

Proceedings of the 23rd International Symposium on Logistics (ISL 2018) *Big Data Enabled Supply Chain Innovations*

**Bali, Indonesia
8 – 11th July 2018**



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Editors: KS Pawar, A Potter, Caroline Chan and Nyoman Pujawan
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Website:

www.isl21.org – managed by The University of Nottingham, Nottingham, UK

Registration coordination:

Mejimedia.com

Front cover:

Temple, Bali

ISBN:

ISBN-13 9780853583240

Published by:

Centre for Concurrent Enterprise, Nottingham University Business School, Jubilee Campus, Wollaton Road Nottingham, NG8 1BB, UK

Edited by:

K S Pawar, A Potter, C Chan and N Pujawan

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INTRODUCTION

Once again we are delighted to welcome our friends and colleagues, both old and new, to the 23rd International Symposium on Logistics in the exotic location of Bali Island, Indonesia. Bali, the famed Island of the Gods, with its lush forests, sandy beaches, volcanic mountains, rugged coastlines and iconic rice terraces is colloquially described as a piece of paradise on earth. Its colourful, spiritual and unique culture have made the island home to an abundance of historical and archeological attractions, with over 20,000 temples (including Pura Taman Ayun, Pura Ulun Danu Bratan and Tanah Lot) shaping its landscape. Considering the location and the global challenges and current trends, the chosen theme for ISL2018 is "*Big Data Enabled Supply Chain Innovations*". The 23rd ISL aims to provide a forum for both academics and practitioners to discuss the current and future research in the area of logistics and supply chain management. The papers in this book proceedings represent the latest in academic thinking, as well as case examples of successful implementations. The 23rd ISL, also presents an opportunity to engage in various discussions and debates during the course of the event and see how our 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 our cumulative know-how in our discipline can be successfully applied to develop the next generation of experts through our 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 in previous years, all abstracts and/or full papers were reviewed by two or more 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:

- General Supply Chain Management
- Supply Chain Design and Planning
- Customer-Supplier Relationships
- Globalisation and Supply Chain Performance
- Big Data & Supply Chain Analytics
- Technology and ICT in Supply Chains
- Inventory and Warehouse Management
- Complexity, Risk and Uncertainty
- Transport and Distribution
- Last Mile and Urban Logistics
- Sustainability in Logistics and Supply Chains
- Supply Chain Skills, Training and Education

To date ISL has been held in Europe, Africa, Australasia and Asia (please see full list below). Following last year's successful event in a beautiful and charming settings of Ljubljana, Slovenia,

we are very much looking forward to meeting you all at this year's symposium in Bali, Indonesia.

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 Mrs Maeve Rhode, Claudia Amankwah and Jimo Ajeseun for their support throughout the event and Mengfeng Gong for her help in preparing the proceedings.

Professor Kulwant S Pawar, Dr Andrew Potter, Professor Caroline Chan and Professor Nyoman Pujawan – July 2018

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Contents

Session 1: General Supply Chain Management

AN AHP DECISION SUPPORT SYSTEM FOR REVERSE LOGISTICS STRATEGY DEVELOPMENT IN ONLINE RETAILING INDUSTRY <i>Lee, Pei-Hsuan; Hsu, Sheng-Chin; Chen, Shiou-Yu</i>	2
AN APPLICATION OF VALUE STREAM MAPPING TO IMPROVE A PROCUREMENT PROCESS <i>Puttibarncharoensri, Piyawan; Chuensunk, Phasinee</i>	10
CONSUMERS' PARTICIPATION IN CO-CREATING LOGISTICS SERVICE VALUES <i>Wang, Xueqin; Wong, Yiik Diew; Teo, Chee Chong; Yuen, Kum Fai</i>	18
DIGITIZATION OF CRIME DETECTION IN THE SUPPLY CHAIN <i>Pasley, Robert Charles</i>	27
REVERSE FACTORING ADOPTION AN EXPLANATORY STUDY IN THE EUROZONE CONTEXT <i>Guinchard, Julia</i>	36

Session 2: Supply Chain Design and Planning

NETWORK RESILIENCE MODELLING: A NEW ZEALAND FORESTRY CASE <i>Childerhouse, Paul; Alaqqad, Mohammed; Bezuidenhout, Carel; Zhou, Spring; Christians, Ginny</i>	45
THE OPTIMIZING OF FISHERY COMMODITIES DISTRIBUTION IN INDONESIA <i>Widodo, Kuncoro Harto; Perdana, Yandra Rahardian; Soemardjito, Joewono</i>	54
DECISION MAKING FOR RELIEF DISTRIBUTION PROBLEM IN HUMANITARIAN LOGISTICS <i>Wigati, Slamet Setio; Asih, Anna Maria Sri; Sopha, Bertha Maya</i>	62
THE PRACTICAL OPERATING SCHEME OF VIRTUAL DISTRIBUTION CENTER-CASE OF PARTS DISTRIBUTION BETWEEN TAIWAN AND INDONESIA IN SMALL TRADING COMPANY <i>Lee, Shih Tsung; Lee, Chieh Li</i>	71
LOCATION OPTIMIZATION FOR INTEGRATED MARINE AND FISHERIES CENTRE IN INDONESIA <i>Widodo, Kuncoro Harto; Saduddin, Saduddin; Soemardjito, Joewono; Riyadi, Iwan Puja</i>	79
VOLUME FLEXIBILITY FOR DYNAMIC FACILITY LOCATION PROBLEM IN PRODUCTION DISTRIBUTION NETWORK <i>Shahparvari, Shahrooz; Kam, Booi; Chan, Caroline</i>	88
FOUNDATIONS FOR AGENT-BASED MODELLING AND SIMULATION OF VALLDAL	96

STRAWBERRY SUPPLY CHAIN

Sopha, Bertha Maya; Engelseh, Per; Asih, Anna Maria Sri; Ushada, Mirwan

Session 3: Customer-Supplier Relationships

THIRD PARTY PURCHASE BUYER-SUPPLIER RELATIONSHIPS: A CASE STUDY FROM CHINESE AUTOMOTIVE INDUSTRY 105
Childerhouse, Paul; Shi, Peter; Luying, Liu; Glass, Walter

A STUDY ON THE PASSENGERS' TRAVEL MODES CHOICE BETWEEN TAIWAN AND ITS OFFSHORE ISLANDS 114
Chen, Chia Huei; Chang, Dong-Xian; Lirn, Taih-Cherng

OPERATIONAL FRAMEWORK FOR HEALTHCARE SUPPLIER SELECTION UNDER A FUZZY MULTI-CRITERIA ENVIRONMENT 129
Goh, M; Zhong, S; de Souza, R

LEGITIMACY MECHANISMS IN THE PURCHASING FUNCTION: THE CASE OF INDIRECT ITEMS 137
Moncef, Btissam

Session 4: Globalisation and Supply Chain Performance

ORGANIZATIONAL SUCCESS FACTORS OF LEAD PLANT/SISTER PLANT RELATIONSHIPS IN GLOBAL PRODUCTION NETWORKS 148
Bremer, Peik; Grasmik, Katrin; Tsai, Kune-muh

JAPANESE AUTOMOBILE MANUFACTURERS' EFFORTS TO DEVELOP PARTS LOGISTICS SYSTEMS IN INDIA 157
Hayashi, Katsuhiko

INTELLIGENT DECISION SUPPORT SYSTEM FOR SUPPLIER MANAGEMENT IN SMALL APPLIANCE MANUFACTURING COMPANY 165
Yuen, Fred; Choy, K L

THE LINKAGE OF LEAN-SOCIAL PRACTICES, LEAN-TECHNICAL PRACTICES, AND OPERATIONAL PERFORMANCE IN CONTAINER SHIPPING 173
Kuo, Szu-Yu

QUALITY PERFORMANCE OF FOOD SAFETY: INSIGHTS FROM THE THAI FOOD MANUFACTURING INDUSTRY 181
Pradabwong, Jiraporn; Braziotis, Christos

Session 5: Big Data & Supply Chain Analytics

SUPPLIER SELECTION USING DATA ANALYTICS: A COLLABORATIVE FILTERING-BASED APPROACH 190
Pouraghabagher, Reza; Sarfaraz, Owais Ahmed

BIG DATA ANALYTICS AS A SOLUTION TOOL FOR NP HARD OPTIMIZATION 199

PROBLEMS IN INVENTORY MANAGEMENT <i>Antic, Slobodan; Djordjevic, Lena; Lisec, Andrej</i>	
BIG-DATA DEPLOYMENT IN SHAPING INDONESIA'S E-COMMERCE BASED REGIONAL CONNECTIVITY <i>Sangka, Khresna Bayu; Iskandar, Doddy; Nurminarsih, Siti; Chalil, Tengku; Ayu, Oryza</i>	207
ESTIMATING EXHAUST EMISSION OF OIL TANKER VESSELS USING BIG DATA IN THE PORT OF SINGAPORE <i>Xiao, Zengqi; Lam, Jasmine Siu Lee</i>	212
Session 6: Technology and ICT in Supply Chains	
DIGITALIZATION IN INDUSTRIAL LOGISTICS AND SUPPLY CHAINS – THE CONTEMPORARY SITUATION IN SWEDEN AND FINLAND <i>Sandberg, Erik; Hemilä, Jukka</i>	222
THE IMPACT OF 3D PRINTING ON SUPPLY CHAINS: HYPE VS REALITY <i>Amankwah, Claudia; Rogers, Helen</i>	230
NETWORKED USE OF ADDITIVE MANUFACTURING CASE STUDY <i>Engelseth, Per; Mushtaq, Waqas; Salman, Maryam</i>	238
THE IMPACT OF E-COMMERCE INSTITUTIONAL MECHANISM ON THE FIRM COLLABORATION PERFORMANCE: THE ROLE OF TRUST IN THE INTER-ORGANIZATION SYSTEM <i>Masri, Ni-Wayan; Chou, Shih-Wei</i>	246
FEASIBILITY OF FOOD LOSS REDUCTION WITH BLOCKCHAIN IN THE EMERGING ECONOMY CONTEXT <i>Kayikci, Yasanur; Subramanian, Nachiappan</i>	255
Session 7: Inventory and Warehouse Management	
THE EFFECT OF RESPOND TO REQUEST ABILITY ON QUANTITY ORDER FOR DETERMINISTIC MODEL OF PERISHABLE ITEM: CASE STUDY OF INDONESIAN SUGARCANE INDUSTRY <i>Masudin, Ilyas; Noviana, Dina; Jie, Ferry</i>	264
A STUDY OF THE DILATED SEAT BOOKING SYSTEM APPLIED TO THE JAPANESE WIREFRAME MANUFACTURE COMPANY <i>Nakamura, Yoshiki; Ohba, Masaaki; Hayashi, Chihiro; Yamamoto, Hisashi; Oomiya, Nozomi</i>	272
SLAM FOR AUTOMATED UNMANNED GROUND VEHICLE WITH ROS <i>San, Khin Thida; Park, Je Min; Lee, Seon Jeong; Chang, Yoon Seok</i>	281

Session 8: Complexity, Risk and Uncertainty

HYBRID CATEGORY MANAGEMENT IN A MUNICIPALITY <i>Engelseth, Per; Svenning, Geir Arne; Taknes, Jocelyn</i>	289
NETWORKED RISK MANAGEMENT IN CHANGE – HOW SME’S ADAPT TO MEGATRENDS <i>Pääkkönen, Emma; Vilko, Jyri</i>	297
FOOD SUPPLY CHAIN VULNERABILITY: A REVIEW OF EMERGING CHALLENGES AND RESPONSES <i>O'Reilly, Seamus; Sloane, Alan; Henchion, Maeve</i>	309

Session 9: Transport and Distribution

ANALYSIS OF NORTHERN SEA ROUTE AND BALTIC SEA COMBINED SHIPPING COMPETITIVENESS FOR BULK SHIPPING: CASE OF POST 2020 SULPHUR REGULATIONS <i>Keltto, Tuomo Iisakki; Woo, Su-Han; Kwon, Won-Soon</i>	316
IMPACT OF THE EUROPEAN ROAD TRANSPORT MARKET DEREGULATION: THE CASE OF CABOTAGE IN GERMANY <i>Sternberg, Henrik; Hofmann, Erik</i>	326
AN EXPLORATION OF THE ADOPTION BARRIERS OF DELIVERY DRONES IN LOGISTICS COMPANIES <i>Edwards, David; Subramanian, Nachiappan; Chaudhuri, Atanu; Zeng, Wen</i>	335
EVALUATION OF LIQUEFIED NATURAL GAS BUNKERING PORT SELECTION <i>Kim, A-Rom; Seo, Young-Joon; Shin, Soo-Yong</i>	343
PERFORMANCE ATTRIBUTES OF SMART AND SUSTAINABLE PORTS <i>Lam, Jasmine Siu Lee</i>	351
PORT AUTHORITY CHALLENGE: FRAMING EFFECT AND PORT RESIDENTS’ PERCEPTIONS OF NIMBY FACILITIES TO INTEGRATE THE LOCAL SUSTAINABLE DEVELOPMENT <i>Lirn, Ted TC; Chen, Yenming J.; Lu, Chin-Shan; Wu, Tienhua; Huo, Kuang-Chung</i>	357
SOLVING THE VEHICLE ROUTING PROBLEM WITH PRACTICAL CONSIDERATIONS <i>Lu, Chung-Cheng; Chang, Cheng-Yu</i>	362
DISTRIBUTION OF LOCALLY PRODUCED FOOD <i>Medved, Mihael; Šamec, Blaž; Lisec, Andrej</i>	371
THE STUDY OF GRAIN IMPORTERS’ TRANSPORT MODE CHOICE BEHAVIOR <i>Chen, Hui-Ling; Shih, Shi-Zen; Lirn, Taih-Cherng</i>	377

Session 10: Last Mile and Urban Logistics

CITY LOGISTICS PRACTICES IN DEVELOPING COUNTRIES <i>Arvianto, Ary; Asih, Anna Maria Sri; Sopha, Bertha Maya</i>	392
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CHALLENGES WITH TOOLS AND TECHNOLOGIES SUPPORTING COLLABORATION AMONG STAKEHOLDERS IN URBAN LOGISTICS <i>Grudpan, Supara; Baalsrud Hauge, Jannicke; Klaus-Dieter, Thoben</i>	404
GAME THEORETIC ANALYSIS OF COORDINATION AMONG HUMANITARIAN ORGANIZATIONS IN THE LAST MILE <i>Lu, Qing; Wu, Jie; Goh, Mark</i>	413
MODELLING THE DELIVERY SLOTS FOR THE LAST MILE DELIVERY: COSTS AND EMISSIONS <i>Demir, Emrah; Abouarghoub, Wessam; Syntetos, Aris</i>	422
AN INVESTIGATION INTO COMPETENCY REQUIREMENTS OF OPERATIONS MANAGERS IN THIRD-PARTY LOGISTICS (3PL) FIRMS: A CASE OF INDONESIA <i>Sangka, Khresna Bayu; Rahman, Shams; Jie, Ferry</i>	431
Session 11: Sustainability in Logistics and Supply Chains	
AN INVESTIGATION OF ENVIRONMENTAL DISCLOSURES OF GLOBAL LOGISTICS FIRMS USING SOCIAL NETWORK ANALYSIS <i>Yadlapalli, Aswini; Rahman, Shams</i>	440
CHALLENGES AND OPPORTUNITIES OF GREEN LOGISTICS IN HUNGARY. AN EXPLORATORY RESEARCH <i>Diófási-Kovács, Orsolya; Evangelista, Pietro</i>	451
OPEN-LOOP SUPPLY CHAINS: OVERCOMING SHORTAGES AND SUSTAINABILITY ISSUES IN REMANUFACTURING <i>Kalverkamp, Matthias</i>	460
WEEE FLOWS: A CASE STUDY OF A REVERSE SUPPLY CHAIN FOR MIXED SMALL ELECTRICAL WASTE <i>Cheng, Siu-Yee; Bititci, Umit; Greening, Philip; Rutherford, Christine; Karamperidis, Stavros</i>	469
DETERMINANTS AND MITIGATION STRATEGIES FOR FOOD WASTE: A CASE STUDY FROM A UNIVERSITY'S STUDENT CANTEEN <i>Faldella, Elisa; Pawar, Kulwant S; Accorsi, Riccardo; Ferrari, Emilio</i>	478
UNDERSTANDING BUYER STRINGENT ENVIRONMENTAL REQUIREMENTS IN THE CONTEXT OF SUSTAINABLE SUPPLY CHAIN <i>Shumon, Rezaul; Rahman, Shams; Kamrul, Ahsan</i>	487
Session 12: Supply Chain Skills, Training and Education	
AN ASSESSMENT OF THE SKILL GAP OF THE LOGISTICS PROFESSIONALS – A CASE OF BANGLADESH <i>Wali, Muhammad Maruf; Rahman, Shams; Chan, Caroline; Islam, Samsul</i>	499

A NOVEL APPROACH FOR SAFETY AND PRODUCTIVITY ON HUMAN MACHINE COOPERATION <i>Chen, Chao-Nan; Liu, Tung-Kuan; Hsueh, Po-Wen; Chen, Yen-Ming J.; Ho, Wen-Hsien; Tsai, Jinn-Tsong; Chou, Jyh-Horng</i>	508
ATTRACTING THE BEST STUDENTS TO STUDY LOGISTICS AND SUPPLY CHAIN MANAGEMENT – THE GUARANTEED JOB APPROACH <i>Hubbard, Nick</i>	516
COMPETENCY REQUIREMENTS FOR LOGISTICS AND SUPPLY CHAIN PROFESSIONALS: AN ANALYSIS OF MARKET DEMAND <i>Ahsan, Kamrul; Rahman, Shams</i>	525

Session 1: General Supply Chain Management

An AHP Decision Support System for Reverse Logistics Strategy Development in Online Retailing Industry

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Abstract

Purpose of this paper

The ability to manage product returns has become more and more vital, especially with the rising of e-commerce retailing, free returns or more flexible returns policies have been proven to increase customer satisfaction and repeated purchase behaviours. Therefore, one of the critical decisions to implement return management effectively is to build an appropriate reverse logistics strategy development that can enhance customer value, reduce logistics cost and cycle time. However, there is less research on evaluating the criteria for reverse logistics strategy developments for online retailing. For filling in this research gap, this research aims to build an effective evaluation framework for online retailers to select optimal strategies of reverse logistics. By the proposed hierarchical model that offers online retailers a reference when make decisions of selecting reverse logistics strategy.

Design/methodology/approach

Building a reverse logistics strategy development needs to take many sophisticated and inter-related factors into consideration. Thus, this study proposes an Analytic Hierarchy Process (AHP) framework to evaluate the reverse logistics strategy developments for online retailing. First, we collected relevant information and knowledge to construct an AHP hierarchy to evaluate the solution which experts want to take when they consider establishing the reverse logistics for online retailing and incorporate the approach of rank pair-wise comparison (RPC) used to measure the relative weights among criteria.

Findings

Empirical data collected from Taiwanese online retailing are used to illustrate the feasibility of the proposed approach. The results provide an evaluation model on strategic choice of reverse logistics for online retailing

Value

In this paper, it not only found the factors affecting the reverse logistics strategy developments for online retailing, but also helped online retailing managers to focus on the most important factors and select the best solutions with the purposes of effective returning management.

Keywords: Online Retailing; Reverse Logistics Strategy; AHP

Introduction

With the growing maturity of online shopping, customers can not try on; they only get the information of products from text or pictures, so there is a gap between products which customers receive and information from websites. Therefore, the demand of return is rising. On the other hand, many online retailers improve their return policy in order to increase customer satisfaction because of increasingly competitive pressure. As a result, more and more companies are establishing return policies. For example, COSTCO accepts customers returning goods without reasons. Uniqlo, Zara and H&M allow customers to return product within 30 days. Moreover, compared with zero returns, an appropriate return rate can improve the company's profitability, and track the reasons to improve the products because they know why customers want to return.

In the past, companies are focused on forward logistics to reduce the cost of distribution. Now, the planning of forward logistics is quite completed, but companies ignore the importance of reverse logistics. However, the high disposal cost and difficulty of land acquisition make companies who reluctantly invest in reverse logistics. Therefore, if the costs of processing returned products reduce, it will increase the willingness of companies to invest in reverse logistics.

Then, the reverse logistics strategy development for online retailing is a critical decision. However, there is less research on evaluating the criteria for reverse logistics strategy developments for online retailing. For filling in this research gap, this research aims to build an effective evaluation framework for online retailers to select optimal strategies of reverse logistics. It provides a reference for decision makers, and reduces the cost of reverse logistics.

In Taiwan, Market Intelligence & Consulting Institute (2017) also surveyed the B2C and C2C shopping websites used frequently, and it found that the top three B2C websites are Yahoo (47.7%), PChome (46.8%) and MOMO (36.1%). Sylvie Van den Kerkhof(2018) indicates that the flexibility of transportation and return service model are not a sunk cost, but the key of increasing customer willingness of repurchasing. Griffis et al (2012) indicates that the rapid return procedure can increase the frequency of repurchasing. In addition, Wood (2001) indicates that lenient return policies will reduce the time for customers to consider whether to buy or not and the time of searching information after ordering. Therefore, it increases the chances of ordering and reduces the time for considering whether to return or not.

Literature Review

Reverse Logistics on Online Shopping

Zaarour et al (2014) indicate that products are returned to the retailer because of defects and damages during transportation, product recalls, impulse purchases, and inaccurate order fulfilments. Because online shopping is different from the brick-and-mortar, the reasons for returning product are also different. Xiangyun (2006) shows that there are six reasons for returning product on online shopping, such as a regulation for protecting customers, information unbalance, impulse purchases, competition within industry, and quality of products. Many reasons cause frequently returning on online shopping and lead to a lot of reverse logistics activities; therefore, Robinson (2014) indicates the different stages in return process, including return policy and preparation, receiving, exchange item or refund, inspection and sorting, and finally asset recovery. Below the Figure 1 shows:

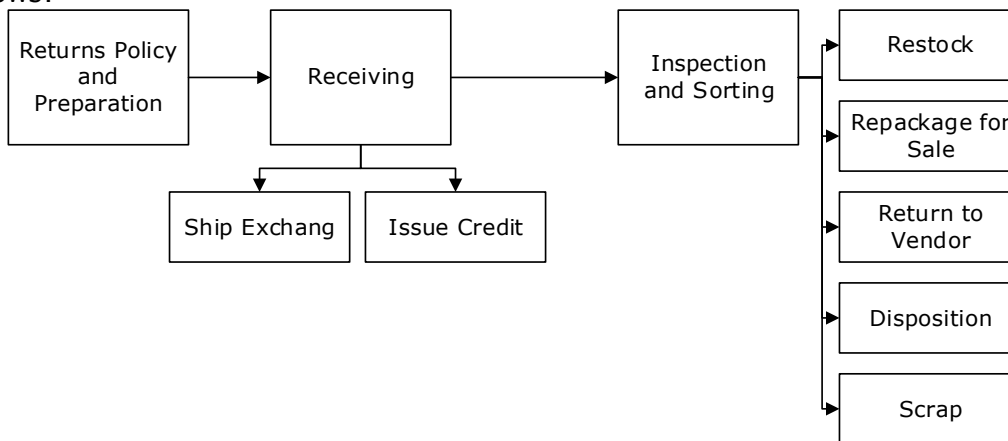


Figure 1- stages in return process

1. Returns Policy:

The establishment of a return policy is to reduce the impact of return and encourage customers to purchase. Most online retailers take the same return policy in order to maintain their competitiveness.

2. Returns Preparation:

For example, online retailers make an easy instruction about the process of return.

3. Receiving:

The purpose is to ensure the returned items matching to the original order in order to refund or exchange.

4. Refund or Exchange Item:

Once the products have been received and validated at the receiving process, refund can be taken or exchange item.

5. Inspection and Sorting:

In this stage, it is including restock, repackaging for sale, return to supplier, disposition and scrap.

6. Asset Recovery:

Rapidly processing, sorting and resale of returned assets is one of the best opportunities for online retailers to make profit with reverse logistics and recover the highest value.

After interviewing with experts, we found that the online retailers in Taiwan did not establish reverse logistics centre. They just set up the reverse logistics department in the logistics center to deal with return products. Moreover, the category of clothing and shoes have higher rate of return than electrical products. Therefore, there are three types of B2C return product in Taiwan. Below the Figure 2 shows:

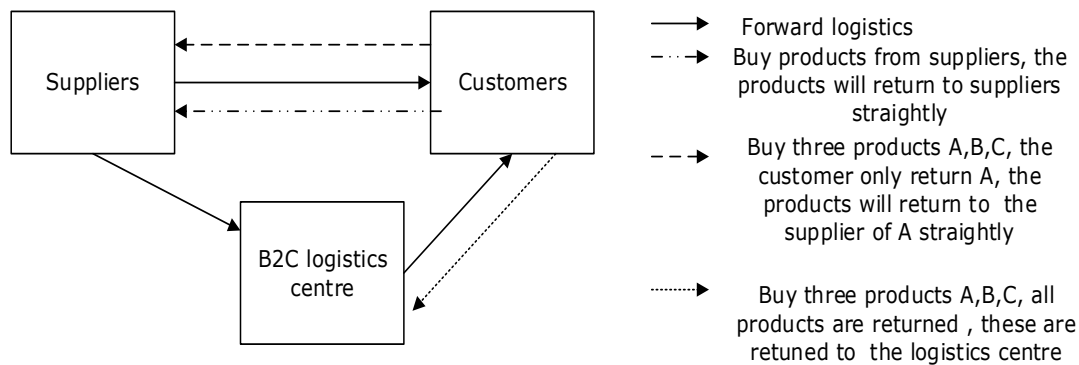


Figure 2-three types of B2C product return in Taiwan

Strategies Development on Reverse Logistics

Because there are many corporates taking lenient return policy, such as Uniqlo, Zara and H&M which allow customers to return product within 30 days. Therefore, these customers are more willing to make other purchases. Fei(2009) indicates that there are three ways of product return, including online retailers receiving returned product, manufacturers receiving returned product, and the third party logicians receiving. Below the Figure 3 shows:

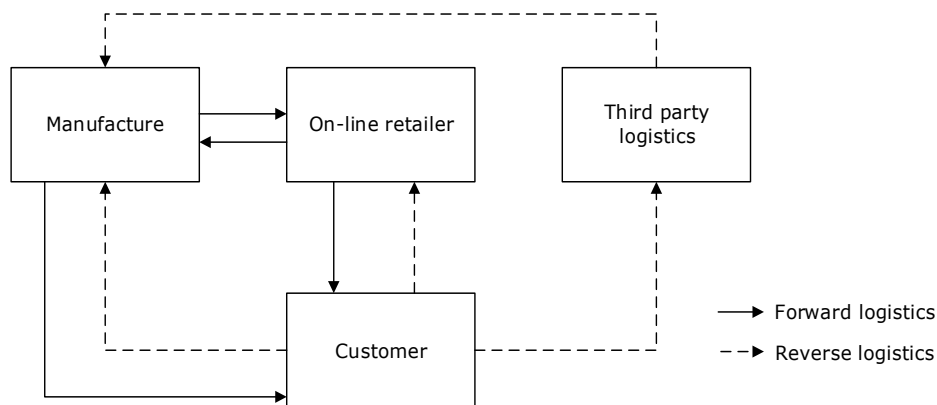


Figure 3 -three ways of B2C product return

According to Chopra & Meindl (2015), they show the measurement on the logistics performance including inventory, transportation, facilities and handling, information, and response time. In this paper, we apply this structure as measurement of reverse logistics activities which includes facilities, transportation, information, and response time, as shown in Table 1. In this table, we know that reverse logistics activities of two companies are different in facilities and response time. Y company outsources its logistics centre, and M company is self-operated. Moreover, response time of M company is faster than Y company. Furthermore, Blackburn et al (2004) classify the reverse logistics supply chain into centralized one and decentralized one. Centralized reverse supply chains are suited for functional products (predictable demand, long life cycle) and decentralized supply chains are suited for innovative products (variable demand, short life cycle). In addition, Gobbi (2011) indicates the application on the centralized or decentralized strategy (as shown in Table 2). He shows that returned products with high residual value and high marginal value need a decentralized reverse supply chain. On the other hand, products with high marginal value and low residual value, products with low residual value and high marginal value, products with low residual value and low marginal value, all of them need a centralized reverse supply chain.

