might be described in several different papers. In the first case, they just count as one, in the latter the content was compared in order to identify any mismatching in the results.

The first keywords selected did not work in several databases such as in IEEE, thus the first author modified the keywords up to four times, in order to encompass the findings which aims to cover as complete as possible papers related to this topic. In ASCE database the author only focus on Journal of Professional Issues in Engineering Education and Practice, Journal of Computing in Civil Engineering, Journal of Risk and Uncertainty in Engineering Systems, Part A: Civil Engineering, Journal of Highway and Transportation Research and Development (English Edition) and Journal of Urban Planning and Development) since there are a lot of irrelevant papers identified by the keywords.

Limitations

There are some limitation identified, for instance keywords and databases used as well as published year of papers include. Not all papers provide the methodology in developing the games and some of paper provides the information more than one simulations or serious games. Furthermore, a number of existing simulations in urban transport planning could not be included, because no papers related to those simulations in accessed databases.

RESULT

Based on the methods explained above, the result of the analysis is expressed in this section.

Paper identified

Table 1 presents the number of papers in identified by search term in the different databases. 4964 papers related to this topic were identified. This large number of paper caused by the general keywords, such as serious games and simulation. However, using the determined selection criteria, 40 papers were finally considered and reviewed [9].

Table 1 Number of papers identified from each database and considered to review

Databases	Identified	Included
Science Direct	513	9
IEEE	279	12
ERIC	669	1
Web of Science	772	2
European Journal of Engineering Education	636	5
ASCE	677	1
ASEE Annual Conference Proceedings	401	2
Simulation and Gaming (Sage Publications)	238	3
Games and Culture (Sage Publications)	5	1
TRB	1	1
Google Scholar	3	3
SCOPUS	770	0
Total	4964	40

Paper excluded

The large number of papers (4964) detected by keywords are all somehow relevant, but some are still excluded because the relevance is not sufficiently. A typical example is simulation and games in civil engineering education. Transport engineering and planning is part or sub division of civil engineering studies, but also comprises much more. Only papers related to using games for either education or planning of multi modal transport were included. We also searched for papers on decision making tool for participatory urban planning and development [1], Virtual Environmental Technology for Public Participatory in urban planning process [7], Virtual Construction Simulator for Construction for Architecture, engineering students [14], 3D Visualization to support communications during stakeholders in urban planning meeting [2]. Main challenge here was that either the papers did not mention the name of the application, or there are no articles on a specific application. In all cases such papers were excluded.

Paper included / selected

Based on the selection criteria, 40 papers are included and further analysed. Most papers discussing mathematical model and algorithms were excluded, some papers on algorithms and model included. These included papers on models and algorithms are designed to support and improved the existing simulation and games.

Categorization of papers

In the next step, the 40 identified papers were categorized [9]. It is 18 papers on simulations and 22 papers on serious games as well as games.

Results related to simulation

Simulation has been used for urban transport planning since 1950s [12]. It helps to visualize the complexity of urban transport planning, as well as for educational purpose. Of the identified 18 papers, 3 review simulation and 15 are related to simulation development. There is an investigation on the use of Windows-based software called Darwin 3.1 as tool to help student in designing and analyzing pavement design (transport infrastructure). The authors claims that using software in delivering knowledge will give advantages for students to understand the concept through the case study and give more time to analyse the result. Another researcher team evaluates two micro-simulations tools to model traffic flow theory and advance control strategies. They argue that using the simulations allows students to explore complex traffic modelling processes, to think critically, and to learn by experiences [9]. In [9], a paper also utilized VISSIM and VR4MAX

as tools to communicate a design alternative to decision makers and public audiences. The tools are widely used in simulating single mode transport operations.

Since using simulation contributes the positive impact of understanding the complexity of some subjects and provides the solution in transformation of teaching methods from "chalk and talk" to technology-based, several simulations has been developed[11]. There are 15 papers describe about design and development of simulations [9]. They occupy simulations related to both transport and urban planning. In [9] the author explained the development of a multi-agent model system named MASE simulate land use change, a novel prototype of SimUrban, a simulation for urban development and land use change, and a Virtual Environment (VE) for architecture and urban planning project. Another kind of urban simulation is having purpose to support public participation in urban planning by using 3-D visualization and Augmented Reality (AR) for multi-user interaction. In addition, some papers explained the design of improvement of existing simulations, for example the improvement of the visualization of UrbanSim simulation by developing the indicator browser (a web-based interface for visualizing UrbanSim simulation results). Also, an application which combines GIS, RS, and SLEUTH to analyse and model different policy scenarios of urban growth [9].

More than half number of papers on simulation describe the simulation in order to support urban planning and development both in design and policy making [9]. For example, the model and prototype to support land use planning, tool for urban design, tool for supporting public participation, design additional tool to support UrbanSim and visualization for policy scenario and urban growth [9].