Table 1- measurement of reverse logistics activities

	Y Company	M company
Facilities	Set up the reverse logistics department in the logistics center, and the logistics center is outsourced.	Set up the reverse logistics department in the logistics center, and the logistics center is self-operated.
Transportation	Outsourcing	Outsourcing
Information	Build their own information system.	Build their own information system.
Response time	Deal with returned product in 2 days.	Deal with returned product within a day.

Table 2- application on the centralized or decentralized strategy

	low residual value	high residual value
high marginal value	Centralized reverse supply chain	Decentralized reverse supply chain
low marginal value	Centralized reverse supply chain	Centralized reverse supply chain

Methodology

Building a reverse logistics strategy development needs to take many sophisticated and inter-related factors into consideration. First, we collected relevant information and knowledge to construct an AHP hierarchy. After referencing literatures and discussing with the experts of online retailing, this study classifies them into five criteria: (1) the location of facility, (2) transportation, (3) customer service, (4) economy, (5) the function of reverse logistics. This paper adopts five criteria which include 15 sub-criteria, as shown in Figure 4. Then, we incorporated Lu and Liu (2014) the approach of rank pair-wise comparison (RPC) to calculate the relative weights for the 5 criteria and 15 sub-criteria using the same 1-9 scale ($s = 9$). As shown in Table 3, the adjusted range (d) for 5 objectives ($n = 5$) is 0.00122, whereas the adjusted range for 3 objectives ($n = 3$) is 0.1. The former includes criteria comparisons for (1) the location of facility, (2) transportation, (3) customer service, (4) economy, (5) the function of reverse logistics. The latter is used for sub-criteria. All criteria and sub-criteria are calculated from the responses by the RPC and are used to determine the total relative weights of the average of normalized columns. Finally, we evaluate the solution which experts want to take when they consider establishing the reverse logistics for online retailing.

Table 3- Possible adjusted ranges between consecutive linguistic variables

Scales(s)	Evaluated elements (n)							
	2	3	4	5	6	7	8	9
1~5	1	0.166667	0.032258	0.00641	0.00128	0.000256	0.0000512	0.0000102
1~7	1	0.125	0.017544	0.0025	0.000357	0.000051	0.0000729	0.00000104
1~9	1	0.1	0.010989	0.00122	0.000135	0.0000151	0.0000167	0.000000186

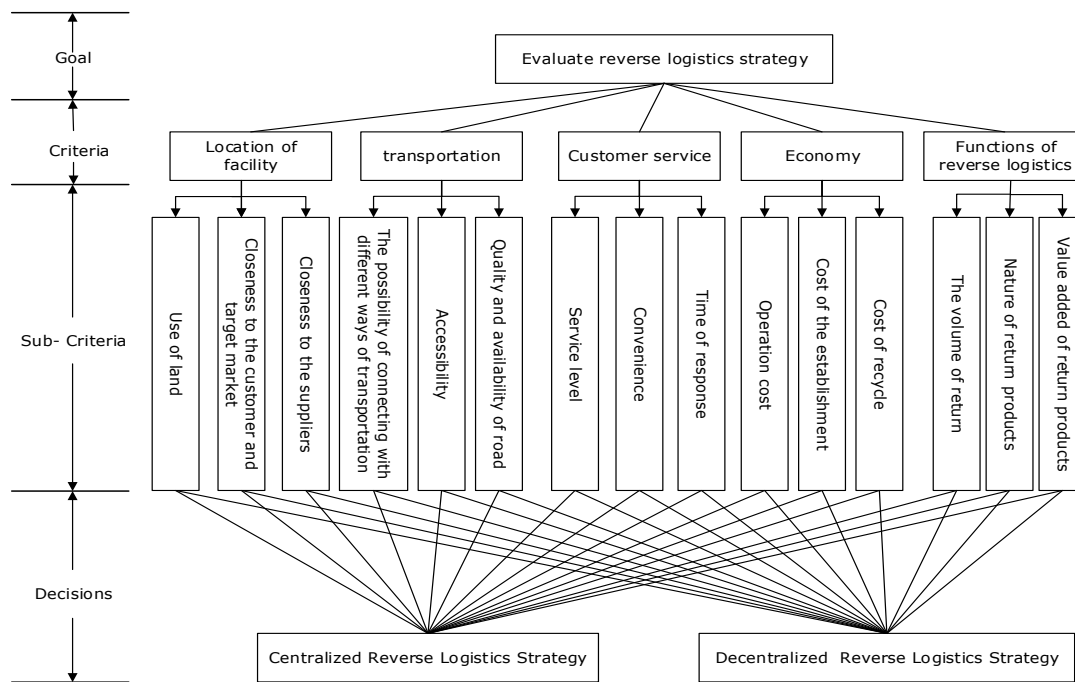


Figure 4- AHP hierarchy of reverse logistics strategy

Results

In this paper, we had surveyed with 6 experts from different companies. The results indicate the proposed methodology is able to solve the multi-criteria decision problem for choosing the best reverse logistics strategy alternative. The results (as shown in Table 4) show the location of facility has the highest weight, and the second one is customer service. Moreover, under the location of facility, closeness to the customer and target market has the highest weight. In customer service, convenience is the first consideration factor. Then, as shown in Table 5, we know that experts consider that decentralized reverse logistics is more appropriate.

Table 4 -Results for comparison of evaluation criteria and sub-criteria

Criteria(weight)	Sub-criteria	Relative weight	Rank
The location of facility(0.23)	Use of Land	0.369	2
	Closeness to the customer and target market	0.423	1
	Closeness to the suppliers	0.208	3
Transportation (0.196)	The possibility of connecting with different ways of transportation	0.388	1
	Accessibility	0.388	1
	Quality and availability of road	0.223	3
Customer Service(0.203)	Service level	0.363	2
	Convenience	0.379	1
	Time of response	0.258	3
Economy(0.182)	Operation cost	0.394	1
	Cost of the establishment	0.39	2
	Cost of recycle	0.216	3
The function of reverse logistics (0.19)	The volume of return	0.377	1
	Nature of return products	0.315	2
	Value added of return products	0.308	3
$\lambda_{max}=5.008; CI=0.002; RI=1.12; CR=0.002 < 0.10$			

Table 5 -Results for comparison of evaluation alternatives

Alternatives	Relative weight	Rank
Centralized reverse logistics	0.474	2
Decentralized reverse logistics	0.526	1

Discussion and Conclusions

According to the results of the investigation from the experts, we learned that the experts believe that the most important evaluation factor is the location of facility (0.23) when the online retailers want to establish a reverse logistics strategy (centralized one or decentralized one). On the other hand, we can conclude that the customer service is the second evaluation factor because online retailers establish a reverse logistics strategy in order to satisfy customer.

Griffis et al (2012) indicates that the rapid return procedure can increase the frequency of repurchase. Customers will not return products frequently just because of convenient return procedure, but repurchasing more frequently. Therefore, the convenient return procedure is important. Then, the sub criterion-closeness to the customer and target market under the location of facility has the highest weight; the sub criterion-convenience under the customer service also has the highest weight. These results indicate that the experts all consider satisfying customer is the most important thing when building a reverse logistics strategy. Therefore, the decentralized reverse logistics strategy has higher weight than the centralized one. It shows that decentralized one is more suited for reverse logistics strategy.

In this paper, it shows that experts consider economy is the last consideration factor. Perhaps, because the equipment and technology of reverse logistics are not mature now, the online retailers in Taiwan need to spend more funds on reverse logistics.

As the online retailers have not yet established a complete reverse logistics strategy now, we can't discuss whether the decentralized model is suited for reverse logistics strategy in actual cases. Therefore, this is the direction that can be explored in the future.

In addition, as technology advances, we advise that online retailers in Taiwan can apply automatic equipment to improve efficiency and reduce costs of reverse logistics in the future. In Taiwan, the role of online retailers just do sorting and inspection because returned products are sent to the suppliers to repair or dispose. Therefore, we suggest that online retailers can establish a department of remanufacturing to make these returned products can be further reused and reduce the cost of disposal.

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AN APPLICATION OF VALUE STREAM MAPPING TO IMPROVE THE PROCUREMENT PROCESS

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Abstract

Purpose of this research

This research, by an MSc student and her university Adviser, was to find a solution to a regular delay problem in procuring spare parts for machinery breakdowns. The focus company, in Thailand, generates electricity which it feeds into the National Grid. The rules for suppliers to tender for contracts is strict. There are three types. One, which has the worst record for exceeding the standard times for processing requisition orders from the company's Production Managers, is the focus for analysis and improvement.

Design/ Methodology / Approach

This research uses a Lean approach, specifically the 'Value Stream Mapping' technique to visualize a procurement process and its sub-processes. Current 'maps' are produced, which highlight the sub-processes and their time problems. A fishbone diagram clarifies the causes, and leads to action to eliminate the Lean 'wastes'. There are numerous Tables, Figures, and Maps which would feature well in a Powerpoint presentation.

Findings

Two major causes (wastes) were identified in the procurement processes, both were communication delays, caused by procurement officers: a) time spent in clarifying requisitions from Production Management, and b) time spent in operating the tender system for selecting appropriate suppliers of replacement parts to restore machine breakdowns to their normal needed generating work.

Value

What may be new in this research is that 'Value Stream Mapping' has previously been used for manufacturing problems. Here it has proved effective for human processing, and may have even wider applicability. Although there are a few published papers on electricity generating firms (including a Provincial State firm in India), the need for security in such a terrorist-prone industry is a deterrent.

Research Limitations

It did not explore the Company's SAP-ERP software system, recently installed, to integrate the company which was founded in 2013 as a merger of two firms. It also has a Head Office, and five generating plants in different towns. These complexities were not considered because of limited time and resources. The lost opportunity (value-added) costs were considered but have been omitted from this conference paper to avoid over-complexity.

Practical Implications

This research is of considerable importance to this Company, because of its contribution to the provision of electricity to the National Grid, which itself is subject to wide fluctuations in demand and supply. This Company also produces steam and processed water, processes which could also benefit from this research.

1. Introduction

The firm in this case study is an electricity generating company in Thailand whose long lead time in the procurement of spare parts for its machines has caused complaints by its production managers. This adversely affects the company's internal productive reliability, and impacts the National Grid. A Lean technique, Value Stream Mapping (VSM), was chosen to improve the procurement process.

Analysis of the data of purchase orders for twelve months from May 2015 to April 2016 found that the lead time in the purchase order process was 26% greater than the standard time allowed. There are four types of tendering for suppliers of spare parts. The Written Bidding method (for values up to US\$60,000) experiences the highest number of delays, with 151 orders affected (54% of the total orders). Average lead time for these orders is 50.5 days, against the standard time allowed of 15 days.

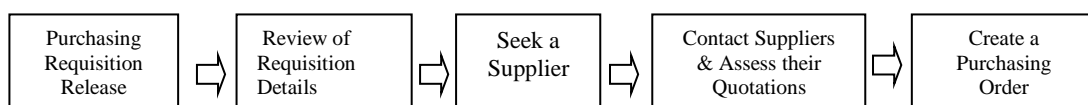
The major causes of this problem are from 'Lean waste', in communications, by the procurement officers to clarify Production Managers' specifications, and to seek suppliers from multiple sources. After the root causes were revealed, process improvement plans were designed, to eliminate waste so as to achieve the standard time allowed.

2. Background of the Research

Procurement is an important part of supply chains, through buying supplies of goods and services, using appropriate processes to secure suitable suppliers, at the best price, for specific quantities for specified delivery dates and locations. The duration of the procurement process is important for critical manufacturing components, especially after a machine breakdown.

The Procurement Department received many complaints from the managers of production departments, about delays in providing spare parts and maintenance services, which are bought from external suppliers. The Purchase Order (PO) process is shown in Figure 1 below.

Figure 1: Purchase Order Process



Source: Author

The PO processing is the lead time, after the Purchasing Requisition (PR) is released from the company's SAP-ERP (SAP,nd) computer system, until a specific Purchasing Order is created by this system. For the 12-month period, May 2015 to April 2016, 2,313 purchase orders were issued. PO processing time exceeded the set standard time in 593 orders (26%. of total orders).

3. Literature Review

Lean Concept. Lean methodology improves a supply chain flow by identifying 'wastes', with a focus on quality, process, and customer service. It can reduce lead time to deliver products (Cusumano & Kentaro, 1998).

Value Stream Mapping (VSM). Value Stream Mapping is a Lean tool to map events within a process. Its maps are one-page diagrams of flows of products, materials, and information (Rother & Shook, 1998). The map helps to find costly wastes, and helps to identify ways to streamline material and information flows to reduce lead times (Womack & Jones, 2003).

Cause and Effect (Fishbone) Diagram. This display tool shows possible causes of the problem. Ishikawa (1990) listed four categories: Man, Methods, Machines, and Materials

4. Research Methodology

The methods in the Literature Review were applied to analyse the collected data.

Data Collection. This consisted of: (a) Historical POs orders, with other relevant PO process documents; (b) Observation data of the work steps and operating methods of the procurement department; (c) Interview Data from all four purchasing officers.

Data Analysis. This Company has three different contract categories for suppliers of spare parts. These vary according to price limits, the lowest (Price Negotiation) being for up to US\$2,000, requiring a minimum of only one supplier to tender. The next category (Written Bidding), is from US\$2,000 to US\$60,000, requiring at least two tender bidders. The top category (Invited Bidding) is for contracts worth more than US\$60,000, requiring at least three bidders.

Table 1 below is an analysis of the Purchase Orders and time taken for the three categories for selecting a supplier.

Table 1: Purchase Orders Numbers & Times, May 2015-April 2016

Procurement Method	PO Processing Standard Time (Days)	Purchase Order Time Comparison				Total Quantity
		Achieve standard time		Over standard time		
		Quantity	Percentage	Quantity	Percentage	
Written Bidding	15	129	46%	151	54%	280
Invited Bidding	45	10	63%	6	37%	16
Price Negotiation	15	1236	76%	380	24%	1,616
Total		1,375	74%	537	26%	1,912

Source: Author

It will be seen that the highest number of purchase order delays is the Written Bidding method. That PO processing time exceeds the standard time in 151 orders, 54% of the total for this method. Therefore, this study focused on this supplier selection category.

5. Findings

Current State: Times and Map

Table 2 below shows the summary of current lead times in the PO process. PO processing time is 50.5 days.

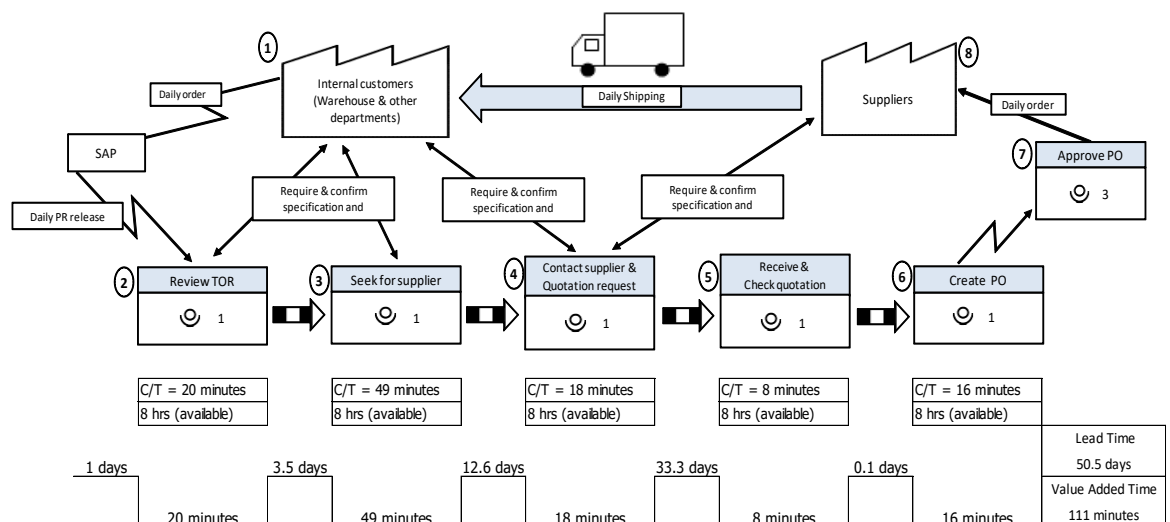
Table 2: Analysis of Current Lead Times

Sub-process	Days
PR Release	1
Review TOR	3.5
Seeking for Supplier	12.6
Contact Supplier & Request for Quotation	33.3
Receive Quotation & Check	0.1
Create Purchase Order	-
Total	50.5

Source: Author

A VSM map is created of the current PO process, as shown in Figure 3 below.

Figure 3: Value Stream Mapping of Current PO Process



Source: Author

* 1 day = 1440 minute or 24 hours

Figure 3 shows the total lead time average as 50.5 days, which is more than the standard time permitted. It also shows two 'waste' activities, revealed in more detail in Table 3 below.

Table 3: Waste Activities in Current Process

Waste Activity	Sub Process
Communication activity to request and confirm specifications, between suppliers, purchasing officer and Production Manager.	<ul style="list-style-type: none"> - Review TOR - Seek a supplier - Contact supplier and request quotation
Select a supplier from multiple sources	<ul style="list-style-type: none"> - Select a supplier

Source: Author

This information helps to find the root causes of delays, which are:

(a) **Incomplete TOR (Terms of Reference) Form.** A Production Manager inserts the essential details for the specification of what is needed. But, there is a blank part which is often unclear. This causes more communication activity to request and confirm the specification and condition in three sub-processes.

(b) **No supplier list.** Purchasing officers never record the supplier source. They seek suppliers from many sources which takes a long time to make the selection.

(c) **Purchasing officers' lack of training in the SAP computer system.** This system has many useful modules to assist the purchasing officers; however, they lack expertise in its use and capability. This is a cause of wasted days.

6. The Future Improved Process

Future VSM Map of the Purchase Order Process

Using VSM enables the researcher to create a new, future, map, without the identified wastes and their causes, so that PO processing times will reduce to the set standard times. The lead times, current and future, are in Table 5 below.

Table 5: Comparisons Time between Current State and Future State

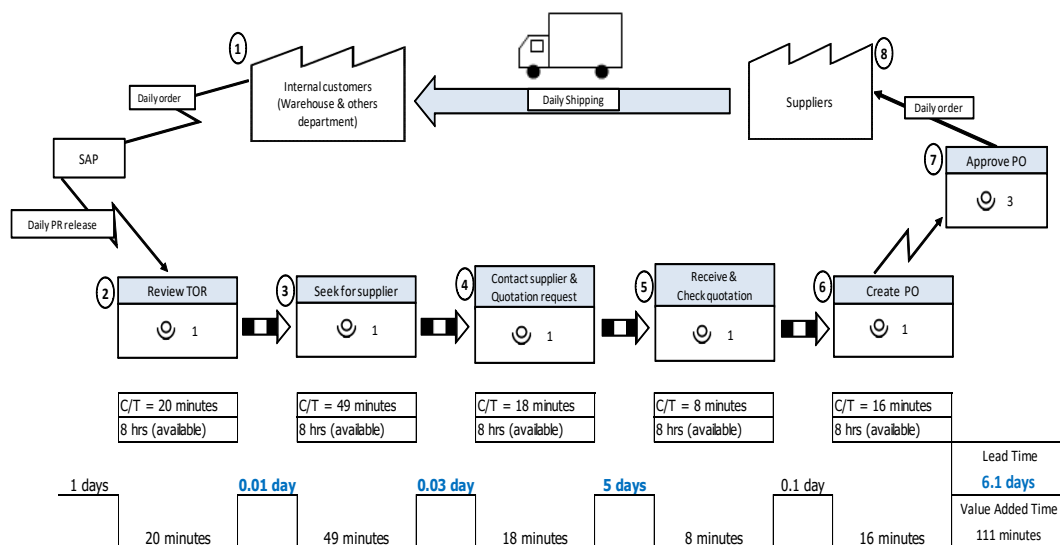
Sub- process	Waste	Lead Time	
		Current State	Future State
		Days	Days
PR Release	-	1	1
Review TOR	Communication activity	3.5	0.01
Seek for supplier	-Communication activity -Seeking for supplier from multiple sources	12.6	0.03
Contact supplier and request for quotation	-Communication activity -Waiting for quotation activity*	33.3	5
Receive and check quotation	-	0.1	0.10
Create PO	-	-	-
Total		50.5	6.1

Source: Author

The total PO processing time has been reduced by 88%, from 50.5 days to 6.1 days.

Figure 4, below, shows the Value Stream Map of the future state. It has no waste activities and the lead time is reduced to 6.1 days which easily achieves the standard time of less than 15 days.

Figure 4: Value Stream Map of the Future State



Source: Author

* 1 day = 1440 minute or 24 hours

7. Implementing the Plan to Improve

The work improvement plan has three steps:

(a) Create a new TOR form. Much of the existing form consists of general requirements, not detailed important information as to exactly what is needed, such as specification of spare parts needed, and delivery requirements.

(b) Training and implementation in a new module in the SAP system to reduce time for seeking suppliers from too many sources, by creating a precise list of trusted suppliers. There is *Purchasing* Information Record and Source list.

(c) Setting KPIs to measure and monitor the monthly performance of the purchasing officers and procurement department, so that the improvements are sustained. First is an Average PO processing time to measure the monthly performance. Second is a KPI to measure the number of monthly purchase orders, and PO processing time against the standard time.

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CONSUMERS' PARTICIPATION IN CO-CREATING LOGISTICS SERVICE VALUES

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Abstract

Purpose of this paper:

Increasingly, logistics industry offers innovative solutions that interact with end-consumers directly (DHL, 2013, Bhattacharjya *et al.*, 2016). Consumers are encouraged to participate in co-creating last-mile logistics service values. Built on the synthesised insights from "consumer logistics" and the "Value Co-creation (VCC)" concept, this study proposes a conceptual framework of consumers' involvement in last-mile logistics from a VCC perspective.

Design/methodology/approach:

The paper is based on a synthesised analysis of peer-reviewed journal articles. Scopus of Elsevier and Social Science Citation Index (SSCI) of Thomson Reuters are employed as search databases to obtain reliable, robust and cross-checked journal articles (Galvagno *et al.*, 2014)

Findings:

Consumers are empowered to influence specific changes in the service offerings, whereas logistics service providers (LSPs) accrue benefits in transferring parts of the service obligations to consumers (Rouquet *et al.*, 2017). Given the mutual benefits, the trend of VCC is expected to gain strong development in last-mile logistics. However, three major discordances exist: 1) consumers' resistance in adopting the innovation service concept of VCC; 2) the potential risk of exploitation and the associated concern on service fairness; and 3) a lack of proper governance mechanism of the co-creation relationship.

Value:

This research conceptualises consumers' role in last-mile logistics from a VCC perspective. By integrating the insights on the interactive value formation in the management of last-mile logistics service, this study offers a unique angle to manage consumers' involvement in last-mile logistics.

Keywords:

Consumer logistics, Value co-creation, Service innovation, Exploitation, Relationship governance

INTRODUCTION

The concept of value co-creation (VCC) has been attracting much research attention over the past decade (Vargo et al., 2008). VCC refers to an interactive value formation process where service systems (e.g. service providers and customers) collaborate to create values (Galvagno et al., 2014). Under such a premise, customers are viewed as proactive co-creators of service values, whereas service providers assume the role of facilitators of value creation. Scholars have advocated that VCC allows service providers to foster closer and more profitable relationships with their customers, and at the same time, allows the customers to induce changes in service offerings.

VCC is also practised in the context of last-mile logistics (Rouquet et al., 2017; Yazdanparast et al., 2010). As embodied within the concept of “consumer logistics” (Bahn et al., 2015; Granzin and Bahn, 1989), consumers are inducted to participate in logistics services in the form of reverse logistics (Yuan et al., 2016), self-collection (Wang et al., 2018), crowd-sourcing delivery (Carbone et al., 2017), etc. In so doing, consumers are empowered to influence specific changes in the service offerings (e.g., by self-collecting parcels, consumers take control of the time and the place of collection), whereas logistics service providers (LSPs) accrue benefits in transferring parts of the service obligations to consumers (Rouquet et al., 2017). With the proliferation of B2C e-commerce and advancement in enabling service technologies, LSPs are increasingly offering innovative solutions that invite end-consumers’ participation. Given the mutual benefits, the trend of VCC is expected to gain a strong development in last-mile logistics. Therefore, it is highly timely to extend the last-mile logistics research by incorporating the critical concept of VCC. However, with a few exceptions (Bahn et al., 2015; Rouquet et al., 2017; Yazdanparast et al., 2010), research on consumers’ participation in logistics services has been largely rudimentary, and even less has been conducted from the VCC perspective.

Importantly, the concept of co-creating values with consumers is not without controversies. Some VCC researchers regard the concept as an “angelic” vision of an idyllic market where consumers and producers live in harmony (Cova and Dallı, 2009), whereas the discordant side of VCC has been under-investigated. First, from a service innovation perspective, consumers’ hesitation / resistance in adopting the innovative service concept represents the initial barrier to a co-creation relationship that could be mutually beneficial. Second, the potential risk of exploitation and the associated concern on service fairness further impedes a harmonious co-creation experience. Finally, VCC also implies the need of consumer control as consumers’ scepticism towards the co-creation initiatives brings uncertainties to the value outcomes. However, despite the many controversial aspects, extant research has predominantly advocated the positive aspects of VCC.

The purpose of this study is to propose a conceptual framework of consumers’ involvement in last-mile logistics with a special focus on the three discordant components of the value formation process. This is achieved by selectively reviewing the VCC literature and applying the synthesised insights to consumers’ participation in co-creating logistics services. The remaining of this study is organised as follows. Starting with a brief description of the review process, an overview of the logistics literature addressing consumers’ participation is firstly provided. Next, the synthesised findings along with five propositions regarding the discordances in co-creating logistics values are presented. As a conclusion, a unified framework is proposed, suggesting a dynamic and contingent view of consumers’ co-creation of logistics values.

DATA COLLECTION METHOD

In this study, existing publications are located and evaluated, synthesised insights are presented and a unified framework is proposed. An iterative cycle for data extraction is

conducted starting from defining / refining search keywords, identifying / screening literature, to completing the analysis. As the topic of VCC has been approached from different research streams, appropriate databases have to be selected to ensure a comprehensive coverage of business-related peer-reviewed journals. In line with such considerations, Scopus of Elsevier and Social Science Citation Index (SSCI) of Thomson Reuters are identified, both of which are employed as search databases to obtain reliable, robust and cross-checked data. Following the guidelines developed by Denyer and Tranfield (2009), a three-phase methodology for data mapping, refinement, and evaluation is used. A collection of 84 research articles are identified, which are included for analysis in this review study.

VCC IN LOGISTICS STUDIES

The VCC concept has been reported in logistics literature albeit implicitly and in a limited extent. Under the Unified Service Theory (Sampson and Froehle, 2006), service supply chain has been characterised as bidirectional relationships with intensive customers' involvements. Customers interact with LSPs in a reciprocal manner by assuming expanded roles as both receivers and providers of resources. It is recognised that services can only be delivered when appropriate customer resources are received. As critically pointed out by Carbone et al. (2017), consumers are collectively forming a powerful crowd that can be potentially integrated into the formation of logistics values. To this end, consumers' participation in logistics are increasingly conceptualised as collaborative activities that exert a great impact on the sustainable development of logistics services. Table 1 provides a summary of the selected logistics literature that examines the VCC concept.

Indeed, the notion of consumers' participation in logistics services was proposed several decades ago by Granzin and Bahn (1989). To quote the illustration in their original work, "the consumer logistics system engages in such diverse logistics activities as storing food in containers for future use, dehydrating foods to reduce bulk, and packaging Christmas gifts to be shipped to relatives". In the same study, the authors further conceptualised consumer logistics into five subsystems including location selection, inventory holding, transportation, handling and storage, and communication. In this regard, consumers are recognised to perform logistics activities to meet their daily consumption needs by utilising their own resources (Carbone et al., 2017; Granzin et al., 2005). However, their pioneering work did not gain much attention from logistics scholars, as the conceptualisation on consumer logistics was more intuitively understood as consumer behaviours rather than logistics activities.

More recently, with the combined emergence of VCC concept and enabling service technologies, a variety of innovative logistics solutions are promoted by LSPs that interact with consumers directly. Reverse logistics, self-collection, and even crowd-sourcing delivery are all vivid examples, which serve as substantive evidence of co-created logistics services with consumers' participation. As such, consumer logistics are increasingly being viewed as collaborative activities that exert a great impact on logistics value formation (Bahn et al., 2015) and consumers' participation in logistics becomes a critical variable in the supply chain design (Rouquet et al., 2017). Thus, it is highly timely to examine consumers' role as an active co-creator of logistics values. The research field of consumer logistics holds great potentials in generating synthesised insights that enrich both the logistics and consumer behaviour literature (Bahn et al., 2015). The following proposition is thus proposed:

Proposition 1: Consumers are forming an intelligent crowd that can be potentially integrated in co-creating logistics values. Consumers' participation in logistics are collaborative activities that greatly impact on the formation of logistics values.

Table 1: Selected logistics literature from the VCC perspective

Source	Context	Method	Theory	Finding
Bahn et al. (2015)	Shopping-related logistics	Empirical validation / exploratory survey	Service-dominant logic and value co-creation	Ten categories of consumer logistics activities are proposed; technologies have enabled collaborative value creation in consumer logistics
Carbone et al. (2017)	Crowd logistics	Conceptual development / Content analysis	Value co-creation	Crowd is conceptualised as a co-creator of logistics values and the practice of crowd logistics is likely to disrupt the traditional logistics industry
Dixit and Badgaiyan (2016)	Reverse logistics	Empirical validation	Theory of Planned Behaviour	Perceived behaviour control, subjective norms, moral norms and willingness to sacrifice are critical factors in formation of return intention
Granzin and Bahn (1989)	General	Conceptual development	Industrial logistics system	Consumers perform a range of consumer logistics in location selection, inventory, transportation, handling storage and communication
Rai et al. (2017)	Crowd-delivery (crowd logistics)	Literature synthesis	Sustainability	Crowd logistics is defined with 18 characteristics. The economic, social and environmental impacts are established in relation to the 18 characteristics identified.
Rouquet et al. (2017)	General	Conceptual development / case study	-	Customer participation in logistics is a key variable in supply chain design and motivating customer participation is critical
Teller et al. (2006)	Shopping-related logistics	Empirical validation	-	Shoppers are unable to convert logistics efforts into costs
Yuan et al. (2016)	Reverse logistics	Empirical validation	Value-belief-norm / neutralisation theory	People form more positive attitude to reverse exchange when they are ethically concerned, yet they may not behave consistently when using neutralisation

Among the limited research on consumer logistics, (Teller et al., 2006) found that consumers are "amateurs" in terms of cost consciousness as they perceive the process of logistics cost calculation being complex and time-consuming. Dixit and Badgaiyan (2016) identified numerous psychological factors that motivate consumers' participation in reverse logistics. By applying Theory of Planned Behaviour, several attitudinal considerations are held to influence consumers' intention (Dixit and Badgaiyan, 2016). Yuan et al. (2016), on the other hand, added a dimension of uncertainty to consumers' decision-making process. They suggested a neutralisation process that led to inconsistencies between consumers' attitude and intention of conducting reverse logistics. Hence, there seems to be a complicated mechanism that obscures a straightforward interpretation of consumers' co-creation behaviour of logistics values. Therein, a consensus is yet to be reached by logistics scholars. Uncertainties exist in consumers' participation in co-creating logistics services. In particular, issues of *innovation adoption barrier*, *exploitation* and *consumer scepticism* have been at the centre of much debate.

DISCORDANCE 1: INITIAL ADOPTION BARRIER TO CO-CREATION

As compared to conventional full services in the form of *offerings*, VCC represents a fundamental shift in the nature of last-mile logistics. An initial adoption barrier may exist that prevents a smooth transition of consumers from assuming a traditional role as service recipients to an unfamiliar role of service co-creators. Indeed, the feasibility of any innovative service concepts should always be balanced against the perceptions and behavioural responses of the consumers. Of interest are the motivational factors that drive consumers' initial adoption of co-creation options over the conventional alternatives.

In particular, innovative self-service technologies (SSTs) are dramatically changing the way how business logistics are conceived, developed and delivered. For example, a promising innovative SST is found in e-commerce last-mile logistics, whereby the option of technology-based self-collection service, otherwise known as Automatic Parcel Station (APS), gradually prevails over conventional home deliveries (Wang et al., 2018). Consumers are empowered to participate in self-collection from centralised APS at their convenient time and location (Collins, 2015). It represents a fundamental shift in the nature of e-commerce logistics as compared to conventional delivery that entails many carriers making home deliveries to fragmented destinations of end consumers and costs hours of consumers' waiting time for parcel reception. In this regard, consumers using APS are important contributors to firms' productivity by taking a co-production role, portrayed as "co-creators of value" (Vargo et al., 2008).

Studies on consumers' adoption of innovation, SSTs in particular, have been attracting much attention in industries where the levels of end-customer interactivity and technological integration are high, such as retailing and financial services. Considerable efforts have been placed on identifying consumers' attitudinal, behavioural factors that affect the adoption behaviour. Whereas in the field of logistics studies, extant research has largely ignored innovations, despite the emergence of many innovative concepts. On the other hand, among the few studies on logistics innovation, due to the inherent interdependence between logistics firms along the supply chain, most research was conducted from the organisations' perspective aiming to establish the relationship between innovative logistics practices and organisations' competitive advantage (Grawe, 2009; Hazen and Byrd, 2012). Consequently, consumers' receptivity, which is crucial to the adoption of last-mile innovations, has not been addressed. Indeed, last-mile delivery is a consumer-oriented service with a strong behavioural element (Collins, 2015). The key factors that motivate consumers' adoption of the innovation co-creation concept remain to be explored. Therefore, we propose the following proposition:

Proposition 2: An initial adoption barrier exists that may prevents a harmonious value co-creation process of logistics services. The uncertainty of value outcomes lies in the varied innovation / technology receptivity levels of consumers.

DISCORDANCE 2: EXPLOITATION IN CO-CREATING SATISFACTORY LOGISTICS EXPERIENCE

Further to overcoming the initial barrier, a satisfactory co-creation experience is essential to ensure consumers' continuous participation so as to foster mutually beneficial relationships in the long term. However, while VCC empowers consumers with an active role in service creation, it also connotes a sense of exploitation (Cova et al., 2011). VCC signifies a changing role of consumers from a passive recipient of value to an active value (co)-creator. Yet, there clearly exists an asymmetry between the value that consumers contribute to the markets and the value that returns to the consumers. To illustrate, in the case of reverse logistics, consumers' time and efforts are exploited to perform materials handling & recycling; in the case of self-collection and crowd-sourcing delivery, consumers are inducted to retrieve and transport freight parcels.

To a certain extent, consumers contribute with their “free labour” (or marginally incentivised labour) and essentially work as “partial-employees” to handle parts of the service obligations that are conventionally under the full purview of LSPs (Sampson and Spring, 2012). The exploitative view represents an interpretation of VCC that counterbalances the overly optimistic assumption that consumers and service providers interact in harmony (Cova and Dalli, 2009). However, it is also acknowledged that there is no general rule as to when exploitation would be profoundly felt by consumers. To this end, consumers’ exploitation concern is forever a hidden discordance that nevertheless impacts on the value outcomes.

Under such arrangements, questions are naturally raised such as “will consumers feel being exploited/unfairly treated by LSPs when involved in VCC?” and “how will the fairness concern influence consumers’ co-creation experience of the logistics service?” Indeed, the fairness issue is a central theme in the VCC discussion from individual consumer’s perspective (Chou et al., 2016; Gebauer et al., 2013), and consumers’ unfairness perception has been found to trigger the “dark-side” of VCC leading to diminution of service values (e.g. dissatisfaction by consumers, and loss of profit to service providers) (Gebauer et al., 2013). In this regard, a fairness consideration becomes critical in consumers’ evaluation of co-creating experiences. The VCC concept may be critically challenged by consumers as to “why are the economic benefits enjoyed solely by the firms whereas I’m rightfully part of it?” Most likely, fairness would become a concern of consumers when the individual and social rewards obtained from VCC interactions are not sufficiently justifiable compared to their commitment. Therefore, the ambiguous distinction between empowerment and exploitation prompts the fairness considerations to consumers that guide their participation in VCC.

Valuable insights from the general VCC literature may be referenced in examining the fairness perspective of co-creating consumer logistics. In particular, VCC literature distinguishes two specific roles of consumers, as co-designers and / or co-producers (Dong, 2015). Co-designers participate in VCC by sharing critical information and opinions that are personal and subjective to consumers, such as in a health consultation with a doctor and a travel itinerary design with a travel agency. Co-producers, on the other hand, contribute to VCC with their physical efforts, which are generally impersonal and replaceable by service employees. Given the different natures of consumers’ roles, scholars have suggested that the role as a co-designer creates greater values to consumers and represents a unique contribution to the service outcome (Dong, 2015). In contrast, the role as a co-producer may be perceived as a “chore” if it is simply an excuse from service providers to divert the workload to consumers. To this end, the issue of consumer exploitation becomes especially salient when consumers assume the role as a co-producer. In this study, consumers’ role in co-creating logistics services falls primarily into the category of a co-producer, whereby consumers’ physical efforts are exploited to perform activities such as materials handling, products return and parcels self-collection. While consumers may value the sense of empowerment by performing the “do-it-yourself” activities, the fairness perception inevitably surfaces when consumers realise that they are “co-creating with” as well as “producing for” the LSPs. However, the critical impact of the fairness perception on consumers’ co-creation in logistics services has been lacking in the literature. Therefore, the following proposition is proposed:

Proposition 3: A paradoxical impression of empowerment and exploitation exists that may prevent a harmonious value co-creation process of logistics services. The uncertainty of value outcomes lies in consumers’ perceptual differences of the participatory fairness of the co-creation initiatives.

DISCORDANCE 3: AN UNKNOWN CROWD OF SCEPTICAL LOGISTICS CONSUMERS
Finally, while LSPs may capitalise on consumers’ contributions, they may face a potential risk of losing control to the unknown crowd (Cova et al., 2011) when co-creating logistics services with consumers. In this regard, the congruence between consumers’ value

orientations and LSPs' value propositions becomes crucial to promote a sense of "relating", where consumers personally identify the co-creator roles with themselves (Dong et al., 2015).

In response, LSPs are increasingly implementing green co-creation initiatives (e.g. reverse logistics and self-collection) that invoke on consumers' green consciousness, thus eliciting willing contributions from consumers. General evidence suggests that a growing number of consumers are willing to pay for green products and companies also benefit from various co-creation initiatives in terms of cost savings, new market opportunities, enhanced brand image and customer loyalty. The concept of "going green" is integrated into the corporate strategies, and perhaps more importantly, communicated to the current and potential customers. To this end, a clear demonstration of environmental commitments is of vital importance to establish a proper co-creation relationship with consumers (Raska and Shaw, 2012).

However, literature suggests that consumers are sceptical about the true motive of service provider's initiatives (Raska and Shaw, 2012). Depending on the extent to which consumers perceive they are being taken advantage of, some co-creation motives are inferred as positive or benevolent (for the benefits of consumers or public), while some motives are inferred as negative or greedy (self-serving). In fact, there are widespread concerns that firms are disseminating incomplete or even misleading environmental information, yet hiding the true business agenda from consumers. This is probably attributed to certain irresponsible corporate behaviours that are made known to the public, which causes consumers to doubt the consistency in firms' green assertions and related performances. Increasingly, consumers are becoming more critical of firms' green practices especially when cost motives are perceived to be more salient than environmental ones (Rahman et al., 2015). Therefore, a thorough understand of green consumerism and green scepticism is necessary to effectively stimulate voluntary contributions. Hence, the following proposition is proposed:

Proposition 4: In the context of green logistics, consumers' scepticism towards LSPs' co-creation initiatives exists that may prevent a harmonious value co-creation process. The uncertainty of value outcomes lies in the level of congruence of consumers' value orientation and LSPs' value proposition, which is further contingent upon consumers' general (green) scepticism.

CONCLUSION

Based on the synthesised findings of this review study, a unified framework of co-creating consumer logistics is presented in Figure 1. The review findings contribute to theory in several ways. First, we zoom into the value formation process of consumers' co-creation of logistics services, which reveals the complex psychological mechanisms that underpin consumers' participation behaviours. Rather than adopting the abstracted concept of VCC, this review comprehensively examines the value formation process starting from consumers' initial adoption of the concept (a service innovation perspective), to consumers' evaluation of the participation experience (a satisfaction formation perspective) and finally narrowing down to the context of green logistics (a perspective of managing relationship with scepticism). Furthermore, in each stage of the value formation process, discordances are identified that result in uncertainties in the value outcomes. Respectively, initial adoption barrier, exploitation concern and value congruence are identified as the discordances that impede optimal values to be formed. Zooming one level down, it is found that the discordances are further associated with the heterogeneity in consumers' innovation receptivity, perceptions on participatory fairness and green scepticism. In this regard, this review departs from the conceptual level of VCC and zooms into the perceptual level of consumers. By so doing, it contributes to VCC literature with a discordant perspective, which integrates the business realities into the optimistic VCC discussion.

Managerially, LSPs must realise that consumers possess more powers in “dictating” their logistics service needs. It is imperative for LSPs to embrace this trend of consumer participation by fostering a collaborative relationship with participating consumers. However, it must also be realised that risks exist in co-creating logistics services with consumers, which result in uncertainties in the value outcomes as embedded in each of the discordances identified. For example, associated with consumers’ innovation receptivity are the risks of resource under-utilisation (e.g. investment in self-collection facilities) for LSPs and an undesirable service standard to consumers. Associated with consumers’ fairness concern are the risks of causing dissatisfaction to consumers and hence losing profits to LSPs. Associated with consumers’ green scepticism are the risks of a vulnerable co-creation relationship where LSPs need to devote extra efforts to overcome consumers’ scepticism. Consequently, values may be co-destroyed with consumers’ participation in the collaborative value formation process, rather than value co-creation.

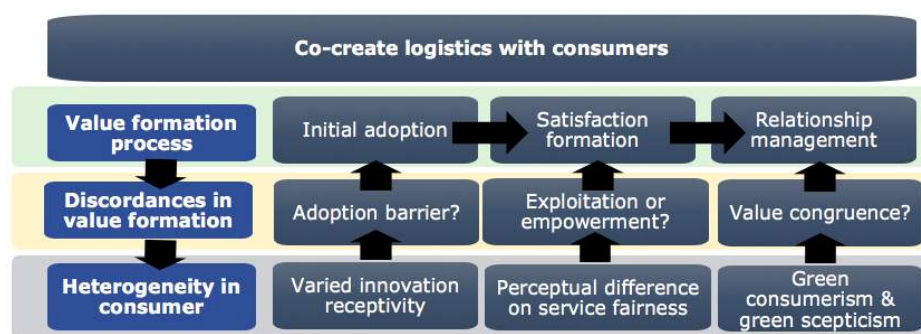


Figure 1: A unified conceptual framework

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DIGITIZATION OF CRIME DETECTION IN THE SUPPLY CHAIN

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Abstract

Purpose of paper:

Increasingly customers focus not just on product function and price, but also on organisational level attributes such as the ethical behaviour of vendors and their supply chains. Increasing effort is aimed at reducing or eliminating behaviour seen as unacceptable (Gold et al, 2015). Methods for detecting this behaviour range from police operations at car washes (Chesney et al, 2017) to efforts to detect slavery via satellite imagery such as the "Slavery from Space" project. Whilst efforts have been made to mine the web for certain types of activity and language (e.g. Johansson et al, 2016) less effort has gone into detecting the signs of modern slavery on the web. Efforts have been made to publicise the story of people caught up in modern slavery, however, such as the "Contemporary Narratives" project. The aim of this paper is to explore the possibilities of using web mining to detect modern slavery to provide a reliable digital source of data for authorities and organisations interested in reducing modern slavery by mining the web. Existing narratives could be used to "bootstrap" this detection process via language models.

Methodology:

This paper will review literature relevant to the task of detecting crime, especially crime linked to modern slavery. Themes to be explored are cross disciplinary: 1/ motivation and identification of urgent cases and types of modern slavery 2/ a summary of methods used in Natural Language Processing (NLP) that might be adapted for use in this task.

Findings:

We find that literature exists that describes NLP techniques for similar tasks. We contend that with adaptations they could be used to achieve our aims. Promising areas of modern slavery are described.

Value:

We suggest new ways to detect modern slavery that result from a cross disciplinary view of web mining technology and efforts to publicise modern slavery cases. We start to explore this aspect of digitising the supply chain, by creating digital methods of detection of modern slavery in supply chains.

Research implications:

Future work would focus on the detailed adaption of the methods, the further identification of "bootstrap" data, and verification against cases discovered by other methods.

Practical implications:

This work is high impact, modern slavery is a current issue and is receiving increasing research attention. Digitization and the production of actionable data are also current.

INTRODUCTION

Increasingly customers focus not just on product function and price, but also on organisational level attributes such as the ethical behaviour of vendors and their supply chains. Increasing effort is aimed at reducing or eliminating behaviour seen as unacceptable (Gold, Trautrim, & Trodd, 2015). Attention in industry publications such as (Ranganathan, 2018) suggests an increasing focus on these issues within supply chains. Methods for detecting this behaviour range from police operations at car washes (Chesney, Gold, & Trautrim, 2017) to efforts to detect slavery via satellite imagery such as the "Slavery from Space" project (Boyd, et al., 2018). These efforts require that the activity is visible or can be detected by recording physical behaviour. The internet appears to offer an opportunity for perpetrators to organise without detection. Efforts have been made to mine the web for certain types of activity and language such as terrorism (Johansson, Kaati, & Sahlgren, 2016) and illegal trading on the Dark Web

(Baravalle, Lopez, & Lee, 2016). Less effort has gone into detecting the signs of modern slavery on the web. We describe the main uses of the internet to perpetrate Modern Slavery offences and describe responses.

This paper reviews literature relevant to the task of detecting crime linked to modern slavery. Firstly we outline areas where modern slavery is prevalent in the supply chain using a new model. We summarise broad fields where web technology is used in modern slavery detection. We next summarise web mining and Natural Language Processing (NLP) methods previously used in the detection of content that seems similar to content about modern slavery. These might be adapted for use in this task.

We refer to "digitization of the supply chain" as taking operations currently accomplished manually, via paper based systems or via relatively simple ERP packages and increasing the level of involvement of digital technology to a point where it digitally transforms the activity. In our case we are looking at automating a part of supply chain auditing and control to allow detection of modern slavery activities in supply chains.

MODERN SLAVERY AND THE SUPPLY CHAIN

Modern slavery is "situations of exploitation that a person cannot refuse or leave because of threats, violence, and coercion, abuse of power or deception" (GSI, 2016, p. 158). Many workers are obliged to work for money in order to survive, there are six features defined by the ILO that distinguish Modern Slavery from so call "Wage Slavery" (New, 2015). Many cases of slavery do not involve human trafficking (Gold, Trautrim, & Trodd, 2015).

No organisation would publicise its direct use of modern slaves. However, slavery is hidden in supply chains at varying distances from the top tier company to a greater or lesser degree (Gold, Trautrim, & Trodd, 2015). In some industries the labour supply chain may contain slaves at very little distance from the top level (in care homes for example) (Emberson & Trautrim, 2017). At the other end of the scale there may be Modern Slavery in the brick kilns used to create the bricks used to create facilities in which outsourced work in the garment industry. Somewhere between these lies the garments themselves which may have been produced by a contractor working for a second tier supplier. This second tier supplier operates in the country of production and produces products for the western market. This in itself creates a distance, but this is exacerbated by an informal arrangement with supplier lower down the chain who may subcontract to individuals working in their own homes with very little oversight. Even the larger suppliers below tier two are less likely to adhere to strict health and safety and other regulations, see for example the Rana Plaza building collapse.

Typologies have been created such as <https://polarisproject.org/typology> and a report from the Home Office (Cooper, Ellis, Hesketh, & Fair, 2017). These allow cases to be categorised and theories to be created which explain how each market operates. These categories of Modern Slavery vary in the degree to which they impact on supply chains and logistics of modern companies.

(Boyd, et al., 2018) explain a method for detecting brick kilns using satellite imagery., however most slavery would not be visible from space. For example where common activities can be either legal or not for example sex, car wash businesses and agricultural activity, it would be impossible to categorise the images into those containing slavery and those that do not, indeed physical evidence viewable in satellite imagery is clearly not available for some types of slavery. It is likely that quarrying, brick kilns, forest clearing for drug cultivation, fishing villages, charcoal burning and many others do produce physical evidence and thus would be detectable. In some cases these would be distinguishable from legal activities. In order to be more certain data gathered about the locations of activities could be triangulated with other data. This data could be gathered manually, However many of these activities are likely to be coordinated using mobile or web technology. It is our hypothesis that since little attention is paid to these coordination activities they are not done in a clandestine way. Such clandestine behaviour would most likely cost more and therefore much of this communication is most likely done in plain sight.

(Allain, Crane, LeBaron, & Behbahani, 2013) show that supply chains link the formal UK economy to the less formal economy, where most forced labour occurs. They find that

time-sensitive activities are the most likely places to find evidence of this forced labour. This they find is due to complexity in the labour supply chain, which fosters forced labour. They describe product supply chains as short and less complex and thus not so vulnerable to containing forced labour.

(Baker & Campbell, 2013) outline the Information Communication Technologies that traffickers (involved with trafficking in persons) are benefiting from. The methods highlighted are use of "disposable" mobile phones, those that can be obtained without identification. The use of mobile phones to control and track those being trafficked. The use of "re-mailers" to obfuscate identifying information while using email. The use of "virtual identities" which are either anonymous by design or created using false information. The ability to advertise in chat rooms, social media sites and advertising sites. The use of online employment advertising sites to create false job adverts to entice victims (a "bait and switch" tactic), the use of code languages in social media such as Twitter. The following technologies were found to have been used: Web message and bulletin boards, websites and search engines, chat rooms, peer to peer networks and file swapping programs, FTP, Encryption and mobile internet services.

(Crane, 2013) Describes how modern slavery can become a management practice. They emphasise the lack of management focus on modern slavery and the difficulty estimating the numbers involved due to the clandestine nature of the practices. It is contended that slavery tends to occur in the low margin parts of the supply chain, which in many cases is far from the focus organisation at the top of the chain where margins are typically higher. Organisations exploit slavery while at the same time insulating themselves from it and its negative effects. Pressures against slavery exist "practices are likely to become more diffuse in industries where slave operators are part of strong geographic social networks that collectively deflect the intrusion of institutional pressures." Slavery exists in geographic clusters where similar conditions exist. Crane explains the pressure top tier organisations can exert to eradicate slavery and also the tactics (such as extending the supply chain) that can have to opposite effect. Crane builds a model of factors in modern slavery, some of which relate directly to the supply chain.

NGO work such as that by (Burns, Oosterhoff, & Joseph, 2016) exposes modern slavery and creates understanding and theory about the pressures that foster it. Working in Tamil Nadu they studied the patterns and dynamics of cotton weaving in this area. They do this using case narratives. In terms of communication opportunities they found that the workers were kept away from visitors such as family and were followed in order to stop them talking. Accidents are covered up by the management, thus avoiding medical attention which might make the condition public and give the worker opportunities to communicate. The workers were typically hidden when the mills were inspected.

(Datta, 2014) reports on recent uses of technology to unearth evidence of slavery and to find its extent and location. Focusing on Big Data the report shows maps at a country level based on percentage enslaved categorising countries from Best to Worst. Haiti, Mauritania, Pakistan and India are at the high end while most western countries are very low in prevalence of modern slavery. Using finer-grained data they are then able to do a comparative study looking at one place in 2009 and 2011 and looking for differences. They use a number of measures such as number of children in school and two meals a day and find that these measures have improved between the two snapshots.