Regarding transport planning, in [9] also described the development of a prototype collaborator named CLINT to support logistic planning and simulations to support transport studies for university students. They created ADAM to deliver knowledge about travel demand models, SONG for understanding the process of transportation network development, ROAD to acquire the work of roadway geometry design and OASIS to study traffic signal control. Applied simulations related to traffic studies are also constructed by some researchers [9]. For example, design of an algorithm to simulate a route choice in a congested transportation network, development of a simulation of travel time for pedestrian, model traffic signal junction as independent agent, and a driving simulator as part of traffic education. For transport safety and communication among the vehicles, in [9] enlighten the demonstration of the architecture and design framework for Mobile Wireless Vehicular Environment Simulation (MoVES).

Papers on Serious Games and Games

Proposed keywords resulted in 7 papers which review (serious) games in urban transport planning [9]. The majority of papers evaluate SimCity and Second Life [9]. Most of the researchers concluded with positive responds to these games. However, there are also criticism of SimCity (an entertainment game which is used in educational context) since the model which used in developing it is criticized as a fictional work by urban planners. Another paper also analyzed a serious game Face Your World to deliver knowledge related to public participation in urban planning. Regarding transport planning, review existed serious games in transportation such as Enduro, SimCity, CityOne, and Waze. Papers in developing and designing serious games consist of several different purposes such as urban planning, traffic studies, transport infrastructure, planning process, land use development, and relationship among the topic in urban planning. Besides used for teaching and learning purposes, the games are also used in industry and practical life. For instance, a paper compared a video game design target audience and game expert, developed a rail cargo management game, built SprintCity, a game on rail infrastructure and urban development, and constructed a serious game about airport planning with multi-stakeholders involved [9].

Related to traffic studies, there is a paper in [9] designed a model for short path game which support the transportation network. In traffic safety game category, a paper proposed a multiplayer game over VANET. Another authors designed and developed a serious game "Transmilenio" to public transport rules awareness explained in [9]. There are also some publications in term of decision making in urban planning [9], for example the development of QuAG, a role-playing game, development of Next Campus and development of You Place It. One of strategic planning games development was also appeared in [9], as well as development of SIMPLAN, a model to help in urban planning policies, and a paper about reconstruction of the of a town in the middle age, although it has purpose to learn the history about the town, however it is also considered as part of urban studies. [9] provides an example of game design for mobile-based games to challenge urban planner and policymakers to experience the complex cultural economies of a highway, and designing a model of land-use and transport to be integrated with a political serious game. This can be used as a framework to support decision makers to gain a better understanding of a complex problem in city planning. Based on these findings, it can be seen that serious games have been used in several area in order to support urban and transport planning. Nevertheless, none of the games specifically discuss about multimodal mobility [9].

Discussion

The need of tools to support government, urban planners as wells as students to overcome the complexity in urban transport planning has led to development of various simulations and games in this field [21]. The identified 40 papers show a big diversity related to serious games and simulation design as well as development. It categories from simulation and serious games related to building the city and transport infrastructure, traffic studies, planning a new project in urban area to dealing with public participation in urban planning. Finally, also a game for business development in transport service was identified.

The review shows that in general visualizations has positive impact on understanding the complexity. Furthermore, the approach can be used as in delivering the knowledge for adult education. This is consistent with [16] and [19]. More specific, simulations used in transportation practices [8] have given an active learning activities to students [5] and can thus be recommended to be included as an integral or supportive part of the curriculum for urban transport planning both for higher education and vocational training.

Simulations and serious games are not only used to support students' learning process, but also as a tool to improve the quality of life in transport safety (VANETs) and practical education. This claim is in line with [5] who found that most of the games in transportation analysis deal with construction and evolution of transportation networks, based on simple economic models. Simulations can be divided into three categories, which consist of business simulations, flight simulations, and urban planning. The authors of the identified papers also agree upon that simulation games have the capability to address the complexity in transportation. However, there is still a lack of visualizations especially games which consider specific actors and interdependencies among transportation modes in urban area. This literature review leads to a conclusion that there is still a need to a visualization in order to support urban transport planning, especially that involve multimodal mobility concept.

CONCLUSION

This systematic literature review exposes that there are various purposes of research papers in simulations and serious games related to urban transport planning, but that there is not many games and simulation that can be easily adopted for educational purposes of multi-modal urban transport planning. Thus, based on this result, we have identified a need for developing a tool that can be used for educational purposes on urban transport planning. Furthermore, the majority of the simulation and games focus on urban planning

especially public participation, therefore it becomes more important to develop such a game which cover the knowledge that can be used for educational purposes on transport studies since the existed ones do not comprise multimodal transport planning specifically. In addition, since the benefit of using serious games and simulations have been confirmed by several works, in future, it is recommended to look at some other complex fields which appropriate to employ serious games and simulation as the media for knowledge transfer.

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