(New, 2015) examines modern slavery in the supply chain. They find that the issue is often seen alongside other issues of sustainability, but is different in some ways. Although organisations are generally against modern slavery practices eradication of these practices does not always seem to be effective using similar approaches as to other sustainability issues. Attempts to detect or quantify the occurrence of slavery through questionnaires and audit visits may fail because to the pressures in the system that reduce or remove motivation to report it. Legislation has been introduced, such as the modern slavery act, which effectively forces organisations to police their own supply chain. Many of the statements made by organisations in order to comply with the Modern Slavery Act 2015 are transparent but appear to have little or no effect. An example was given in the form of vegetable cultivation in the UK. A police operation uncovered modern slavery, however this was not instigated by the focus organisations, large supermarkets,

but by a local council and a government organisation. This suggests that in this case the governance in these organisations was not functioning to reduce Modern slavery practices. It should also be noted that the victims themselves did not report these issues despite being in a country where the police can be relied upon and a mobile communication network has nearly complete geographical coverage. They suggest two actions to counter these issues: one, to make low level data accessible to the general public, two that governments might intervene to reduce to power of corporations so that the pressures that cause Modern Slavery are not so strong.

(Gold, Trautrim, & Trodd, 2015) suggest various approaches for detection of slavery in the supply chain one strand of which is the suggestion that "Indicators and data sources are triangulated to substantiate suspicion of slavery in specific geographical areas and industry sectors". We aim to follow this approach by using web mining to detect signs of modern slavery in the supply chain.

MODEL OF COMMUNICATION WITHIN MODERN SLAVERY IN SUPPLY CHAINS

Figure 1 shows our model of Modern Slavery in the supply chain. The lines show communication or influence and the boxes show entities and concepts within this context. Where communication exists it is not clear whether that communication is often online apart from a couple of clear example of adverts on the social networks (20) (Latonero, 2011) and online classified websites (Grant, 2018). It is also clear from our own experimentation that individuals looking to sell kidneys advertise openly on social media. The role of mobile phones (16) and private networks (17) is unclear, but as (Latonero, et al., 2012) states it is likely that they are involved in at least some aspects of modern slavery (in this case human trafficking). This will not be true in all cases in some modern slavery contexts one of the distinguishing factors of the victims is illiteracy (Gausman, Chernoff, Duger, Bhabha, & Chu, 2016). Focus organisations operate in such a way that they may be insulated from modern slavery, but at the same time creating the environment where it can flourish (New, 2015) (10). Supply Chain Management (8) is often not connected with slavery; the issues it attempts to solve are more about efficiency and quality of suppliers. At the same time these organisations may derive value from the slavery value chain. Money (18) circulates with slavery and may be a visible signal. On the top left (13,14,15) governmental intervention attempts to change the ecosystem, making slavery more difficult, more costly in terms of reputation. However the statements produced often have little to do with the actual tacit practices in organisations and provide a pseudo-transparency where nothing important is stated (Hodgson, 2017). Slavery causes associated poor practices (7) such as waste, HR and environmental issues (Bales, 2016) and these may be detected as secondary signs. There is clearly much communication around victims (1), survivors (3), perpetrators (2), family, friends and community (19). Some communication will occur from victims and survivors to authorities (11), but this may be muted by the context. A perhaps more accessible route to reports is through NGOs (4) who run their own investigations without being involved in the communities that make reporting difficult. Another route is through incidental reporting, for example medics contacts with injured victims.

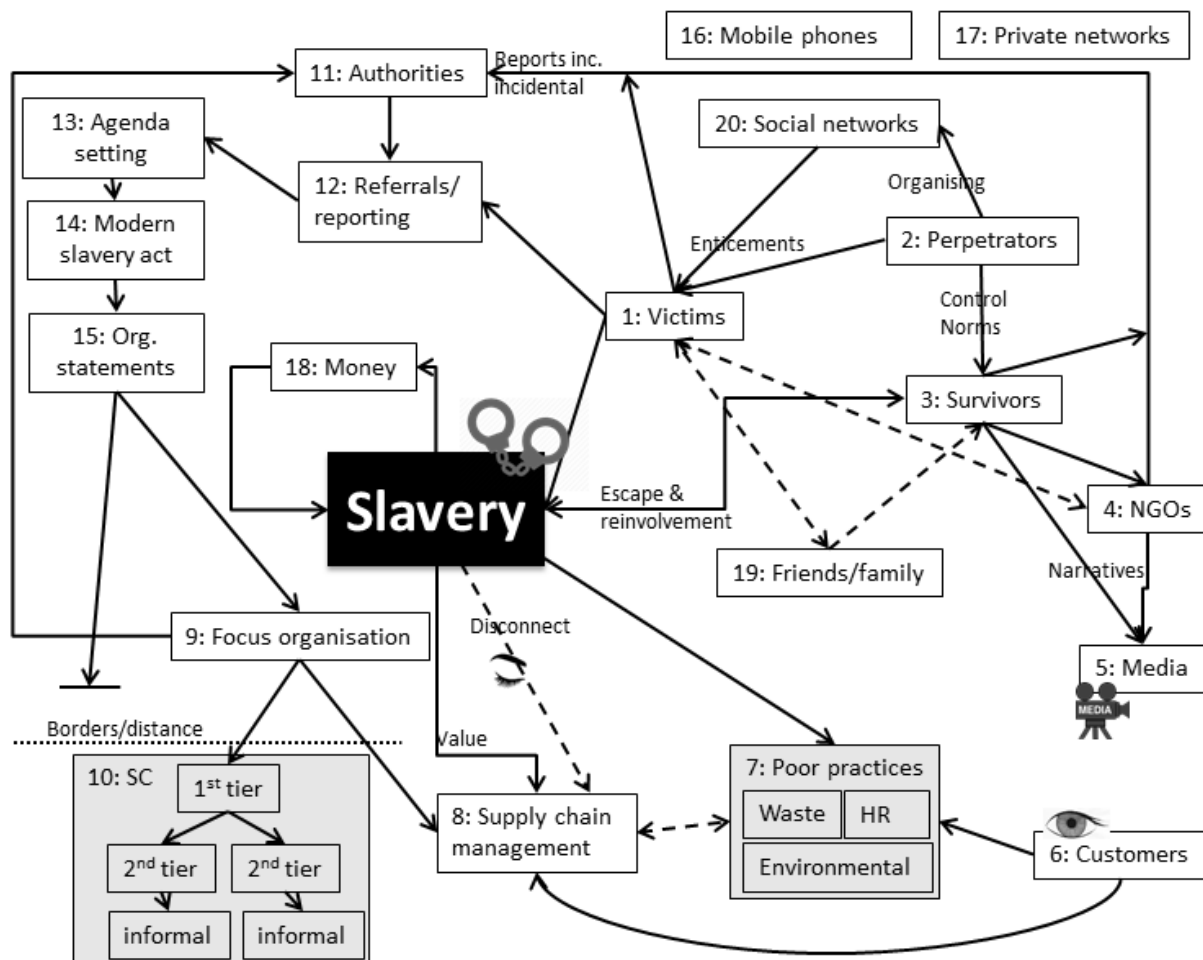


Figure 1: Model of slavery communication channels

THE MODEL AND DIFFERENT SECTORS OF MODERN SLAVERY

Modern Slavery is not a single phenomenon. Different industrial sectors contain it in different ways. Several areas of modern slavery have been uncovered and publicised.

The following examples are close to home, in industrialised countries. In agriculture (in UK and abroad), people are used to harvest crops in less than ideal conditions and under the minimum wage (Davies, 2017). As mentioned before some care home staff have been shown to be made vulnerable by a culture of short term contracts involving agencies who are not as ethical as the care homes. (Emberson & Trautrim, 2017) found that the labour supply chain in the UK health sector may be using modern slaves; managers thought that the way care homes are now organised made this more likely.

As stated above and in the literature focus organisation often use physical distance to insulate themselves from the reputational effects of modern slavery in their supply chains. We describe examples where this may be the case. Extractive quarrying of stone such as sandstone in India for the domestic trade some of which is exported to be used as patio paving in Western nations such as the UK. (Balch, 2015) describes a UNICEF report which exposes the child labour in the patio stone business in Rajasthan.

Further down the supply chain brick production is indirectly involved in the construction of infrastructure. Building regulation is weak and not enforced effectively leading to many disasters due to unsafe buildings such as the Rana Plaza building collapse. Brick kilns in the South Asian so called brick belt are often staffed by slaves in indentured labourers paying off debts incurred by themselves or their families (Boyd, et al., 2018). The garment industry is rife with poor working conditions and high risks. Much of this is hidden by a long supply chain which often ends in individuals working at home with no standards being upheld at all. The prawn industry in Thailand (Kittinger, et al., 2017) has been uncovered as an indirect user of slaves in the production of food for prawn farms.

USING WEB TECHNOLOGY TO DETECT MODERN SLAVERY

Consulting Figure 1 we can see various parts of the model where perpetrators are likely to need to communicate. Some of these areas require the public to be able to read the communications provided and to contact the author of that communication. These are risky for the perpetrators, and an opportunity for the detection of this activity. Other communications could be done clandestinely, but are probably not.

Reuters suggest (Nagaraj, 2017) that by web mining various sources of evidence can be gathered "mobile phones, media reports and surveillance cameras can all be mined for real-time data" below and in Figure 1 we look at the various ways such content is produced. Reuters use 200 human researchers as well as automated approach because they do not believe that a fully automated approach has the same impact (Reuters, 2016). (Business Insider, 2017) describes the use of job posting website to advertise jobs that entice workers into slavery conditions. It suggests that online reviewing systems rating advertisers on job sites might be a way to reduce these issues by crowdsourcing reputation. (Bowler, 2014) describe the <https://collaborate.org/home> website which is a platform integrating various data sources. This integration gives the data as a whole greater value than the constituent parts. (Digital Agenda, 2017) outline examples of technology used by smugglers who use WhatsApp and similar messaging apps. Salesforce apps are being used against them. Stop The Traffick (<https://www.stophetraffik.org/>), an NGO, targets Facebook adverts geographically at likely victims in order to stop them being trafficked again. 40% that escape are vulnerable to re-trafficking. (Myres, 2017) describes the use of technology by perpetrators to move faster than the response, but also the potential use of technology to gather data which can be used to identify patterns of human trafficking. For example truckers call a hotline to report advertising of sex adverts, this can be combined with other information to make trafficking unprofitable for perpetrators.

(Latonero, 2011) focusses on online classified sites. Although the focus is on trafficking, and not supply chains it is likely that some of the communication in the informal supply chain takes place online, including advertising. This report did not find this to be the case however suggesting that the context of this form of trafficking leads to much of it being done face to face with people known to the victims. Despite this some examples in the US were discovered (using a seized GPS to find victims of the sex trade and using MySpace content to prove grooming had taken place). Such advertising sites have been used to entrap perpetrators, by advertising services likely to encourage contact. In terms of labour trafficking this report suggests that due to its clandestine nature advert are obfuscated and that it may be hard to web mine for these adverts. However it may be that there are language signals that can be exploited. The use of Twitter for detecting sex trade is explored using a dictionary approach. A decision support system is described that uses semi-automated processing, the inclusion of human judgement being viewed as important in these sorts of cases. NLP, facial recognition and mapping were mentioned as key enabling technologies. Information sharing, crowdsourcing and flagging and education via mobile phones were also suggested as avenues for future research. (Latonero, et al., 2012) describe the rise of the use of mobile phones and smart phones and how they might be used by traffickers. Refugees making their way to Europe use technology such as GPS, mapping and social network to ease their passage (Latonero & Kift, 2018). The same technologies can be used for surveillance of such populations.

It would be possible to build corpora of survivor narratives of contemporary slavery by mining the web. Existing narratives might be used to "bootstrap" this detection process via language models. As a contributing approach to this typical slavery survivor language could be collected. A similar approach has been successful in collecting spatial language by (Stock, et al., 2013). A corpus such as this may be a suitable source for key words and phrases that allow the web to be mined via a search engine.

It would be possible to web mining content related to modern slavery activities. For example referring to our general model in Figure 1 We can see that communication takes place in several relationships between actors in a modern slavery context. Firstly communication between directly between perpetrators of modern slavery in order to organise their activities. These may be hidden by encryption and direct contact (not

publically available) or may be in the open). Survivor blogs are designed to publicise the plight of modern slaves so are likely to be public. They are somewhat sanitised in content and may have been written to appeal to an audience rather than to contain actual specific examples. Slaves may issue calls for help, in the physical world garment worker found that sewing messages into the clothing products they were producing was effective as a call for help to the outside world. Similar messages may be issued on line. There may be secondary evidence such as people living in poverty.

Various methods have been used to extract extremist content (Agarwal & Sureka, 2015), radicalisation content (Agarwal & Sureka, 2015), terror related content (Johansson, Kaati, & Sahlgren, 2016) (Pelzer, 2018) (Elovici, Kandel, Last, Shapira, & Zaafrany, 2004), violent content in Arabic social media (Abdelfatah, Terejanu, & Alhelbawy), events in social media (Gao, Wang, Padmanabhan, Yin, & Cao, 2018), novel content on dark webs (Kaati, Johansson, & Forsman, 2016).

The data collected could be used to create visualisation showing areas of high risk by using mapping and location aspects. Much social media content has location metadata. (Porto de Albuquerque, Herfort, Brenning, & Zipf, 2015) describe how social media often uses location and that this information can be used to aggregate social media posts via Big Data to use in conditions of natural disaster where information is scarce but the need for it great. One major problem with this approach is the small number of relevant posts compared to posts in general. They develop a method that combines authoritative data with social media data, for example using knowledge about the known location of floods to test the relevance of Twitter messages. There would seem to be opportunities to use this approach to guide the search for modern slavery using data from supply chains.

Within these areas research questions need to be answered. For example in the case of extremism detection the relevant content is characterised by "signal signals" (Johansson, Kaati, & Sahlgren, 2016). We have suggested that a language model can be built for each type of modern slavery. However it may be that the language is not sufficiently uniform. Another issue is lack of content, it may be that access to mobile phones and the web would also vary. In the brick belt it may be that phones are shared or are even not available, whereas in the sex trade they are probably a prerequisite to business and used for communication to clients and for pimps to control their workers. It is highly likely that the context and types of communication detectable vary per type of Modern Slavery.

One serious issue with these methods is the likelihood that supply chain management will not be mentioned in content about modern slavery or the poor conditions that exist at the bottom of the supply chain. Rather any content will be disconnected from the second and first tier suppliers and from the focus organisation. This implies that the context of each type of MS is needed in order to connect it to likely areas of commerce, and that any language model and geographic context used would need to be specific to that supply chain instance.

CONCLUSION

We suggest new ways to detect modern slavery that result from a cross disciplinary view of web mining technology and efforts to publicise modern slavery cases. We start to explore this aspect of digitising the supply chain.

Modern Slavery, digitization and actionable data are current issues. Future work would focus on adaption of the methods, identification of "bootstrap" data, and verification against known cases.

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REVERSE FACTORING ADOPTION AN EXPLANATORY STUDY IN THE EUROZONE CONTEXT

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ABSTRACT

Companies have developed Supply Chain Finance (SCF) programs in order to improve cash generation and working capital management. These strategies aim to integrate operational and financial flows within the supply chain management (SCM) in order to optimize costs and contribute to financial performance of the firms.

The purpose of this research is to propose a model to focus on the understanding of the effects of the reverse factoring as a SCF solution on the firm financial performance. We propose a quantitative approach to investigate first its effects on the cash generation and second its relationship with the cost of capital including a medium term time horizon for Eurozone companies.

Keywords

Supply Chain Finance; Reverse Factoring; Financial performance; Cost of capital

INTRODUCTION

The liquidity scarcity has encouraged companies to develop strategies for cash management as a way to increase liquidity (de Goeij and Onstein 2016). In this new context, Supply Chain Finance (SCF) programs have been developed and defined by More & Basu, (2013) (in Huff and Rogers, 2015) as "managing, planning, and controlling all the transaction activities and processes related to the flow of cash among [supply chain] stakeholders in order to improve their working capital". Traditionally, Supply Chain Management (SCM) has focused on the management of physical flows and information flows between partners across the entire supply chain. However, SCM is applied in today's business world to improve cash generation.

SCF programs aim to integrate operational and financial flows within the SCM. Their goal is to optimize the asset management of all supply chain members by reducing management costs and seeking to contribute to financial performance. This has a specific relevance in a context with a constant pressure from customers for longer credits windows, which implies the search of new financing solution when the availability of credit is limited (Protopappa - Sieke and Seifert, 2016). As a matter of fact, a better visibility of cash and product flows enhance working capital utilization and reduce working capital requirements (Protopappa - Sieke and Seifert, 2016). Moreover, New businesses' opportunities might occur thank to SCF program by allowing supply chain financing solution to better working capital collaboration (Randal and Farris, 2009).

According to Pfohl and Gomm (2009), a common ground for the contributions in the literature is the focus on the financial impact of SCM upon the value chain in terms of inventory, process, and cash management or by means of synchronization and collaboration. These variables affect the free cash flow of each company involved by increased sales or decreased costs, as well as the cost of capital by reducing assets (Pfohl and Gomm, 2009). Nevertheless, the explicit consideration of the influence of SCM measures on the capital cost rate has been lacking so far (Pfohl and Gomm 2009).

Reverse factoring is the most widely used SCF solution. In many countries, experts observe an increase in payment delays despite Europe's long-standing desire to regulate payment lead times for trade transactions (European Directive 2000/35 of June, 29th 2000). The tightening of the conditions leaves companies with a reduced access of access to bank credit to finance their working capital requirement. Companies must seek new solutions to obtain cash without risk. Among the existing solutions, reverse factoring is appearing as an innovative financial solution that combines operations security, simplicity and flexibility of use (Mazars, 2012).

Surveys indicate that the evolution of reverse factoring lies mainly in the technological improvement that makes possible to: provide capital to a higher number of suppliers at a lower rate, increase transparency and flexibility, and involve new players – such as logistics service providers (Gelsomino et al, 2016). However, this perspective is taken into account in only a limited number of articles although it is quite well established among practitioners (Gelsomino et al, 2016).

This paper aims to understand the effect of SCF programs on the firm performance. Proposing a research design, we aim to investigate on the impact of reverse factoring implementation and the efficiency of such corporate strategy through the potential rewards on the cost of capital. We target eurozone firms that developed this solution and disclose about this alternative financing source: Do firms manage to better the organization with the combination of such action?

The paper is organized as follow: The first section discusses the literature on SCF programs and the measure of its impact on firms' performance. The second section proposes a methodology design. The final section is a conclusion to the current research proposal.

LITERATURE REVIEW

Supply Chain Finance: enhancing and improving cash within the supply chain

The academic community has begun to focus on the SCF with pioneers studies from Christopher and Ryals (1999) and Lambert and Pohlen (2011). They highlighted explicitly how the SCM aims to increase the profitability of the supply chain partners and consequently improve company's financial value. SCM allows for common goals, resulting in reduced conflict and increased efficiency and alignment of the strategic and operational goals (Pohlen et Godsby, 2003). Recently, Gelsomino et al. (2016) conducted a literature review to classify the research on SCF using 119 papers published from 2010 and 2014 in peer-reviewed journals and in the proceeding of international conferences. There results emphasize two major perspectives: the "finance oriented" and the "supply chain oriented".

The first perspective considers SCF as a set of short-term financial solutions mainly from buyer-driven perspective and including financial institutions or lenders as crucial partners. Thus, Lamoureux and Evans (2011) define SCF as *"a combination of technology solutions and financial services that closely connect global value chain anchors, suppliers, financial institutions and, frequently, technology service providers. They are designed to improve the effectiveness of financial supply chains by preventing detrimental cost shifting and by improving the visibility, availability, delivery, and cost of cash for all global value chain participants"*. In this definition, the authors pay interest to payables and receivables but not to inventories (Gelsomino et al., 2016). The definition of Chen and Hu (2011) is closer but underlines the capital constraints that justify the importance of SCF *"as an innovative financial solution, bridges the bank and capital-constrained firms in the supply chain, reduces the mismatch risk of supply and demand in the financial flow, and creates value for supply chain with capital constraints"*. The finance-oriented perspective could also be called a "buyer-driven" one as it refers to a set of buyer driven financial solutions (Gelsomino et al., 2016). This buyer driven payables solutions focus mainly on one SCF instrument: revere factoring.

The second perspective is the « supply chain perspective » that extends the framework of working capital optimization to include inventories" (Gelsomino et al., 2016). It considers that the working capital optimization could be achieved in the absence of specific financial solution provided by a lender (Gelsomino et al., 2016). Chritopher and Ryals (1999), Lambert and Pohlen (2001) use the term of value creation to underline the role of SCM in enhancing and improving cash. They highlighted the drivers of value creation in SCM that are directly and indirectly affected by SCM:

- Revenue growth: SCM can have a critical impact on sales volume, customer retention and loyalty, and new product development
- Reducing operational costs: by improving the quality of the supply chain relationships, which allows for the compression of time in the supply chain and thus the improvement of customer service and the reduction or elimination of non-value added activities
- Equity efficiency: by rationalizing investments in assets and distribution networks, which are substantial and can weaken the return on investment. Hence, the development of practices such as outsourcing to reduce investments in fixed assets
- Working capital efficiency: the WCR can be reduced by reducing lead times and inventories in the supply chain and, consequently, reducing the cash to cash cycle time.

However, as a general trend, the articles that take this perspective tend to provide holistic analyses of the SCF approach, without describing any specific solutions or practices (Gelsomino et al., 2016).

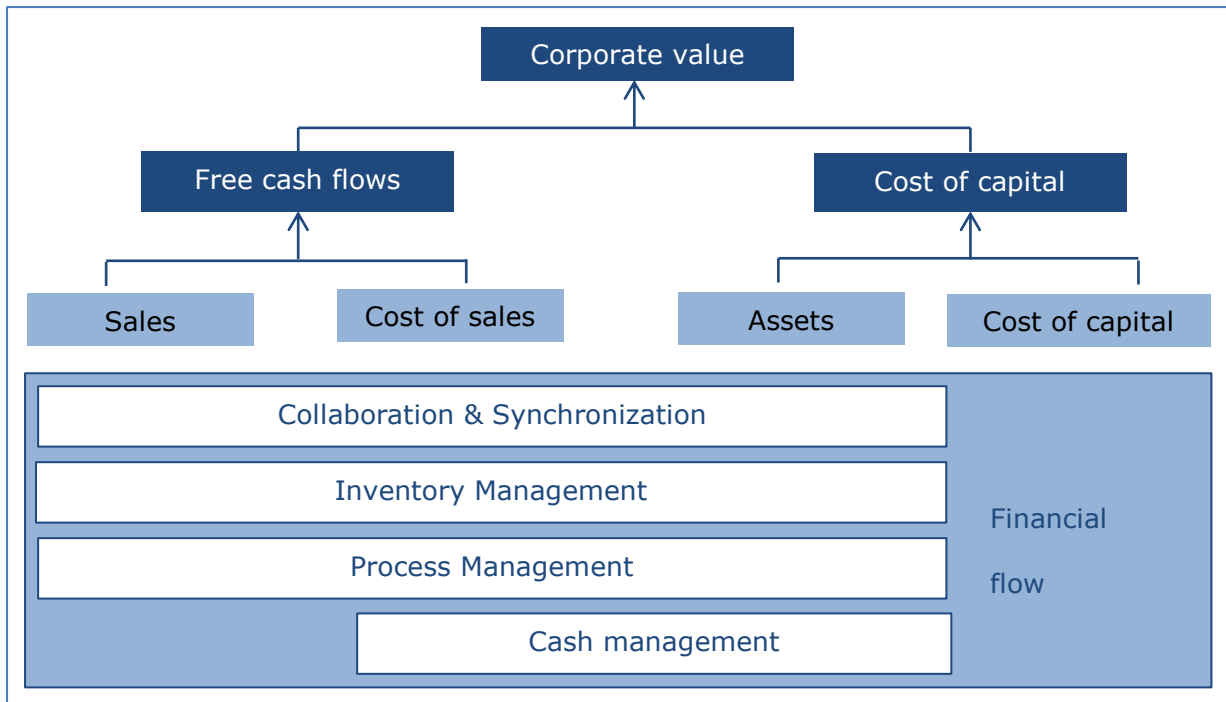


Figure 1: The influence of SCM on the corporate value
Adapted from Pfohl and Gomm (2009)

Reverse factoring: a new alternative to fund payables

The tensions that result from the deterioration of the economic environment encourage the buyer to look for measures to improve their cash flows. Extending suppliers payment terms is one example of these measures (de Goeij and Onstein 2016). This temptation is growing but is legally inapplicable in some European countries (see LME in France), is risky for the supplier and can weaken the entire supply chain. In this context, reverse factoring has a particular interest. It can be seen as a specific form of a more general SCF concept, although some authors, particularly in the trade and commercial press, use the terms interchangeably (Dello Iacono and al. 2014). Reverse factoring is an arrangement between a buyer, its supplier and a financial institution. The latter offers a supplier credit for the period of the payment term against the credit rating of the buyer as explained in the figure 2.

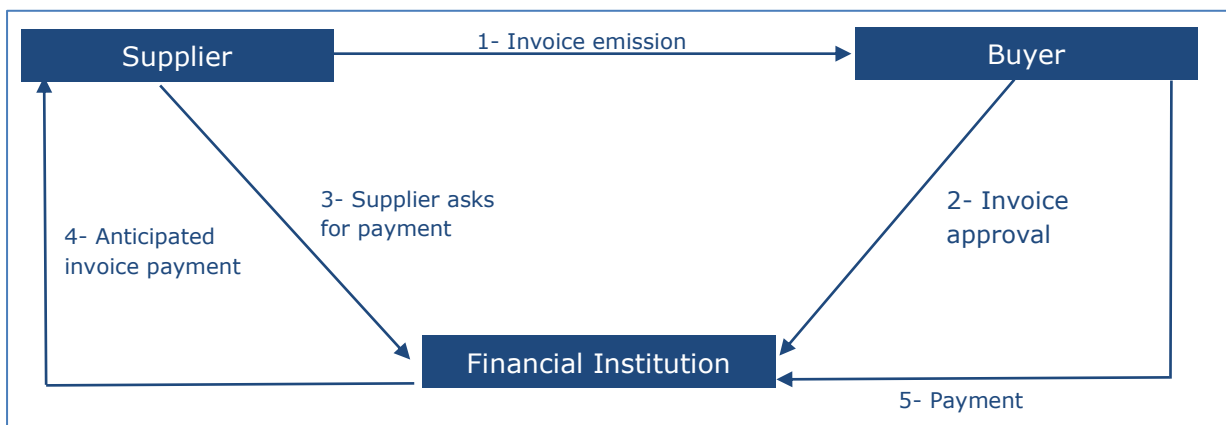


Figure 2: Explanation of reverse factoring

The challenge of Collaborative Reverse Factoring, when it is considered as a collaborative arrangement, is to provide suppliers with access to advantageous early payment terms. This allows the buyer, if necessary, to negotiate upwards its payment deadlines without

impact on the working capital of its suppliers and in all cases to secure its supplies from suppliers who accept the arrangement. Recent technological advances allow reverse factoring to be offered efficiently (Hurtrez and Salvadori, 2010). The arrangement is thus similar to traditional factoring, but it is reversed in the sense that the buyer, not the supplier, takes the initiative toward the financial institution (Dello Iacono et al., 2014). Thus, reverse factoring aims to reconcile working capital optimization and to secure the suppliers in a collaborative approach. According to a survey among executives, Seifert and Seifert (2011) find that buyers managed to reduce net working capital by 13 percent on average through reverse factoring. Despite this attractiveness of reverse factoring, it has not yet seen massive adoption in Europe (Mazars, 2012).

By studying the factors that influence the lifecycle and value of reverse factoring adoption, (Dello Iacono et al., 2014) identify the following market factors as key for direct benefits: competition, interest rates, receivables volumes, and firms’ working capital goals. The authors find that reverse factoring can yield direct benefits for all supply chain participants, but that these benefits are highly sensitive to market conditions. Thus, this reluctance in Europe could be explained by the absence of empirical evidence about under which conditions reverse factoring can succeed: How to evaluate the impact of reverse factoring on firm financial performance? This leads us to question the effect of a reverse factoring program on the cost of capital and to propose the methodology design as follows.

METHODOLOGY

Identify the impact of Reverse factoring on the cash flows

Cost of capital (CC) is a multiple of the Weight average cost of capital (WACC) and the total Capital employed (CE). CC is considered as a relevant item to appreciate value creation process within the firm. Regarding its contribution to Economic value added as a measure of value creation, and thus financial performance.

CE is balanced with the net investment of the firm that includes the working capital requirement (WCR). WCR comprises all current assets items as current liabilities items. Knowing that reverse factoring affects mainly suppliers’ payables and inventories, we aimed to link its effects in term of variation over the total CE and thus CC. According to Pfohl and Gomm (2009), the task of SCF is to save capital cost thank to better mutual adjustments or with new financing solutions within the SCM such as reverse factoring.

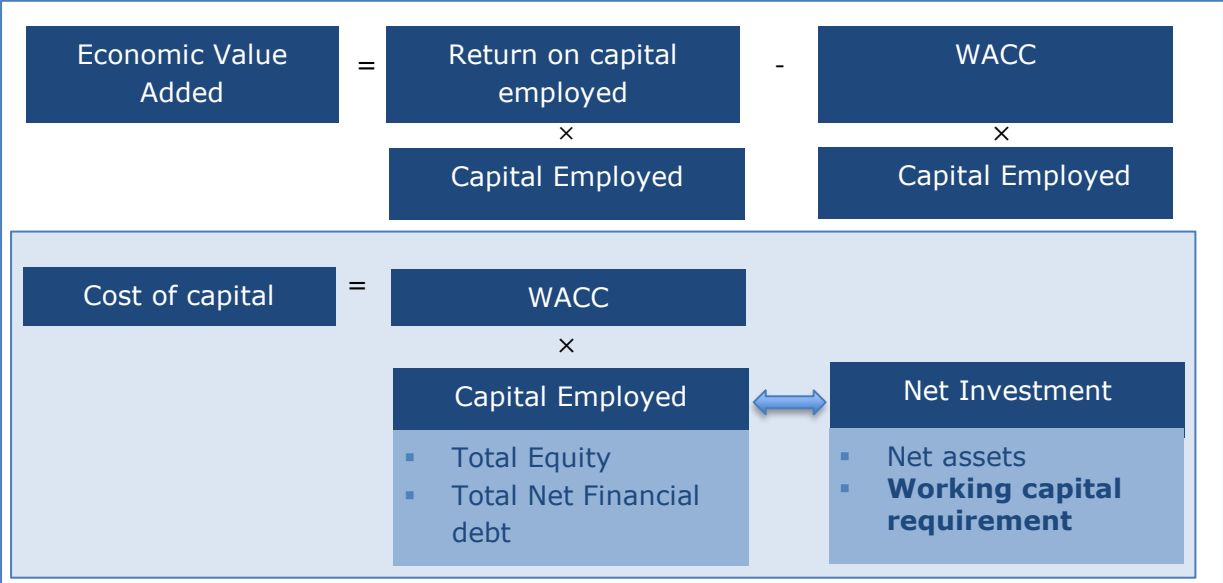


Figure 3: Cost of capital and EVA
Adapted from Pfohl and Gomm (2009)

The research design proposed in this research paper aims to highlight the effect of a reverse factoring program implementation on the firm performance: How to evaluate the impact of reverse factoring on firm financial performance? In other words, does reverse factoring contribute to better financial cash flows and thus value creation for the firm by its impact on the cost of capital? First of all, before to understand the effect of SCF program on the firm performance, we have to identify when the program is effective. The implementation of a reverse factoring solution in SCM doesn't automatically imply a shift in working capital requirement.

The item, which suits to examine a clear shift in a corporate strategy with the introduction of a reverse factoring, is the cash conversion cycle (CCC). It is a key metric in order to have a dynamical approach of the working capital requirement and of the firm current payment strategy. It expresses the number of days that it takes for a company to convert resource inputs into cash flows. It is associated to a liquidity indicator.

It is computed as:

$$\begin{aligned} \text{CCC} &= \text{Average turnover period} \\ &+ \text{Period of receivable} \\ &- \text{Period of payable} \end{aligned}$$

Identify the impact of Reverse factoring on cost of capital

In order to investigate on the effect of reverse factoring implementation and the efficiency of such corporate strategy, we should observe a change in cash conversion cycle measure and thus identify when there is a shift between a traditional cash flow management and a SCF program when the firm disclose about such strategic decision.

We target Eurozone firms that developed this solution and disclose about this alternative financing source. We aim to collect data in order to build up a longitudinal study of the effect of reverse factoring on CCC and its component. Thus, the objective is to have a sample of data by using each firm annual reporting metrics and evaluating the impact of a new SCF program on the financial performance.

Reverse factoring might impact the inventory and the suppliers' payables and reduce the working capital requirement at a specific time $t = 0$. However, a specific change in SCM with the implementation of reverse factoring doesn't impact directly the firm performance. The effects might be spread in time due to adjustment of such corporate policy. It has been previously asserted that cash flows changes from a period generate performance changes for up to one year (Huff and Rogers, 2015). Predict the time horizon of the impact from reverse factoring is at stake. A change in strategy might impact firm future financial performance. This lag in time deserves consideration. This is why we will adopt a longitudinal analysis implement time series effects for 5 years after the introduction of the SCF program for each company of our sample, knowing that they did not introduce reverse factoring the same year.

Huff and Rogers (2015) highlights that cash flow management strategy is usually investigated through financial metrics as the asset turnover (AT) the return on asset (ROA), the capital employed (CE) and the return on investment (ROI). These indicators combine to the working capital requirement as the CCC are the base of the comprehension of firm financial efficiency. The annual measures will be used in this research. Therefore, after collecting the static ratios complete why we have variation approaches as an estimation of the change in cash flows measures.

The following econometric analysis proposal attempts to determine whether financial items and SCF items have an effect on companies' cost of capital. Since data for each company are observed over a 5 years' period from the year $t=0$, with the implementation of reverse factoring, until $t=5$, thus 5 years after the change in SCM. The set of variables can be considered as a panel, which requires checking for individual effects, and then, if such

effects are proven to exist, to determine their form. They are of financial but also of SCF character. In addition, it seems consistent to create indicative variables for each year, to detect potential time variations in the change of cost of capital. An initial comprehensive model with an extended set of variables, including individual effects in the form of constants, might enable identification of those that are definitely insignificant, and then allow restricting the initial model.

To conclude, the initial model we aim to test explores the relationship between changes in SCF policy measures and changes in the firm performance through the cost of capital.

Our model thus is defined as:

$$\Delta CC_{it} = \alpha_i CS_i + \beta_t TS_t + \sum_{k=1}^{k=K_1} \gamma_k X_{itk} + \sum_{j=1}^{j=J_1} \delta_j Y_{itj} + \varepsilon_{it}$$

- ΔCC_{it} is the change of the cost of capital for firm i year t
- CS_i , constant specific to company i
- TS_t , the binary variable taking the value 1 for year t, 0 otherwise
- X_{itk} , is the change of financial variable k reported by company i, year t, where K_1 is total number of financial variables taken into account such as:
 - ΔAT_{it} , the change in asset turnover for firm i year t
 - ROA_{it} , the return on asset for firm i year t
 - ΔCE_{it} , the change in capital employed for firm i year t
 - ROI_{it} , the return on investment for firm i year t
- ΔY_{itj} , is the change of SCF variable j reported for company i year t, where J_1 is total number of SCF variables taken into account such as:
 - ΔCCC_{it} , the change in cash conversion cycle of the firm I the year t

CONCLUSION

The issue of the research proposal is to understand if Eurozone firms have improved their financial performance through the implementation of reverse factoring in their SCM. Do they manage to fund the organization with the combination of such action?

Using a longitudinal sample, we aim to seek for a significant relationship between the cost of capital and the reverse factoring thank to its impact over working capital requirement. Our model attempts, including traditional financial items, to demonstrate the impact of Reverse factoring program on the ability of the firm to create value.

Moreover, we consider a potential effect spread in time in order to explain that firms should not expect direct results within a short-term financial gain linked with such corporate policy. Overall, we aim to explain that SCF might generate sustainable financial rewards through reverse factoring and thus, potentially impacts operational and financial decisions within the firms.

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Session 2: Supply Chain Design and Planning

NETWORK RESILIENCE MODELLING: A NEW ZEALAND FORESTRY CASE

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Abstract

Purpose of this paper:

Extended global supply chains are vulnerable to spatially disparate risks. The interconnected and inter-dependency of modern logistical networks means natural disasters can impact a wide range of supply chain actors. Thus highlighting the importance of evaluating network reliance and, if necessary, developing contingency plans to mitigate supply chain disruptions. The objective of this research is to develop a modelling approach to evaluate network resilience. Thus when applied to a specific sector/ product it can be used as a decision support system (DSS) to aid practitioners to identify vulnerabilities and develop contingency plans.

Design/methodology/approach:

The research models the New Zealand's log export logistical network. An innovative two tier modelling approach is developed. Firstly the aggregate national flows are optimised via linear programming thus leading to the identification of regional flows to specific ports. The closure of each port and associated re-routing of logs is then modelled to identify the impact of closing these key export nodes. The validity of the national model is then verified by regional discrete event simulation modelling that assess the process capabilities throughout the logistical network.

Findings:

Exogenous, infrastructural, capacity and transportation risks in a supply chain are all interrelated, which amplify their impact on the affected logistical network. The undesired effect of the disruption events can be reduced using the DSS as it develops recommendations to increase the reliability and resilience of supply chains under multiple disruption scenarios.

Value:

The use of a two-tiered analytical approach enhances validity as each level's limitations and assumptions are reduced when combined with one another in a single DSS.

Research limitations:

The two-tier modelling approach has only been applied to New Zealand's log export supply chains, so needs further applications to insure validity. The limitations in the proposed DSS stems from the inherent nature of the analytical tools used. Even though, the use of linear programming and discrete event simulation allowed the DSS to capture more details of the logistical network, it is inevitable to make some assumptions about the real world.

Practical implications:

A number of specific recommendations can be made based on the application of the DSS. These include increasing the capacity of Napier port as contingency for closures at many of the nation's other ports. New Plymouth is identified as a key vulnerability in the network that policy makers need to prioritise.

INTRODUCTION

The global characteristic of today's market raise concerns regarding the compatibility between the different nodes within a supply chain. Political, economic, infrastructural, cultural and other risks should be considered when operating globally. Tsunamis, strikes, hurricanes, bio security threats and wars and their impact on the logistical networks are all examples of major events that might happen in a certain place and affect other supply chain members in other parts of the world. The labour strike in October 2002 lead to shutting down 29 ports in America's west coast (Wilson,2007). In 2011 Toyota's production capacity dropped by 40,000 vehicles due to Japan's tsunami and the consequent nuclear crisis (Pettit, Croxton, & Fiksel, 2013). Computer manufacturers and Japanese car manufactures' supply chains were disrupted by the Thailand flooding in 2011 (Chopra & Sodhi, 2014). These events and their disastrous consequences show the importance of having a contingency plan for such events to minimize their effect on the companies' supply chains.

Even though complex supply chains' risks and vulnerabilities were widely addressed in the literature, there is not enough empirical research and findings that practitioners can use to mitigate supply chain risks (Brandon-Jones et al., 2014). Furthermore, transportation risks are surprisingly one of the least addressed risk types in the literature (Ho et al., 2015). The literature provides a deep insight on the types of supply chain risks, risk assessment techniques, management strategies and some conceptual frameworks for risk mitigation. Decision Support Systems (DSS) are sought after to present solutions for problems in the supply chain from tactical to strategic level (Tako & Robinson, 2012). Researchers have used different modelling tools to simulate systems under different conditions to prepare these systems for the changes that might happen in their environments and accordingly improving their responsiveness and resilience. These modelling tools include linear programming (Santoso et al., 2005), fuzzy modelling (Petrovic et al., 1998), Discrete Event Simulation (DES) (Terzi & Cavalieri, 2004) and hybrid models (Umeda & Zhang, 2006). Some researchers focused on the aggregate level analysis (e.g. Meepetchdee & Shah, 2007; Cakravastia & Diawati, 1999; Towill, 1996), while other researches addressed the micro level analysis by isolating a certain part of the supply chain to be studied in depth (e.g. Legato & Mazza, 2001; Cheng & Duran, 2004). The integration of multiple tools in one decision support system will allow that system to capture both strategic and operational considerations in the decision-making process in order to produce more reliable recommendations.

Globalization had boosted the number of international trade transactions, as customers started comparing products and services offered by suppliers from all around the world. This trend had in turn increased the total number of vessels of different types by more than 7000 vessels during the period from 2011 to 2016 (Merchant, 2016). Consequently, marine traffic during the same period has witnessed a constant growth that is expected to continue in to the future (Huang et al, 2016). This trend had increased the importance of ports in any logistical network. New Zealand is a major exporter of logs in the global market (Scoop,2014), and it relies on its ports to deliver this product to its international customers. The forestry industry is a major contributor to New Zealand's economy provided more than 18000 jobs in 2014 (NZFOA, 2014). In 2013, New Zealand dominated more than 20% of the world's softwood log trade and became the world largest exporter of softwood log (Scoop,2014). The log industry is a large part of New Zealand's exports contributing by more 16 million m³ of logs in exports in 2014 (NZFOA, 2014). The disruption of this supply chain by a port closure might have catastrophic consequences on New Zealand's economy, which necessitates the creation of contingency plans for such events.

LITERATURE REVIEW

Supply chain risks are defined as the probability and the effect of any unforeseeable events and circumstances that might impair the performance of any part of the supply chain (Ho et

al., 2015). This comprehensive definition includes all types, supply chain disruptions happen when an event prevents the flow of material from following its normal path and arriving at its planned time (Sevensson, 2000). In other words, disruptions are the undesired results associated with supply chain risks. It might be small scale due to minor reasons such as machine breakdown or it might happen at a larger scale due to major events such as wars, unforeseen disasters, earthquakes, economy crises, strikes and biosecurity threats (Blackhurst *et al.*, 2005). These events in turn might lead to shutting down airports and ports and make the use of certain roads prohibitive. The costs associated with these disruptions are high and might have a long-lasting effect on business performance. For example, in 2000 Ericson announced that it lost 400 million Euros due to a disruption in its upstream supply chain, in which the material flow was disrupted by a fire in one of Philips semiconductor plants (Chopra & Sodhi, 2004). Land Rover had to let go 1,400 employees because one of its suppliers announced bankruptcy (Blackhurst *et al.*, 2005).

Supply chain risk is a well-established field of study with ample publications addressing different topics in this discipline. Supply chain risks identification, mitigation frameworks, quantitative and qualitative studies for risk mitigation are among the topics that captured the attention of academics and practitioners in the past three decades. However, some risks including transportation risks have not been addressed sufficiently in the literature (Manuj & Mentzer, 2008). Furthermore, there is a lack in empirical research addressing supply chain risks (Brandon-Jones *et al.* 2014). Ho *et al.* (2015) reviewed 226 articles on supply chain risk, of which only one paper addressed transportation risks and just six addressed macro risks. It can be concluded that there is consensus in the literature that transportation and macro risks still need to be researched more. This research will help bridging these research gaps by investigate the impact of macro risks and there ramification on logistical networks and develop a tool to mitigate the effects of this risk type. This research is an industry sector study, New Zealand's log's sector. More specifically, it is addressing transportation risks associated with log exports under different port closure scenarios. The objective of this research is to provide the building blocks of a tool that functions as a Decision Support System (DSS) to help practitioners in the log industry deciding their course of action in response to sudden major events that might disrupt their supply chains. The resulting decision support system and recommendations of this research aim at improving the resilience of the log supply chain in New Zealand and the logistical network in general. The research is a quantitative cross-sectional study, linear programing and simulation were the main analytical tools.

RESEARCH METHODOLOGY

A linear program was created to simulate New Zealand's logistical network under different port closure scenarios. The objective function of the linear program aimed at optimizing the allocation of logs harvested in different forests across the country to available ports in order to increase supply chain profitability. This model provides an aggregate view of the country's logistical network and identifies focal ports worthy of further investigation. The model findings were used as the starting point of the second part of the research, in which a certain region was selected and simulated using discrete event simulation to capture the fine details of that region's logistical network. Linear programing in conjunction with discrete event simulation and the theory of constraints were used as analytical tools in this research. Linear programing is an optimization tool used to find the minimum or maximum of an objective function (Bazaraa *et al.*, 2011). Discrete event simulation is a tool used to create models that simulate the changes that occur to a system over time, in which the system's status changes instantaneously at discrete and countable points of time (Law, 2006). Forest ownership in New Zealand is divided between international Timber Investment Management Organization's (TIMO's) and locals. Logs are exported from New Zealand via multiple ports. Tauranga port has the largest share of exports followed by Whangarei port

and then Auckland. China is the main customer of New Zealand's logs and New Zealand is competing with other global competitors for a larger share of this market. New Zealand's export log trade channel with china is the largest of its kind in the world, accounting for 13.3 million m³ of exports in 2014.

Scion was used as the main data source for this research in conjunction with other government data as well as export and forest description data. Scion is a specialized research institution in the forestry, wood product and other related industries. Scion is the leading crown research institute in several areas including forestry, bio security, risk management and mitigation ("About Scion", 2009) and is one of the largest forestry research institutes in the world. Accordingly, Scion is experienced in the field and is a credible source of information for the forestry industry. The data collected from the institute will be referred to as (Scion, 2016) or (Scion, 2017). Data collection was in two phases, the first phase relied on historical data concerning the average volumes handled by all the ports included in the study to get some insight on their capacities. This data was collected for the same period for all the ports. Logistical network capacities and distances travelled by trucks or trains to transport logs from the different districts in the country to each port along with the expected costs were gathered during the first phase of data collection. Interviews and road network data-bases were used as a collection method for this phase. In the second phase, the collected data was focused on the details of the activities taking place in different parts in the logistical network. The data was collected by interviewing experts from Scion, the national rail line Kiwi Rail, and other experts in the industry. Interviews covered: current status clarification; available options companies have during these events including routes followed; the costs and time delays associated with these options; details about the activities taking place on different parts of the logistical network and logistical network facilities' capacities.

MACRO ANALYSIS AND RESULTS

The capacity of each port was evaluated using historical data of the log export volume handled by each port per quarter during the period Jan-2010 to Jun-2016 obtained from the Ministry of Primary Industry (MPI). The maximum volume handled per quarter during any time of this period was multiplied by four and assumed to be 70% of the port maximum annual capacity (Scion, 2017). The log industry is a large part of the forestry industry, comprising more 16 million cubic meters of log in exports (New Zealand Forest Owners Association [NZFOA], 2017). The total planted area stocked for forests production is estimated at 1.72 million hectares as at 1 April 2015. The North Island is divided into five wood supply regions: Northland, Central North Island, East Coast, Hawke's Bay, and Southern North Island (MPI ,2017 b). The South Island is divided into four wood supply regions: Nelson/ Marlborough, West Coast, Otago/ South Island, and Canterbury (MPI ,2017 b). Regional yields of these areas in m³JAS were calculated. The volume used by local processing mills, the processing volumes was calculated using historical data. It was also assumed that the surplus quantity will be exported and that the international market demand can absorb these quantities. The objective of the linear program is to maximize the profit of the supply chain by redistributing the logs on the available ports in response to a port closure. The closure period was estimated to be one year (Scion, 2016). The model reallocates the quantities of logs to be exported through the available ports (Q_{ij}) during the closure period, while considering the port capacities, the shock in log price due to the port closure, harvesting cost, transport costs, and port costs. The model also considers the option of delaying the harvesting until the closed port reopens after one year. This option has an additional maintenance cost and additional revenue (due to the forest growth during the closure period) that the model takes into account.

Total cost = Transportation cost + Port and Harvesting costs + Waiting Cost

$$Cst = \sum_{i=1}^E \sum_{j=1}^n (\text{Min}[Ct_{Dij} \cdot Q_{ij} , \sum_{s=1}^k (Ct_{Fjs} \cdot Q_{ij}/S_{sj}) + \sum_{s=1}^k (Cr. RL_{si} /S_{sj} \cdot R_i)Q_{ij}]) + \sum_{i=1}^E \sum_{j=1}^n (Cp_i + Cv) \cdot Q_{ij} + \sum_{j=1}^n Cw_j$$

The total profit is a function of the log selling price, sold quantity minus total cost. The log price is highly volatile and New Zealand is the world's largest exporter of softwood's log, so an anticipated drop in supply from the largest exporter in the world would influence the selling price of logs. Accordingly, the price was assumed to increase in the case of port closure. This increase was proportional to the volume that was supposed to be exported through the port. This assumption was verified by some large exporters, while no evidence exists, anecdotally they agreed with this approach. Similarly, the price will not only restore, but may be lower after the affected port has reopened because excess logs (in waiting) may flood the market. The price drop after the port closure finishes was calculated proportionally to the waiting quantity that caused an excess in the supply. Consequently, three log prices were used; average price when all the ports are operational, price during port closure (higher than the average) and after port closure price (lower than average). Knowing that each scenario will have a certain Rp_i and Ip_i and that the objective function is to maximise the total profit then:

$$\text{Maximise } [P_{\text{ofit}} = \left\{ \begin{array}{ll} \sum_{j=1}^n (Rp_i \cdot Q_{ij}) + IR_j - Cst, & \forall i = \text{waiting} \\ \sum_{i=1}^E \sum_{j=1}^n (Ip_i \cdot Q_{ij}) - Cst, & \forall i \neq \text{waiting} \end{array} \right\} \forall Rp_i, Ip_i] \quad (24)$$

Port capacities constrain the model and the tradeoffs between the incurred costs when using the waiting option and the rerouting options along with their corresponding generated profit forms the optimal solution. The allocation of forests to the ports varies under different closure scenarios, prices and cost levels. For example, Gisborne district's forests are originally allocated to Gisborne port and when the port shuts down some of the logs are exported through Napier and Tauranga ports and the rest wait until the port is reopened. However, under the same closure scenario if the cost is increased or the price is decreased, it is noticed that the allocated quantities to the supporting ports after the closure decreases and the waiting quantity increases. The analysis of the behavior of each district will help forest owners in selecting their forest locations to make their supply chains more resilient and capable to cope with sudden port closures. The mitigation of the port closure impact is dependent on the closure scenario. For example, in the Gisborne port closure scenario it can be concluded that the port is well supported and the waiting quantity can be reduced by expanding the supporting ports that became fully utilized after the closer. In other cases, such as the New Plymouth or Nelson scenarios, expanding the capacities of other ports will not help reducing the impact. Even though each scenario has its own uniqueness, it is possible to find focal ports that can be used to improve the resilience of the whole network. Napier port is a good example because this port is almost fully utilized in three out of five port closure scenarios.

The key insights that can be drawn from this macro analysis are the relations between the different factors that affect the resilience of the logistical network. Each closure event forced the linear program to redistribute the forests on the available ports differently. The different ways that network responds to different closure scenarios provided some insight on the strategic importance of some ports. The effect of transportation costs and price changes on the viability of exporting sheds light on the significance of these factors on the resilience and profitability of the supply chain. These insights allow decision makers to see the most pressing needs that their logistical network requires.

MICRO ANALYSIS AND RESULTS

The simulation of regional logistical flows aims at analysing the details of the logistical network by taking into consideration more constraints than what the linear program to pin

point the weaknesses of the logistical network and to present more realistic solutions. The aim of this step is to consider the operational level constraints, that were not included in the linear program, and to provide a more holistic risk mitigation plan that includes both strategic and operational level insights. In this part of the analysis the iterative thinking process of TOC is employed to spot, investigate, and release bottlenecks. The proposed distribution of forests under certain closure scenario by the linear program provides a high-level solution that needs to be validated by considering the lower level constraints existing in the logistical network.

In 2016 during the time of this research a significant series of earthquakes struck Kaikoura and caused Wellington port to briefly suspend its operations. According to a survey conducted by Scion (2016), logs were rerouted to Napier port, which is consistent with the results of the linear program. However, because the closure was for a short period of time the rerouted quantities was not enough to fill Napier port and to spill over to New Plymouth port as the model predicted. The disruption caused by the earthquake revealed some of the dynamics of responding to Wellington port closure, but it was not severe enough to push the logistical network to its limits. The closure of Wellington port for a period of one year is analysed using the discrete event simulation software ExtendSim to identify the bottlenecks in the region's logistical network. To build a simulation model, the steps that a log goes through from harvesting until it is loaded on the ships was studied. This will help in identifying and including the right sequence of activities, the available capacities and the time needed to execute each activity.

Wellington port is shown in Figure 1 (a), where it services seven districts. After the port is closed these districts are either waiting until the port reopens or rerouted to Napier and New Plymouth ports. Figure 1 (b) shows how the linear program redistributed the forests to the other available ports, while considering every possible distribution to maximise profit. It is important to notice that some of the forests that were originally allocated to Napier port (which was not closed) were now reallocated to other ports in order to make capacity available that will maximise the overall profit. These forests will put pressure on other parts of the logistical network. The forests that are included in the simulation are the ones that were originally allocated to Wellington port and will be rerouted to other ports because of the closure. In addition to the forests that will be sharing the same facilities with the rerouted forests such as train sidings, trucks, port storage yard and other facilities and resources in the logistical network.

The results of the base scenario simulation showed that the total throughput of the logistical network will be 2.98 million m³-JAS of logs, which is less than 50% of the total allocation to Napier and New Plymouth ports after closing Wellington port. Most of the activities are underutilized and the highest utilization is for the train scaling and unloading at Napier Port (72%). Although this activity has the highest utilization, it remains underutilised, so the bottleneck is somewhere else in the supply chain. There are multiple ways to increase the discharge rate from New Plymouth port yard. In the first constraint, this was done by using all the available cranes of the log ships to increase the loading rate. However, after exploiting the second constraint the improved loading rate was insufficient to maintain the yard operating below capacity, which means the ship arrival rate had to be increased. Upsizing the yard at the same discharge rate will not solve the problem as the yard will reach its capacity at a later point in time after which the logistical network will be congested again. Increasing the ship arrival rate will increase the wharf utilization by log ships above 40%, which will affect the other ship types that need to use the wharf.

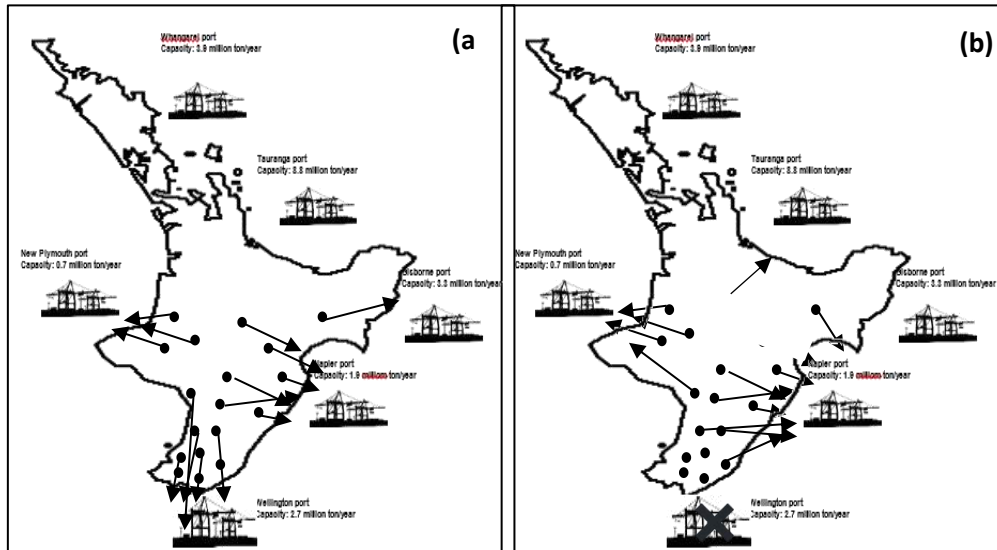


Figure 1. Forest Allocation Before and After Wellington Port Closure

Discussion

It was concluded that the exogenous risk that leads to a port closure might possibly force log exporters to reroute their logs to other ports, which in turn puts enormous pressure on the trains and trucks used in transporting the logs to more distant ports. Approaches used so far tended to focus on strategic or operational level analysis yet failed to capture both levels in their proposed decision support systems. Some researchers such as Meepetchdee and Shah (2007) work had succeeded in capturing the macro analysis of the logistical network, which is useful in making high level decisions. On the other hand, the work of other researchers like Legato and Mazza (2001) had provided an effective tool for analysing sections of the logistical network in depth, which can help decision-makers at the operational level. The methodology used in this research is a combination of both approaches that aims at encompassing both macro and micro level analysis. The approach adopted herein provides researchers with some guidance on the benefit of using multiple analytical tools in the same DSS. Each analytical tool has its own inherent weaknesses and strengths, for example, it is hard to capture the details and dynamics of a certain system in a linear program. On the other hand, although discrete event simulation models cannot provide global optimal solutions, system dynamic and details can be captured using these models. Using single analytical tool in a DSS highlights its weaknesses and therefore reduces the proposed DSS efficiency. Overall, integrating multiple analytical tools would help in eliminating the shortcomings of each tool when used independently.

This research addressed the strategic importance of some focal ports in New Zealand's logistical network, which would be of interest for policy makers. Napier port is a good example as it is almost fully utilized in three out of five closure scenarios. In other words, expanding this port will possibly improve the resilience of the network against three closure scenarios. In addition, Otago and Wellington ports are good examples of well-located ports that can reroute their loads, in case of a closure to the other ports while remaining more profitable than putting these loads on the hold, which makes studying the dynamics of their closure interesting. The forecasted significant increase in log exports during 2020-2025, will put pressure on New Zealand's logistical network. This pressure might cause congestions in the less efficient parts of the logistical network New Plymouth port reveals a remarkable weakness in the North Island's logistical network for two reasons.

Conclusion

It was concluded that exogenous risks, infrastructural risks, capacity risks and transportation risks in a supply chain are all interrelated, which amplify their impact on the affected logistical network. The findings of this research also showed that if the supply chains sharing resources are incompatible. then it will adversely affect the more efficient supply chain. Furthermore, the less efficient supply chain would not gain a significant improvement in its throughput from the access to more resources. This incompatibility will furtherly amplify the adverse effect of supply chain risks. Therefore, it is important to bring the supply chains intending to share resources to a similar level of efficiency to maximize the benefit of resource sharing and minimize the impact of supply chain risks. The undesired effect of the disruption events can be reduced using decision support systems. These decision support systems should be updated with (but not limited to) the status of the affected infrastructure, the capacity of different facilities along the logistical network, costs of different transportation modes used in the logistical network, pricing of the handled product(s) in the logistical network of interest, and the quantity of product(s) to be processed through the logistical network. Having such systems in place would help in minimizing the losses incurred by the supply chain members if a disruption event happens.

The use of an optimisation tool that optimises the performance of the overall logistical network in conjunction with another modelling tool that addresses the fine details of the logistical network allow the researcher to capture both the strategic and operational level analysis. The use of a two-tiered analytical approach provides more validity for the practicality of the proposed recommendations, when compared to researches conducted using a single tool that capture either the strategic or the operational level of analysis. The use of theory of constraints in the context of the extended supply chain is proved in this research to be effective. The integration of TOC approach had helped in identifying bottlenecks in the independent facilities of the supply chain that were hindering the supply chain from achieving its target throughput. It had also helped in discovering the interdependency between activities done in independent facilities in the supply chain. Researchers intending to use similar approaches should consider the compatibility of the tools being integrated to make sure that they would augment the resulting insights and recommendations. The selection of tools should be done carefully to ensure that the weaknesses of one tool are covered by the other tools to create a reliable DSS.

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THE OPTIMIZING OF FISHERY COMMODITIES DISTRIBUTION IN INDONESIA

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Abstract

Purpose of this paper: This paper is aimed at providing the illustration of research results in determining the most optimal distribution system of fishery commodities in Indonesia using a developed distribution model in this research.

Design/methodology/approach: The method used in this research was Linear Programming (LP) method with two assumptions, namely (1) Minimum / Least Cost Allocation and (2) Proportional Minimum / Least Cost Allocation. Design of distribution model used the approach of flow of goods from the producer areas as the origin locations to the consumer areas as the destination locations. In this research, the origin locations were defined as the potential regencies or cities as the fishery commodities producers while the destination locations were defined as the distribution centers (DCs) that distributed in Sumatera, Kalimantan, Sulawesi, Maluku and Papua islands. There were 15 DCs used in analysis.

Findings: The fish supply in each planned DC can be fully distributed to local consumers even though there are still deficit in total number. The result of research indicates that from 15 DCs there are 4 DCs with surplus of supply of fishery commodities. Otherwise there is 1 DC has no supply of fishery commodities or even deficit.

Value: The result of this research can be used as an initial indication for the related stakeholders to analyze the gap between the supply and demand of fishery commodities in Indonesia. Based on the research result it is very important for the related stakeholders in fishery sector development to re-adjust the plan of DC facility development of fishery commodities in Indonesia.

Research limitations/implications (if applicable): This research was limited in 15 DCs of fishery commodities which distributed only in 5 big islands in Indonesia and has not considered yet the existing condition of the transport infrastructure networks and the speed parameters in the developed distribution model. Therefore, the further research

might be extended in a wider area in Indonesia and need to consider other significant parameters that should be identified in order to strengthening the initial findings.

Practical implications (if applicable): This paper will contribute to the Ministry of Marine and Fisheries of Republic of Indonesia in formulating the policy recommendation of the Distribution Centre facility development and the integration of transportation system development for fish commodity in Indonesia. In addition, this research result will support the implementation of National Fish Logistics System as mandated under ministerial law.

INTRODUCTION

Fishery commodities have the characteristics that are easily damaged, therefore it creates supply chain uncertainty (Bellmann et al., 2016). In the case of Indonesia, there are inefficiencies in the distribution chain of fishery products and the lack of quality and quantity of logistics transportation infrastructure that leads to paradoxes where consumers pay more but producers do not also enjoy proportional benefits. Distribution of fishery products is concentrated in remote areas, but it is difficult to distribute due to the limited logistics infrastructure. Ministry of Maritime Affairs and Fisheries (MMAF) to develop fisheries product distribution center (DC) as a facility to consolidate the marine and fishery products that have not fully utilized to meet the needs of local and export markets.

The existence of DC requires supply from production sources. The supply is distributed by the source of production involving the functions of warehouse, inventory, and transportation (Farahani et al., 2012; Tsiakis and Papageorgiou, 2008). The purpose of the distribution is to ensure that products produced by producers are acceptable to consumers in a timely, precise quantity, precise quality and precise purpose (Chen, 2010; Simchi-Levi et al., 2003). The challenge faced in the distribution process is the limited resources of each supply chain entity (Tsiakis and Papageorgiou, 2008). Therefore it requires a robust distribution system approach. Robust distribution network planning is required to ensure that a product can be delivered optimally taking into account resource constraints (Qiu et al., 2018).

Indonesia is an archipelago-based country that is one of the largest sources of fishery production in the world, but now there is a gap in supply-demand fisheries. Therefore, distribution analysis is needed to support SKPT program. The optimization process is done using the location-allocation model to determine the most optimal location in commodity distribution process from the production area to consumption area. The purpose of this paper is to determine the most optimal distribution system with the most efficient distance-based approach from the origin location (fish production center) to the DCs location.

LITERATURE REVIEW

National Fish Logistics System

The embodiment of the logistics system in the context of marine and fisheries sector development is the National Fish Logistics System which is better known as SLIN. To strengthen the support in its implementation, the MMAF issued the Regulation of the Minister of Marine Affairs and Fisheries of the Republic of Indonesia Number 5 / Permen-KP / 2014 on National Fish Logistics System or SLIN. SLIN aims to: (a) increase the capacity and stabilization of national fisheries production and marketing systems; (b) strengthening and expanding connectivity between upstream production centers, downstream production and efficient marketing; and (c) improve the efficiency of supply chain management of fish, materials and production equipment, and information from upstream to downstream. Transportation is one of the essential components in SLIN, in addition to other components, namely: procurement, storage, and distribution. The SLIN operational model can be explained diagrammatically in the following figure.

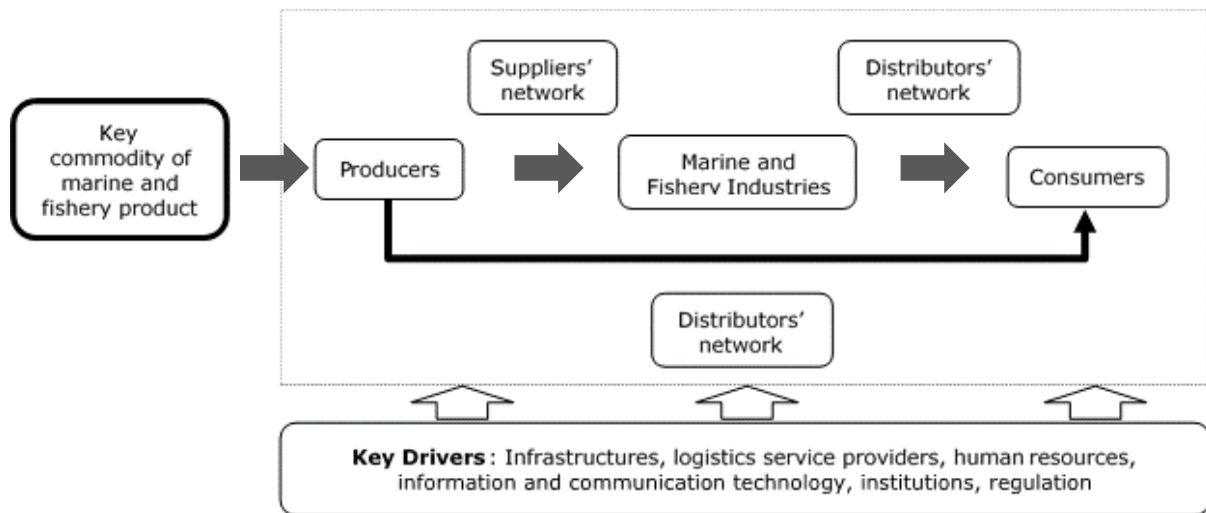


Figure 1 SLIN Operational Model

Based on Figure 1 it can be observed that transportation is an infrastructure component needed to carry out logistical activities, consisting of logistic nodes and logistics links that function to move goods from the origin to the destination point in the form of transportation networks in the land, sea and/or air dimensions as a whole system.

Supply Chain Network

Supply chain network optimization can be done through the optimization approach of the commodity supply-demand pattern. The pattern of supply-demand commodities describes the pattern of movement of commodities from the place of origin to the destination. Place of origin is defined as (a) the origin of the commodity is transported; or (b) the location of the commodity producer, whereas the destination is defined as (a) the port of destination for the delivery of the commodity; or (b) the final shipment location of the commodity or the final distribution node (Coyle et al., 2010; Rodrigue et al., 2009).

METHODOLOGY

Research Framework

The operation of DC will depend on the readiness of the supply of fishery commodities produced from the producer areas around the DC facility. A DC holds the role of aggregate function and commodity distributive function. To optimize the distribution system run by SKPT, information on the demand for supply in consumption centers and the availability of network and distribution services, in this case, is the network of services and network of modes of transportation, is needed. This distribution analysis is needed to support the effectiveness and efficiency of the flow of fishery commodities to meet the domestic purpose as well as the export needs.

Operational Model

For analysis of this fishery distribution system, the operational model is needed to assist in the analysis process as illustrated in the following figure.

Method

The method used in this study is the Linear Programming (LP) method which aims to determine the most optimal distribution system with the most efficient distance-based approach from the origin location (fish and marine production center) to several destinations, in this case, the DC development site. This optimization effort (maximum or minimum) is referred to as the objective function (objective function) of the linear programming. This purpose function consists of decision variables, while these constraints are formulated in constrains function, consisting of decision variables using limited resources, in this case using distance (Perdana and Soemardjito, 2015).

1. *Minimum / Least Cost Allocation.*

In this model, the allocation of fish commodities based on closest distance parameters with the assumption of having the lowest cost will get the maximum allocation based on demand, but the model does not consider the equity allocation factor.

2. *Proportional Minimum / Least Cost Allocation*

This method is a modification of the Least Cost Allocation, but its allocation considers all shipping destination locations to be allotted. The idea is that all delivery destinations will get a quota but will only get supply in accordance with the proportional demand and distance (cost) despite the lack of supply. The greater the demand for the area will get a larger quota, but the greater the mileage then it will get a smaller quota. The intended quota is given by the formula as follows:

$$D_i^* = S_i \frac{D_i/d_{ji}}{\sum_{i=1}^n D_i/d_{ji}}$$

With:

D_i = the actual demand of districts/cities i

S_i = supply of districts/cities i

D_i^* = demand that will be met districts i

d_{ji} = Distance of a location districts j that has a supply to districts i which has a specific demand

Results

Based on the developed model, the description of supply-demand of fishery commodities in each DC development location is presented in Table 1.

Table 1. The result of fishery supply-demand modeling according to DC location

No	Districts/Cities	Production (Ton)	Consumption (Ton)	Balance (Ton)	Supply (Ton)	%
SKPT Simeleu						
1	Kota Subulussalam	68	2.199	-2.087	674,14	100%
SKPT Mentawai						
1	Kota Padang	28.949	25.541	-592	3.155,43	100%
2	Kota Solok	205	1.508	-1.263	1.352,61	83%
3	Kota Sawah Lunto	235	1.137	-878	877,85	98%
4	Kota Bukittinggi	437	3.195	-2.758	302,76	10%
SKPT Natuna						
1	Kab. Landak	637	4.746	-4.109	4.108,62	13,10%
2	Kab. Sanggau	2,9	4.978	-2.078	2.078,10	6,80%
3	Kab. Sekadau	786	2.014	-1.249	1.248,55	4,90%
4	Kota Tanjung Pinang	6.278	10.723	-4.445	4.445,41	14,20%
5	Kab. Sintang	2.063	4.738	-2.654	2.654,48	8,50%
6	Kab. Kep. Meranti	1.881	6.667	-4.787	4.786,31	15,30%
7	Kab. Lamandau	2.723	2.356	332	137,18	0,40%
8	Kab. Sintang	3.991	17.577	-13.925	13.925,39	38,30%
SKPT Kota Neso						
1	Kota Kupang	8.832	10.043	-1.211	1.211,26	0,90%
2	Kab. Timor Tengah Selatan	852	4.143	-3.292	3.291,07	2,50%
3	Kab. Timor Tengah Utara	522	2.207	-1.686	1.685,55	1,30%
4	Kab. Nagekeo	1.257	2.534	-1.277	1.277,13	1,00%
5	Kab. Manggarai Barat	1.335	5.472	-4.137	4.137,32	3,20%
6	Kota Bima	2.902	4.554	-1.652	1.651,58	1,30%
7	Kab. Gowa	1.052	22.391	-21.344	21.339,63	9,90%
8	Kota Makassar	14,6	58.879	-41.279	41.278,60	31,60%
9	Kab. Soppeng	222	8.629	-8.407	8.407,03	3,50%
10	Kota Mataram	2.156	11.192	-9.764	9.763,82	7,50%
11	Kota Pare-Pare	4.413	5.623	-1.211	1.209,88	1,00%
12	Kab. Siderning Rappang	906	13.872	-12.967	12.966,73	9,90%
13	Kab. Enrekang	859	6.964	-6.105	6.105,17	4,70%
14	Kab. Buta	5.608	6.337	-729	728,67	0,90%
15	Kab. Tana Toraja	935	5,15	-4.215	4.214,74	3,20%
16	Kab. Tabanan	6.724	6.754	-30	29,92	0,00%
17	Kab. Toraja Utara	1.769	4.796	-3.027	3.026,87	2,30%
18	Kab. Majene	7.153	8.963	-1.811	1.810,56	1,40%
19	Kab. Mamasa	2.141	4,32	-2.179	2.179,05	1,70%
20	Kab. Bontomatene	2.185	13,127	-10.942	4.351,10	3,30%
SKPT Numukan						
1	Kab. Malinau	689	2.272	-1.583	1.583,19	0,70%
2	Kab. Kota Timor	9.834	11,139	-1.299	1.299,88	0,90%
3	Kab. Kutai Barat	1.555	5.472	-3.967	3.966,87	1,70%
4	Kota Samarinda	8.653	23.518	-14.865	14.864,61	6,30%
5	Kab. Kutai Negeri	1.716	2.643	-926	926,46	0,40%
6	Kota Balikpapan	9.729	19.526	-9.777	9.776,94	4,10%
7	Kota Palu	2.025	15,73	-13.125	13.124,94	5,90%
8	Kab. Gunung Mas	1.628	4.803	-3.175	3.174,90	1,30%
9	Kab. Sintang	2.083	4.738	-2.654	2.654,48	1,10%
10	Kab. Bario Timor	1.886	4.423	-2.757	2.756,98	1,20%
11	Kab. Mamuju Utara	5.962	7.061	-1.119	1.119,24	0,50%
12	Kab. Sigi	33	5.432	-5.399	5.399,38	2,30%
13	Kab. Balangan	312	4.653	-4.341	4.340,85	1,80%
14	Kab. Hulu Sungai Tengah	4.578	10.732	-6.155	6.154,89	2,80%
15	Kab. Sekeloa	786	3.014	-2.249	2.248,55	0,80%
16	Kab. Tayan	3.688	7.459	-3.761	3.761,20	1,60%
17	Kab. Sanggau	2,9	4.978	-2.078	2.078,10	0,90%
18	Kab. Mamasa	2.141	4,32	-2.179	2.179,05	0,90%
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23	Kab. Lamandau	2.723	2.356	332	137,18	0,10%
24	Kab. Enrekang	859	6.964	-6.105	6.105,17	2,00%
25	Kota Moba	827	5.226	-4.399	4.398,56	1,90%
26	Kab. Siderning Rappang	906	13,872	-12.967	12.966,73	5,30%
27	Kota Manado	20.414	22.688	-2.274	2.273,69	1,80%
28	Kota Pare-Pare	4.413	5.623	-1.211	1.209,88	0,50%
29	Kab. Soppeng	222	8.629	-8.407	8.407,03	3,50%
30	Kab. Enrekang	859	6.964	-6.105	6.105,17	4,60%
31	Kab. Makassar	14,6	58.879	-41.279	41.278,60	17,40%
32	Kab. Gowa	1.052	22.391	-21.344	21.339,63	9,90%
33	Kab. Mamassan	26,147	38,742	-12,595	12,595,00	5,30%

The modeling result in Table 1 indicates that the DCs with surplus of product will supply the fish to the nearest areas (districts/cities) that are deficit proportionally to their needs. For example, the amount of surplus production in DC located in Simeleu City will be distributed entirely to Subulussalam City, although the surplus value is not sufficient in Subulussalam City. Another example is the DC in Mentawai City which has a surplus value of 3,135.43 tons that will be distributed to DC in Padang City of 592 tons (19%), City of Solok 1,363 tons (43%), Lebak City of 878 tons (28%) and City of Bukittinggi 303 tons (10%). This approach also applies to other DCs. Meanwhile, There is a DC namely Sarmi that experienced deficits of fish because the fish supply from areas around Sarmi have been distributed to other DCs.

Discussion

The result of model indicates an optimum distribution of fishery commodities based on the most efficient distance. The result could be as an input for improving the transportation network design, because not all the DC locations are supported by the transportation network like ports or even have no links or access from producer areas to the DC location or from DC to consumer areas. The process of transporting commodities from origin and destination locations may use a multimodal approach (SteadieSeifi et al., 2014). The distribution process of fish from producer areas to the location of a DC facility or from the DC to the consumers may use more than one of transportation modes. In the context of the effectiveness of inter-island commodity movements, sea and air transportation modes play an important role. Air transportation mode can be the primary mode choice due to: (a) the absence of accessible sea transportation mode services from the DC location to consumer areas, (b) the efficiency of the distribution process by considering the travel time, (c) the characteristics of perishable fishery products. This paper contributes to policymakers such as the MMAF in formulating the policy to improve transportation network to support the supply and demand of fishery products. Besides, the MMAF also needs to consider in determining the location of DCs in order to support the development of effective and efficient fishery logistics.

Conclusion and Future Research

This paper designs the most optimal fisheries distribution with the assumption of the most efficient distance from the center of fish production area to DCs location. Based on the results it is known that there is a supply-demand gap. An integrated transport network is needed in order to support the distribution process of fishery product on time, appropriate quality, precise quantity, and precise purpose. The distribution of inter-island fishery commodities may use the multimodal approach with sea and air transportation modes services. The characteristics of Indonesia as an archipelago-based country requires sea and air transportation services as an essential element in the national fish logistics system. This research was limited in 15 DCs of fishery commodities which distributed only in 5 big islands in Indonesia and has not considered yet the future plan of the transportation infrastructure and networks development and also the speed parameters in this model. Therefore, the further research might be extended in a wider area in Indonesia and need to consider other significant parameters that should be identified in order to strengthening the initial findings.

ACKNOWLEDGMENTS

The authors would like to thank the MMAF for taking part in providing the financial support to complete this research.

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DECISION MAKING FOR RELIEF DISTRIBUTION PROBLEM IN HUMANITARIAN LOGISTICS

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Abstract

Purpose of this paper: The purpose of this paper is to present a literature review of relief distribution, a part of humanitarian logistics that aims to describes the type of problems discussed in previous papers and suggest directions for future research

Design/methodology/approach: This paper develops a research framework for literature review through four stages. The first stage is the collection of materials by conducting relevant literature searches on international journals and conferences and performs inclusion and exclusion criteria used to narrow the search results. The second stage is descriptive analysis to provide information about the publication of relief distribution from year to year. The third stage is category selection, by categorizing the reviewed papers and the last stage is material evaluation to find a research gap that can be developed in future research.

Findings: provides an overview of the progress of the paper on relief distribution from year to year; finding the problem types discussed in the relief distribution problem, i.e. location/allocation, routing, distribution and evacuation, and integrated, which is the integration of location / allocation, routing, inventory, etc; and identifies research gaps that can be addressed in further research studies.

Value: from the 91 papers reviewed, this paper categorizes past research based on problem type, data modelling type, objective function, time period, commodity type number, and solution method. The paper also describes the distribution of papers from year to year by category and recommends areas for further research.

1. INTRODUCTION

Disaster is an unavoidable phenomenon and the occurrence is often unpredictable. Disasters not only result in loss of lives, but also injured, displaced, material losses, environmental damage and psychological impact on the victim. In the 2003-2012 range, in the world, there are 388 occurrences of natural disasters occurring yearly which resulted in 106,654 casualties and resulted in a financial loss of 156.7 million dollars. In 2013, the number of disasters decreased to 330 events and resulted in 21,610 fatalities and resulted in a financial loss of 118.6 million dollars (Guha-Sapir, et al., 2014).

Casualties and financial losses indicate the need for prevention and response to disasters, therefore, emergency management and humanitarian logistics to the attention of many researchers in recent years. Humanitarian logistics is often used as a measure of success in disaster management. Logistics distribution at the right amount, the right time and the right target will reduce the number of casualties, so logistics planning becomes the core of every relief operation (Ahmadi et al., 2015). Study of disaster relief operation is increasingly important as disaster threats tend to increase (Whybark, 2007).

The study of emergency management in the OR / MS community was reviewed by Altay and Green (2006). Altay and Green (2006) show that mathematical programming was the researcher's concern among all OR techniques. This was confirmed by Hoyos, et al. (2015), 47% of their reviewed papers were mathematical programming, even mathematical programming research with stochastic parameters was increasing in the period 2006 to 2012.

Humanitarian logistics can be defined as the process of planning, implementing and controlling the efficient, cost-effective flow and storage of goods and materials, as well as related information, from point of origin to point of consumption for the purpose of meeting the end beneficiary's requirements (Thomas and Mizusjima, 2005). Studies in literature review that discusses the humanitarian logistics have been conducted (Tomasini and Van Wassenhove (2009), Kovács and Spens (2009), Costa, et al. (2012), Caunhye, et al. (2012), Leiras et al. (2014), Gutjahr and Nolz, (2016) and Habib et al. (2016)).

Caunhye, et al. (2012) classified emergency logistics operations in two main categories, namely; (1) facility location and (2) relief distribution and casualty transportation. An overview of the model structure of each category was given, that was, in terms of horizon planning (single or multi-period), data type (deterministic / stochastic), and the number of levels (single or bi-level) and objective function (single or multi-objective). Literature review research with multi-criteria objectives is discussed further by Gutjahr and Nolz (2016). Hoyos, et al. (2015) conducted a literature review study that discussed OR models with stochastic components in disaster operations management. OR techniques used in the studies reviewed are mathematical programming, simulation models, probability or statistical models, artificial intelligence and expert systems, decision theory methods and queuing theory. They categorized mathematical programming research similar to Caunhye, et al. (2012), ie facility location, resource allocation, relief distribution and casualty transportation. While Leiras, et al. (2014) divides the problem type in humanitarian logistics into facility location, inventory management and routing.

The study of facility locations was further discussed by Boonmee, et al. (2017) that specifically reviewed the mathematical model for facility location optimization. This research classified facility problem based on data type model, that is deterministic facility location problem, stochastic facility location problem, dynamic facility problem, and robust facility problem.

Transportation and distribution analysis in emergency humanitarian logistics was carried out by Safeer, et al. (2014). Safeer, et al. (2014) divided the research into 2 parts: (1) casualty transportation and evacuation and (2) distribution, where each part was classified again based on model parameters and objective function. Anaya-Arenas, et al. (2014) conducted a review of the relief distribution network and classified the relief distribution problems into four categories, namely (1) location/ allocation and network design problems, (2) transportation problems, (3) the combined location and transportation problems, and (4) other less popular, but still important, topics in relief distribution.

The literature review on the facility location, last done in 2017 while the literature review on relief distribution, was last done in 2014, therefore in this paper the researchers conducted a literature review on relief distribution in humanitarian logistics. The research question in this literature review are:

RQ1: What problem are addressed in humanitarian relief distribution in logistics?

RQ2: What is the current position of relief distribution research?

RQ3: What topics can be developed in future research?

2. RESEARCH METHODOLOGY

Literature review in this paper follows the stages given by Seuring and Gold (2012), the outline is divided into 4 stages:

- (1) material collection;
- (2) descriptive analysis;
- (3) category selection; and
- (4) material evaluation

2.1. Material collection

The material used in this paper was obtained by exploration using Science Direct and Google Scholar. In this paper, the material used is limited to material published from 2004 to 2017. The material to be discussed is humanitarian logistic, so the first step is to find a literature review paper that discusses humanitarian logistics, with keyword review, humanitarian, logistic, disaster and emergency. From literature review paper, it is focused to discuss relief distribution on humanitarian logistic, therefore the next step is to find a paper that discusses relief distribution. Keywords used to search these papers are relief, distribution, routing, transportation, allocation, humanitarian, logistic, disaster, and emergency.

From the material obtained then sorted again and issued a paper that is not in accordance with the topic. Paper with the topic of routing, transportation, distribution and allocation in the context of commercial logistics is removed from the material. Likewise, the paper which only deals with the transportation of victims or the evacuation of victims, but does not discuss the distribution of logistics will be removed from the material. Paper used is only a paper published in scientific journals and conferences. Project papers, dissertation reports and papers published in magazines are not used as material. The material used in this research is 91 papers published in journals and conferences, excluding the literature review.

2.2. Descriptive analysis

Descriptive analysis provides information on the number of publications per year and publications per type of problem to illustrate the current trend of publications. Descriptive analysis will be presented in the form of a histogram

2.3. Category selection

In this study, the collected paper material will be classified by type problem. Next for each type of problem will be in the breakdown again based on data modeling type, objective function, time horizon, commodity variations, and tools used to solve the problem.

2.4. Material Evaluation

The classified material is read again and evaluated whether its classification is appropriate. To avoid subjectivity in categorizing the material then be rechecked by other authors. Furthermore, an evaluation of material that has not been discussed and is an important material to be discussed. This material is a topic that can be developed in further research.

3. RESEARCH TOPICS

The topics discussed in this research are focused on relief distribution. In general, relief distribution includes several decision sequences. The first decision to be made concerning the design of the distribution network, consists of the selection of shelter and distribution center to be used to support relief operations. The second decision is the logistics deployment concerns of the allocation of available resources to the distribution center taking into consideration the needs of the affected people they will serve. The third decision relates to the distribution route (Anaya-Arenas, et al., 2014).

Sheu (2007) describes the emergency logistics network consists of suppliers relief, relief distribution centers and demanding relief area. Relief suppliers refer to aid providers, both organizations and individuals. Relief distribution center can be more than one level, for example central distribution center and local / regional distribution center. logistics from relief suppliers will be sent to central distribution center and central distribution center will send local / regional distribution center. Relief suppliers can also send directly to local /

regional distribution centers. Relief demanding areas can be shelter, healthcare center or affected area. Communities in the affected areas will be evacuated toward the shelter, but the wounded would be evacuated to healthcare. Figure 1 illustrates the emergency logistics network.

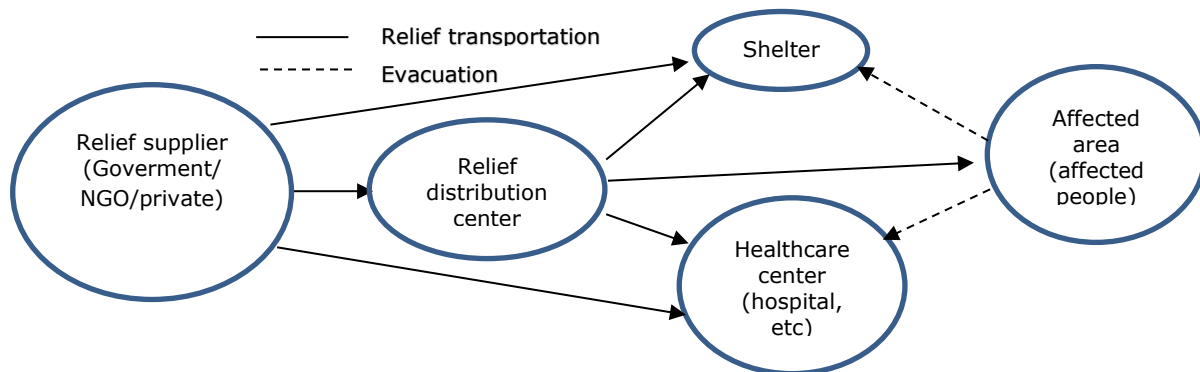


Figure 1. The emergency logistics network.

The existing problems in the emergency logistics network are:

- Determine the location and resource allocation at relief distribution centers, healthcare centers, shelters (location/allocation problem)
- Determine resource distribution route to demanding area (routing problem)
- Integration of location/allocation problem or routing problem with evacuation (distribution and evacuation problem)
- Integration of location / allocation, routing, inventory and other (integrated problem)

Location / allocation problem is a matter of determining distribution center location or health care center or shelter from some existing ones. The corresponding decision variable is a binary variable, which is 1 if the existing candidate is selected and is 0 if the existing candidate is not selected as a distribution center or health care center or shelter. In addition to location determination, another problem is determining the amount of commodity sent from the supplier to the distribution center or to the health care center and the number of commodities sent from the distribution center to the demand point (shelter or affected area).

Routing is an issue of resource / commodity distribution routes in a emergency logistics network. If the distribution network is described as a network model then relief suppliers, distribution centers, shelters, health care centers and affected areas are nodes and arcs indicate possible transport routes. In the routing problem, the decision variable is to determine the selected arc for the resource / commodity transport and specify the number of commodities that can be sent in the selected arc. In each arc there are transportation cost parameters, transport time, minimum limit and maximum limit allowed. The node that receives the request (demand node) has the required number of demand parameters on the node, while the supply node parameter is the number that can be sent. Capacity is a parameter attached to the transshipment node (distribution center). Other parameters are usually related to vehicles used for transportation.

4. LITERATURE BREAKDOWN AND ANALYSIS

This section analyse 91 paper materials. From 91 paper material obtained 28 papers discuss the location / allocation problem, 22 paper discuss the routing problem, 12 paper discuss distribution and evacuation problem and the remaining 29 papers discuss integration problem. Figure 2 shows the distribution of papers from 2004 to 2017.

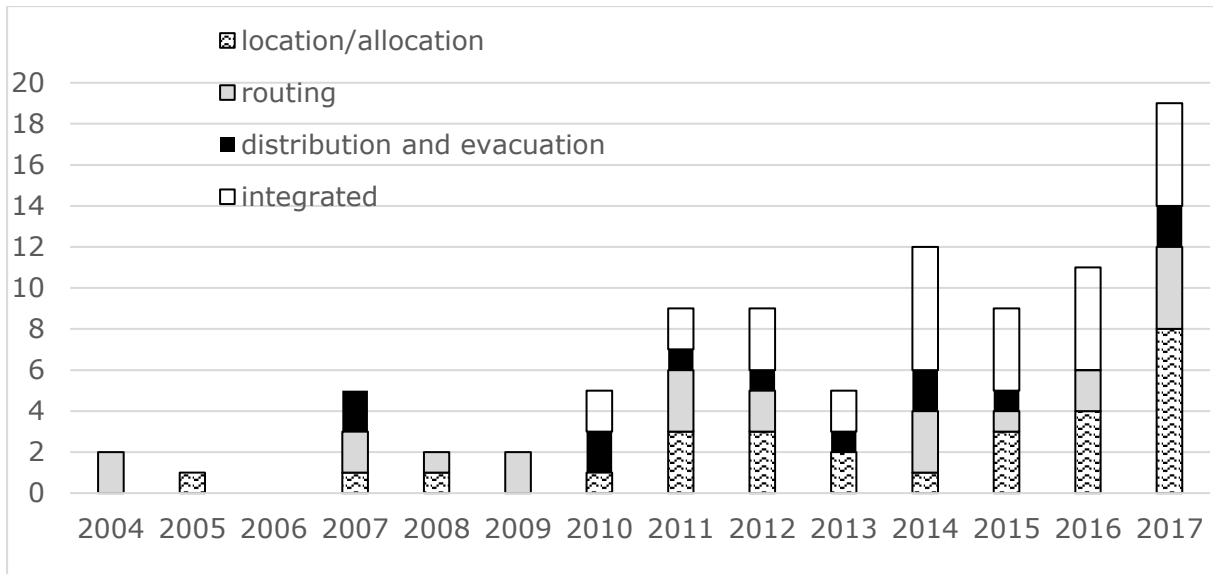


Figure 2. Paper distribution from 2004 to 2017

Figure 2 shows that the number of relief distribution papers from year to year tends to increase. Prior to 2010, the issues discussed were dominated by location / allocation and routing, but start from 2010 the integrated paper began to be discussed and the numbers tended to increase. Location/allocation paper and integrated paper currently dominate in relief distribution paper.

On each problem discussed, the paper can be classified into data modelling type, objective function, time period, commodity type number, and solution method. Based on data modelling type, paper is divided into deterministic and uncertainty. Deterministic paper includes a paper that all model parameters are deterministic. While the uncertainty paper includes a paper that has stochastic and robust model parameters. But there is a paper that develops two models simultaneously in a paper that is a model with deterministic parameters and models that consider uncertainty (Verma and Gaukler (2015), Marcelin et al. (2016) and Ahmadi, et al (2015)). Figure 3 shows the distribution of paper based on the data modelling type.

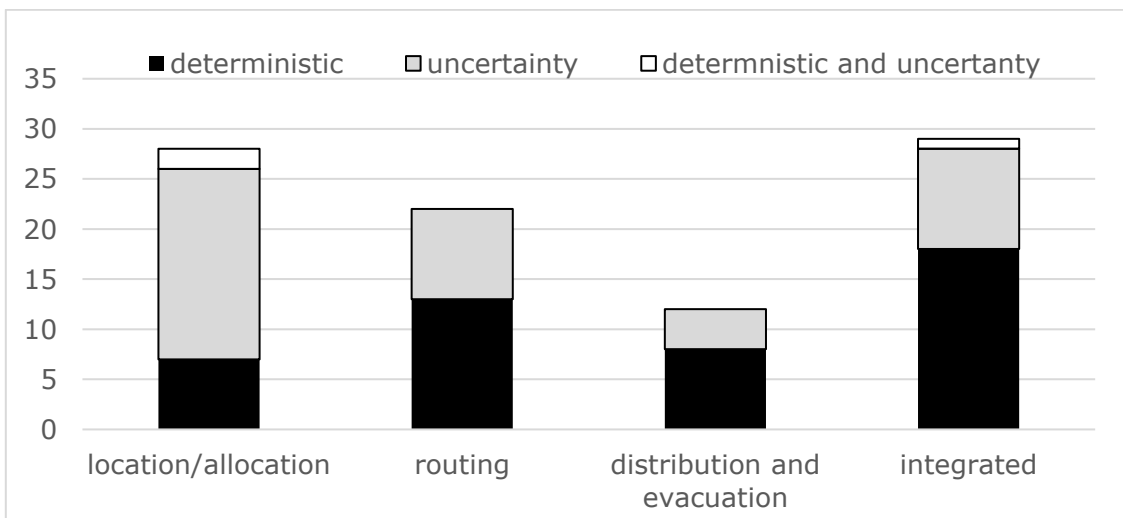


Figure 3. The paper distribution based on the data modelling type

For location / allocation problems, papers with uncertainty data types are more numerous than paper with deterministic data types. But for the other three problems, the number of papers with more deterministic data types than papers with uncertainty data types, even on distribution and evacuation problems, only 4 papers considered uncertainty.

Based on the objective function, papers are divided into single objective and multi objective (Figure 4). From 91 papers, 49 papers are single objective papers, 41 papers are multi objective papers and 1 paper develops single objective and multi objective at the same time. Location / allocation problems and routing problems mostly use single objectives, whereas distribution and evacuation problems and integrated problems mostly use multi objectives

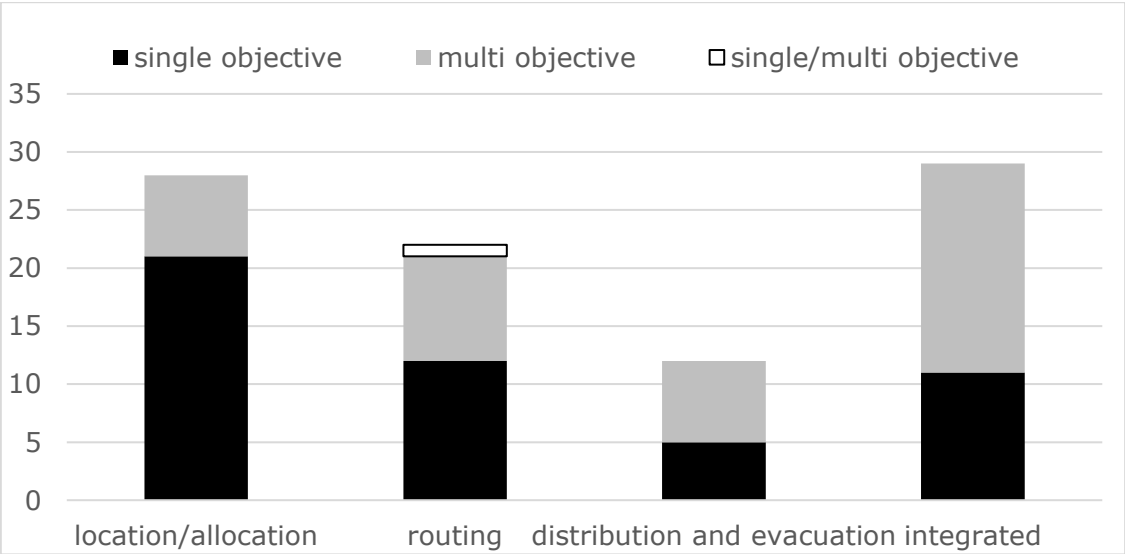


Figure 4. The paper distribution based on the objective function

Single period and multi period are the classification of paper based on the time period. Figure 5 shows the paper distribution based on the time period. Single periods are widely used in the reviewed papers. The use of single period is more in pre disaster phase (preparedness and mitigation) whereas multi period is more used in post disaster phase, especially in response phase.

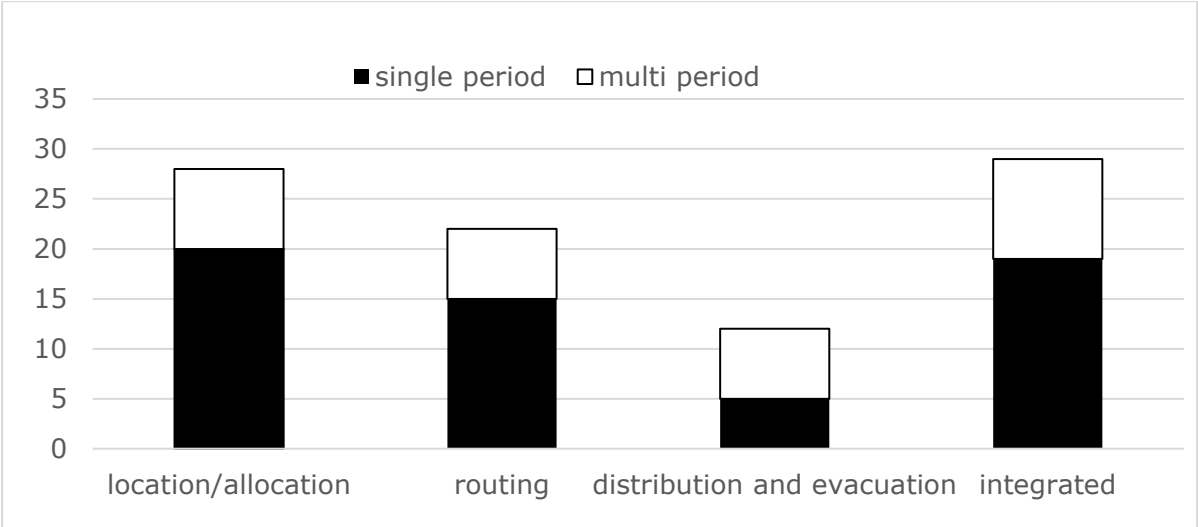


Figure 5. The paper distribution based on the time period

Based commodity type number, it is divided into two types, namely single commodity and multi commodity. The number of papers with multi commodity is almost the same as the number of papers with single commodity. The paper distribution based on commodity type number can be shown in figure 6.

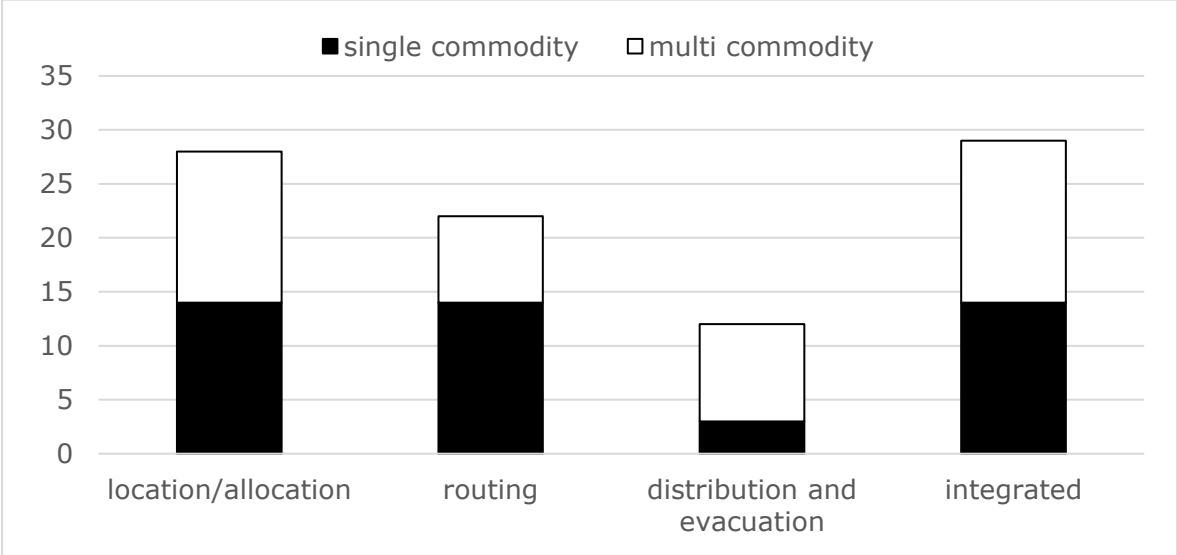


Figure 6. The paper distribution based on the commodity type number

The last paper classification is based on the solution method (figure 7). Based on the differentiated solution method to exact, heuristic (Genetic Algorithm, Ant Colony Optimization, Tabu search, Simulated Annealing and others), exact/heuristic and simulation. There is one paper that only makes the model only but not given the solution. ie on the routing problem. The exact/heuristic solution method means the model developed in the paper is completed in exact and heuristic terms.

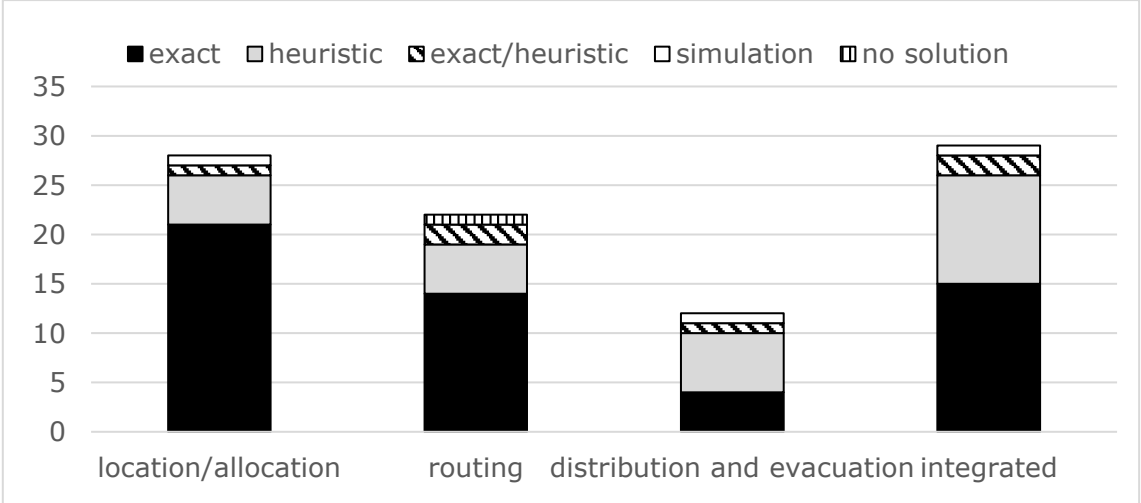


Figure 6. The paper distribution based on the solution method

5. CONCLUSION AND FUTURE RESEARCH

This study reviews literature on relief distribution which is part of humanitarian logistics. In addition to the literature review paper, this study discusses 91 papers written in journals and conference proceedings between 2004 and 2017. The number of papers discussing relief distribution from year to year tends to increase. The analysis of 91 collected papers

has identified four types of problems, namely location / allocation, routing, distribution and evacuation, and integration of location / allocation, routing, inventory, and other (integrated).

Each type of problem discussed is classified by data modelling type (deterministic / uncertainty), objective function (single / multi), time period (single period / multi period), commodity type number (single commodity / multiple commodity), and solution method used (exact / heuristic/simulation). Based on the data modelling type, uncertainty data types are more widely used in location/allocation problems, but for the other three problems, more deterministic data types are used. The uncertainty parameters discussed include travel time, demand on the affected area, relief supply and travel cost

In the integrated problem, the integration discussed are integration of location selection and routing (13 papers), integration of resource allocation and routing (2 papers), integration of location/allocation, routing and inventory (6 papers), integration of location/allocation and inventory (5 papers), integration of distribution and restoration (2 papers) and integration of location/allocation, routing and evacuation (1 paper)

In the issue of distribution and evacuation integration, many papers discuss casualty evacuation, which brings injured victims from the affected area to the medical center or to the shelter. Evacuations for healthy victims were discussed by Salmeron and Apte (2010), Sheu and Pan (2014), Widener, et al. (2015), Manopiniwes and Irohara (2017). The number of healthy casualties evacuated to the shelter will affect the demand for relief commodities such as food, water, medicines, and others on the shelter and will affect the demand for the affected areas, as there may still be populations that are not evacuated or even evacuated. Behavior of the population and cultural culture of the victim determines the number of healthy victims in the shelter, therefore the demand on the shelter is uncertainty. In the paper discussing healthy victims, the demand on the affected area and on the shelter is deterministic and not related to the number of evacuated victims. The existence of this gap is possible as a topic for further research.

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THE PRACTICAL OPERATING SCHEME OF VIRTUAL DISTRIBUTION CENTER-CASE OF PARTS DISTRIBUTION BETWEEN TAIWAN AND INDONESIA IN SMALL TRADING COMPANY

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Abstract

Purpose of this paper:

Taiwan government announced her national policy called Southward Policy to diversify the national business risk from China market. Taiwan government encourages SMEs to develop their products and services for south east countries market especially for India, Indonesia, Philippines, and Vietnam. The author deeply did the research on the practical operating structure between south east countries and Taiwan. For more practical effectiveness and low cost to execute the policy. Virtual distribution would play a very useful role. The objective of this paper is to structure a workable virtual distribution center and work flow.

Design/methodology/approach:

Qualitative and empirical research is the method of this paper. Case study method includes in-depth research into A company. Data and information was gathered from A company and theoretical papers and practical working reports. The experienced and workable flow and structure are really examined and tested.

Findings:

A practical process and working structure was worked out and tested two times.

Value:

A workable structure and practical working flow is concluded and completed for the reference of small and medium trading company.

Practical implications (if applicable):

This study has significant implications for small and medium enterprises called SMEs and for organizations which have to operate supply chain management. SMEs are the main business sectors in Taiwan and they need efficient and low cost international business due to the shortage of human power along with the development of good performance of supply chain management. The efficient and low cost operating process of international business is considered as the key to the

success of small and medium trading companies for the policy of Southward policy.

Key Words: Virtual distribution, Supply Chain Management

Introduction

In the Internet of Things called IOT age, with information symmetry, customers compare prices, delivery schedules, quick responses, and product information for international clients was not possible in the traditional age. These capabilities impacting not only all the customer touch points of an organization, but also, send impacts on all the value (supply) chain. Business sectors are forced to upgrade efficiencies in every aspect of procurement, distribution, manufacturing, sales, service, and marketing. Short time to market pressures and responsiveness also low cost to customer demands are necessary to approach. For reducing the operating cost, upgrading the efficiencies and services of Taiwanese SMEs to meet the competitive request is the most important issues for the southward policy. All Taiwanese SMEs need to become more competitive through improved information sharing, manufacturing on demand, and using real-time collaboration throughout their supply chain. Their goals are increased efficiencies, reduced fulfillment costs, and enhanced time to market. The author focused the empirical research on the small trading companies with virtual distribution center to approach all these requirements to meet their best service for their customers in the ASEAN countries. For the purpose, the key successful factors of virtual distribution center and structuring the practical architecture of virtual distribution center would be generated in the paper.

Literature Review

1. What is virtual distribution of industrial product

A management process that consistently obtains and co-ordinates critical logistical resources provided primarily by virtual corporation members, but also by externals. Virtual distribution of industrial products is multiplied with complementary resources, including industrial production, technology, management and member enterprises engaged in distribution, business flow. I think virtual distribution of industrial products is based on network, and combined with modern information and communication technology as the main means of communication, cooperation innovation, and common development for industrial products. Its information from the supplier is related to the enterprise or organization in the virtual space of dynamic alliance. (Hanbin Wang, 2013)

Diatha Krishna Sundar(2001) mentioned "ICT represents a highly efficient tool for

data collection, but its use is much wider. It offers companies a wide range of possibilities for increasing competitiveness. For example, it allows organizations to create closer partnerships with their customers, suppliers and business partners. It means that organizations are capable of using the potential of ICT for the modernization of a number of managerial processes, which also include supply chain management (SCM)."¹.

2. The requirements of industrial products of virtual distribution center

The main roles of an LC include: Connection of different transport modes into transport chains, Design and implementation of complex distribution networks, various logistical tasks (internal company transport, storage, commissioning, packaging, distribution, and so on), and preparation, implementation and maintenance of the needed infrastructure for cooperating companies. ² According to the significance of services in the creation of added

value for the customer, logistical services can be classified into three groups: a) Basic logistical services, b) Additional logistical services, c) Other services. Case in this paper, basic logistical services is defined. The requirements of virtual distribution center are: Organizations providing basic logistical services: transport companies, private transport agents; forwarding agents; wholesale warehouses, storage areas; packaging factories; installation companies; division workshops; information and communication technology operators.(Vladimír Modrák, 2010)

3. Structure of virtual distribution enterprise

Virtual distribution center: registration of new partners in the system (on the basis of the connection contracts' data), request of new developmental needs from the R&D organizations, catering of the marketing, financial and management activities.

¹ Vladimír Modrák(2010), "DESIGNING AND EFFECTIVENESS OF VIRTUAL DISTRIBUTION CENTERS", Technical University of Kosice, Advanced Logistic Systems Vol. 2.

² Vladimír Modrák(2010), "DESIGNING AND EFFECTIVENESS OF VIRTUAL DISTRIBUTION CENTERS", Technical University of Kosice, Advanced Logistic Systems Vol. 2.

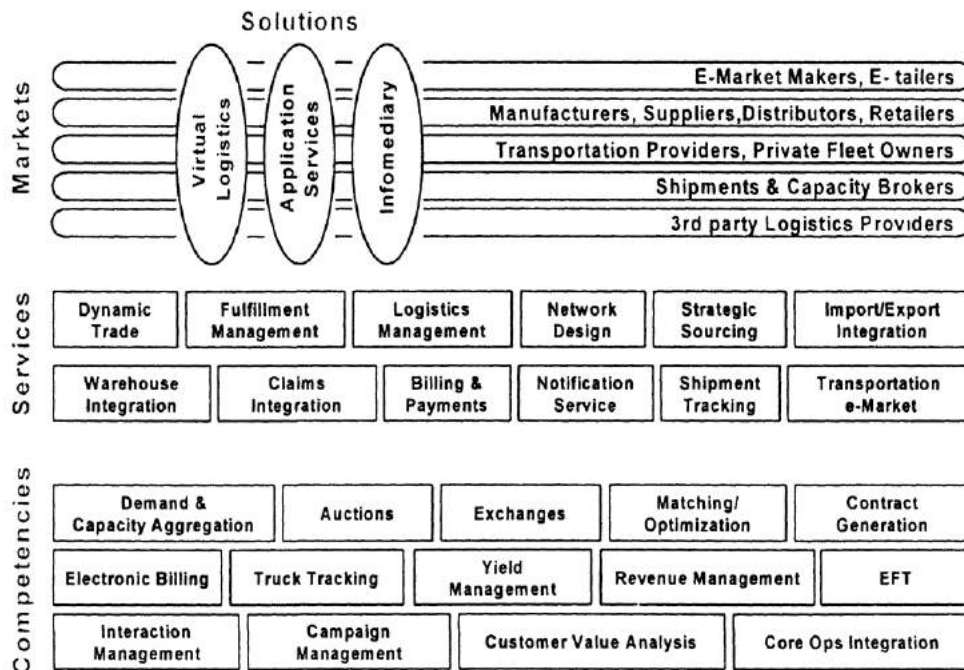


Fig. 1: Markets-Services-Competencies-Solutions framework for Virtual Distribution Network

(Source: Diatha Krishna Sundar(2001), "Integrated Virtual Distribution Network for Quick Responses", Associate Professor & Chairperson - ERP Centre Indian Institute of Management Bangalore, India)

4. Key successful factors of virtual distribution center in B2B business

The necessary steps we take will make the virtual distribution center be successful as the follows:

1. Business and distribution jointly cooperate to determine the desired service missions. The service missions are in fact the driving forces behind the change.
2. We design the new supply chain structure and distribution strategy and we evaluate the related costs and benefits.
3. Then we list the necessary requirements in warehousing, transportation, inventory management. All the requirements are in the field of IT, procedures & control, layout & equipment and organization.
4. Finally we execute one by one. The biggest problems are predicted and observed automatically and of course secure all the actions and flows execution in good quality.

According to Hanna Falk and Linda Hogström(2000), the KSF of virtual distribution center as the follows: 1. Payment must be easy and safe; 2. Delivery must be on time and performed securely; 3. Tie the whole supply chain together with help of information exchange and open communication; 4. Lower operative costs so that the e-commerce market will have a

chance to compete with the traditional market; 5. Concentrate on the core business and avoid carrying out several services at the same time; 6. Face-to-face” contact to a larger extent – make the customer more loyal to the distribution center; 7. Strong customer relationship; 8. All involved parties must possess high competence through the whole supply chain; 9. Increased responsibility for the logistic provider .

Research Design and Methodology

Qualitative and empirical research is the method of this paper. Case study method includes in-depth research into A company. Data and information was gathered from A company and theoretical papers and practical working reports. The experienced and workable flow and structure are practically examined and tested.

Analysis

1. An Introduction to Research Firm

A small trading company engaged in the business of fishing boat parts between Taiwan and Indonesia to meet Taiwan and Indonesia. Main functions of the firm collect the parts of fishing boats then ship goods to Indonesia.

(1). Core competitiveness

Well-qualified human resources and well-qualified value chain of distribution service such as customs broker, transportation, forwarder, warehouse, IT service provider, insurance, bank, and so on are the partners. The authors are the president and vice president of this company who are an integrated international distribution specialist and a professional of international distribution management. All staffs have much and long experience in distribution service. Only three staffs do their efforts on the business since their great supplier relationship including trust, integrity, and good payment term.

(2). A Scheme of Virtual Distribution Center (Fig. 1)

According to experience and in-house resources an operational model to provide great service for SMEs will be explained as the follow. Good IT system, experienced and integrated capability staffs, and experienced distribution service providers are basic team members in this operational model. Naturally, highly efficient & standard operation procedures being formulated are very important.

2. Results

The Research Firm plays to find parts of manufacturer, quote best price, shipment tracking, QC, and distribution arrangement, payment. The firm is capable of integration, source, quality control, good relationship with suppliers, IT system, abnormal management. After test operating, we found that the following SOP and

key successful factors.

(1). Key successful factors

After reviewing literatures and test operating, we found the key successful factors which are: mutual trust and reliability between two sides, smart IT system, good relationship with suppliers such as parts manufacturers and distribution service providers.

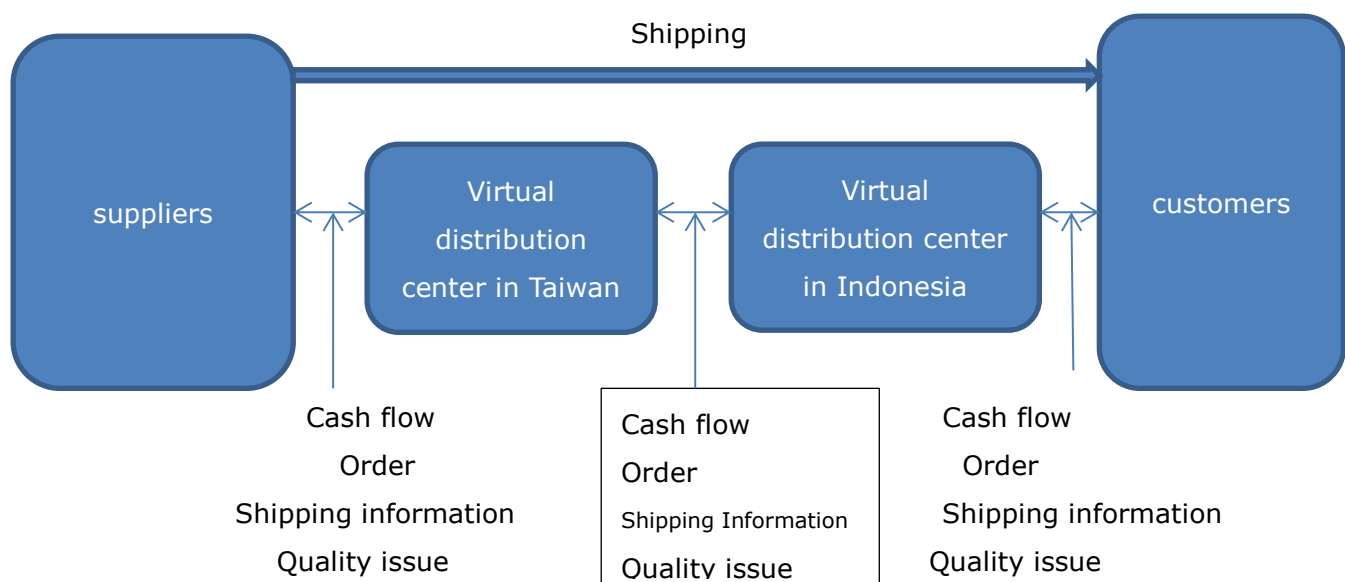


Fig. 1: The Scheme of Virtual Distribution Center

(2). Practical Operating Flow

After test operations, we conclude the operating procedures as the follows:

- A. Requested side (Indonesia) delivers her request to supplied side (Taiwan) on basis of the catalog information.
- B. Supplied side source the best suppliers then place an order.
- C. The supplied side takes the responsibility of product sourcing and quality issue before shipping.
- D. Requested side remits payment to supplied side before shipping.
- E. Requested side's customers receive the shipment then then close the case.

(3). Problem Discussion

After test operating and referring IBM VCC philosophy, we agreed and found the key issues and problems. The requirements of virtual distribution center are:

- A. Demand side
 - a. Consolidated.
 - b. Real-time view on customer data such as customer demand, on-hand inventory, in-transit or fulfilled demands.

- c. Cost- vs. risk-optimized finished goods inventories based on statistical forecasting that records product transitions and short-term trends.
- d. Automated, rule-defined alert mechanism on aged inventory and price protection risk for more effective demand conditioning and serviceability.
- e. Facilitates collaborative forecasting, planning and replenishment (CFPR).

B. Supply

- a. Multi-tier visibility of key supplier data such as forecasts, hub inventory, stock, WIP, receipts or supply commit.
- b. Alerts provided to commodity managers when inventory falls or tends to fall out of control bounds.
- c. Enables effective collaboration with suppliers by driving conditioning actions like hub rebalancing, promotions, expedite shipment and spot purchase.
- d. Registers repetitive order patterns and order skews and thus optimizes supply hub inventory for serviceability and liability.
- e. Factors include historical pull rates, seasonality, replenishment lead times and order variability.

How to generate the basic operating cost and reasonable profit? All the parts price is necessary to decide by two sides and to be transparent. The most important thing is every two sides will invest at least 20% each other. Of course supplied side should have a good, updated, and qualified supplier information. Surely, quality control capability, just in time shipping, communication on line is the basic qualification.

Conclusion

Speed and low cost of maintenance service in different industries are the most important issues. To approach this target is to use the concept of virtual distribution center. For operating smoothly and effectively, we found the basis are mutual trust, good IT system, transparency, reliability, integration capability, also having great supply chain management. Tamás, P., Illés, (2015) pointed out , "If the number of the contracted suppliers will be few, then working of the virtual distribution center will be not cost efficient. In order to reduce this risk a very significant marketing activity will be necessary".³

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LOCATION OPTIMIZATION FOR INTEGRATED MARINE AND FISHERIES CENTRE IN INDONESIA

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Abstract

In realizing the balance between the supply and demand of fishery commodities in Indonesia, location allocation model is used to determine the optimal location for Integrated Marine and Fisheries Centre that cover the production and consumption area. From 15 sites of Integrated Marine and Fisheries Centre development, there are 4 locations indicated to be optimal as the distribution nodes of fish commodities. The locations are: (a) Biak Numfor, (b) Natuna, (c) Nunukan, and (d) Saumlaki. Other locations, which are not included in the 4 most optimal locations, are indicated that they still have limitations for network connectivity and infrastructure services, so the level of optimization indicated is still low.

INTRODUCTION

The condition of the development of fish production and consumption, both domestic and export demand has a tendency to increase. In the Work Plan of the Ministry of Marine Affairs and Fisheries from 2010 until 2014 indicated a trend of increasing fishery production by 10.02% per year and fish processing production by 10.2% per year.

Another positive condition is the increase of fish consumption (domestic) by 7.35% per year. This indicates that the fish in the community has increased. Meanwhile, in the Work Plan of the Ministry of Marine Affairs and Fisheries 2015-2019, the fisheries production target is expected to increase from 24.12 million tons in 2015 to 39.97 million tons by the end of 2019, with fish consumption increasing from 40.9 kg/cap/ year to 54.49 kg/cap/ ear during the same period. In the case of fish production, especially the sea catch, the conditions that occur illustrate the dependence of production on the condition of the season and the indicated production system has not been efficient. In addition, the length of the distribution chain on marketing of fishery products coupled with other less efficient aspects, such as logistics transport infrastructure leads to a paradox in which consumers pay more but producers do not also enjoy proportional benefits.

In contrary, distribution of production of fishery products concentrated in remote areas that require special efforts to be economically valuable or can meet the needs of industrial raw materials and food for direct consumption of the community.

The Ministry of Marine Affairs and Fisheries with approach of development of Integrated Marine and Fishery Centre is expected to be an embryo in order to consolidate the resources of fishery products that have not been fully utilized to meet the needs of local and export markets.

The problems faced today are the limited transportation facilities and infrastructure which impact on the lack of absorption of production, continuity and quantity of supply, the high

cost of transportation of fishery commodities. Sea Toll programs have been implemented and are currently not fully addressing transportation issues for fishery commodity transport

METHODS

Location Allocation Model

Since the 1960s, location-allocation models have been applied to a wide variety of problem contexts but with a general form of structuring service facilities to satisfy demands in optimal ways (Ghosh & Rushton 1987). Location-allocation models are mathematical formulations (Cromley and McLafferty, 2002), which aim to identify the optimal geographical location for facilities based on the demand distribution. Location-allocation models can be used to determine the best locations for new facilities that provide services and commodities to users, and people in need of those supplies. In other words, the location-allocation model is the process that selects the optimal locations of facilities from a set of candidate locations and, simultaneously assigns demands to these locations in the most efficient manner, based on the distribution of demands.

The location-allocation models determine the optimal locations by using several measurements that are based on travel distance, travel time or other forms of cost functions. Researchers have developed a suite of techniques for carrying out location-allocation modelling. These techniques aim at finding the right sites for facility locations that can increase the accessibility and decrease the total weighted cost (e.g. distance, traveling time, or other cost factors). For practical applications, researchers have used these techniques to find optimal locations for hospitals, fire stations, post offices, libraries, day canthers, waste disposal sites, warehouses, schools, bank branches, and sites (Algharib, 2011).

Location-allocation models have two important components in the processes of solving location-allocation problems: the *allocation rules* and the *objective functions*. The allocation rules specify how demands are allocated to the candidate locations, whereas the objective functions influence the optimal location for candidate sites. The aim of the objective functions is concerned with minimizing the transportation costs incurred from moving supplies to demands and at the same time maximizing the accessibility of demands to supplies or maximizing public welfare and services (Keane & Ward, 2002).

The location-allocation models each contains three primary components: 1) the demand locations; 2) the candidate locations for service facilities; and 3) a distance and/or time matrix holding distances or traveling time between services facilities and demands locations. The demand locations represent the distribution of people or commodities that seek services or to be allocated. The demand locations may also possess attribute information such as client locations, population and socio-economic characteristics of the demand locations. The candidate locations for service facilities represent feasible sites that meet a set of criteria as specified by analysts for issues such as the land size, cost and accessibility of the service facilities. A distance matrix or a time matrix stores the distances or travel times between candidates for service facilities and demand locations by considering the physical and social barriers such as traffic congestion, political structure of administrative units, nature of services and others (Keane & Ward, 2002).

P-Median Model

The p-median model was one of the first mathematical models developed to minimise the total weighted distance, which was aggregated across all the supply and demand locations (Hakimi, 1964 and Teitz and Bart, 1968). The operations of this model depend upon the interchange or substitution of the number of locations which are required to select the chosen and candidate locations capable of minimising the weighted distance or time between the supply and demand locations (Church and Sorensen, 1994).

The P-Median method was studied in 1964 by S.L. Hakimi, then in 1974 Shajamadas and H. Benyamin Fisher used this method for determining the hierarchy of locations for the rural area planning units in the Indians. In addition, in 1974, Milton E. Harvey, Ming-Sing

Hung, and J. Randall Brown used this method to identify and activate growth centers for Sierra Leona (Harvey, et al., 1974).

P-Median is one of Optimization Model. This model basically aims to determine the location of service facilities or service center (supply center) so that the level of service provided by the facility and the center to the population (demand point) is spread uneven in one area to be optimal. In this model, the service center (supply center) becomes the point to be determined its location, while the point of demand (demand point) is a more determined location first (Bilang, in Ashar 2002). So the P-Median Model is used to choose the optimal location for the facility services should take into account the principle of the minimum utilization of resources, such as time, cost, service coverage, and others.

Given distances defined between each node-point of a route network, find that point from which the sum of the distances to all other points is least. Weights may be associated with the nodes. The node for which this is true is called the median of the graph. Hakimi (1964) has developed a theorem showing that the desired optimum point is itself a node on the network. That is, there never will lie a point on an arc between two nodes that will have a smaller total distance to the remaining nodes than either of the nodes themselves. This is an important theorem since it has encouraged the development of solution methods which evaluate alternative nodes on the route network to find the solution node. No time needs to be spent unnecessarily examining points along the arcs connecting nodes (Rushton, 1979).

Figure 1. Illustrates a solution to one problem; the partitions are indicated as are the total distances that have been minimized. One important characteristic of this and all solutions to this problem is that the location of each source is optimum with respect to the points in its partition

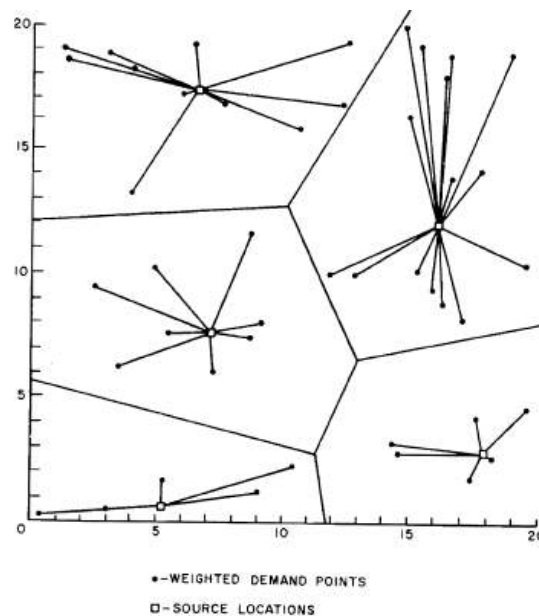


Figure 1. The multi-facility location problem on the plane.

Source: Unpublished paper by James A Kohler.

A mathematical formulation of the distances shown by lines in Fig. 1 is:

$$Z = \sum_{j=1}^m \sum_{i=1}^n a_{ij} w_i \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2}$$

Where:

Z = is the aggregate distance from all demand points to their closest supply centre.

- x_i, y_i = are the coordinates of the i^{th} demand point; ($i = 1, \dots, n$)
- x_j, y_j = are the coordinates of the j^{th} supply centre; ($j = 1, \dots, n$)
- a_{ij} = 1 when demand point i is served from supply center j ;
otherwise $a = 0$.
- w_i = is the weight assigned to the i^{th} demand point

Location allocation model is part of network analyst in ArcGIS (Geographic Information System), the modeling describes the spatial information based on real conditions in the field. For example, the condition of the national road network has been adjusted into real conditions in the field. Some of the parameters that be used in modeling are as follows in Table 1 and 2:

Table 1. Parameters to be considered in the road network analysis

No	Parameter	Remark
1	The speed for each road	Depend on road function, in accordance with Indonesia Government Regulation No. 34 of 2006 on Road, speed of ship and aircraft
2	Directions	One or two ways, depend on the real condition
3	Elevation	Ignore
4	Turn	Ignore
5	Multimode	Depend on data condition
6	Distance of network segment	Calculate geometry in ArcGIS

Table 2. Speed Parameters for Each Transport Mode

No	Mode	Network Topology Type	Transportation Type	Speed
1	Land	Planar	Truck	50 km/hour
2	Sea	Non Planar	Cargo Ship	8 – 25 knot (14,816 – 46,3 km/ hour)
3	Air	Non Planar	Cargo ATR	500 km/ hour
			Cargo Boeing 737 – 800	800 km/ hour

RESULT AND DISCUSSION

Origin zone of fish commodities for modelling are Integrated Marine and Fishery Centres, which located in 9 provinces and 15 regencies. Marketing location is determined in the area which nearest to Integrated Marine and Fishery Centre. Figure 2. Show location of Integrated Marine and Fishery Centre in Indonesia.

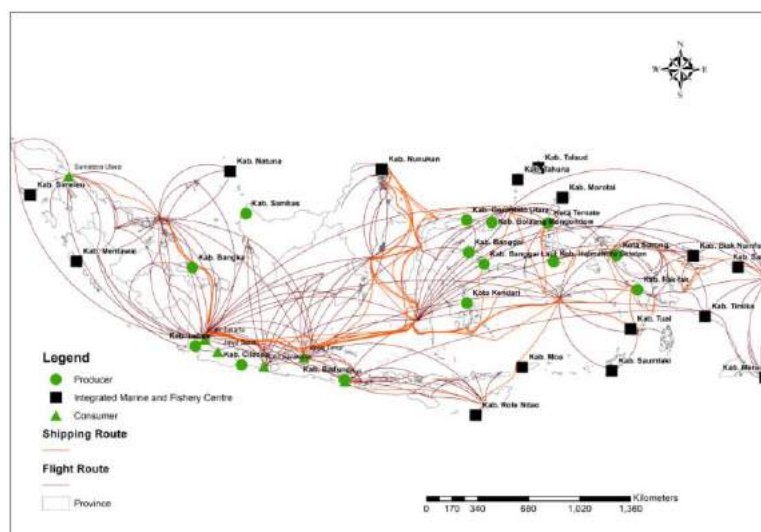


Figure 2. Location of Integrated Marine and Fisheries Centers in Indonesia

Cost Origin-Destination (OD) Matrix from Producer to Integrated Marine and Fisheries Centre

The origin-destination (OD) cost matrix solver finds and measures the least-cost paths along the network from multiple origins to multiple destinations. The best path on the street network is discovered for each origin-destination pair, and the travel times and travel distances are stored as attributes of the output lines. Producer location as origin and Integrated Marine and Fisheries Centre as destination location and using all mode network (land, sea, and airline).

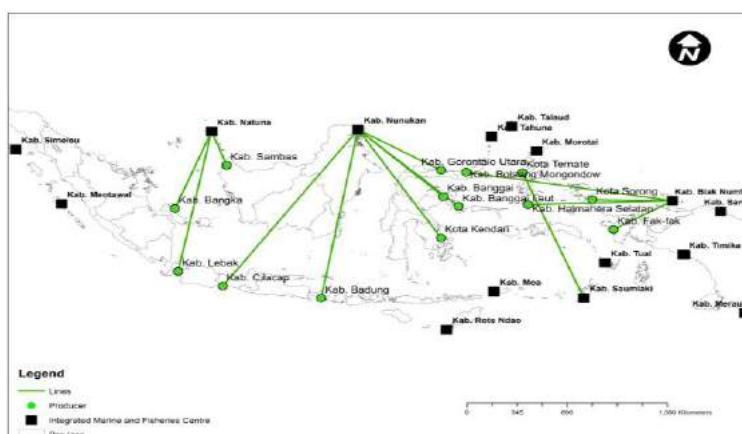


Figure 3. Cost OD Matrix Map from Producer to Integrated Marine and Fisheries Centre, Finding Optimal Destination

Figure 3 and Table 3 shows that selected optimal location for Integrated Marine and Fisheries Centres based on Producer locations, are: (1) Natuna, (2) Nunukan, (3) Saumlaki, and (4) Biak Numfor. Selected optimal locations based on good condition of the infrastructure (multi modes) and travel time parameters.

Table 3. Origin-Destination Matrix for fishery commodities from producer site to Integrated Marine and Fisheries Centre Based on the highest level of optimization.

	Destination	Biak Numfor	Natuna	Nunukan	Saumlaki
Origin					
Gorontalo Utara Regency	-	-	-	231,15	-
Badung Regency	-	-	-	184,72	-
Banggai Regency	-	-	-	123,27	-
Banggai Laut Regency	-	-	-	426,95	-
Bangka Regency	-	-	135,8	-	-
Bolaang Mongondow Regency	336,64	-	-	-	-
Cilacap Regency	-	-	-	387,13	-
Fak-fak Regency	64,26	-	-	-	-
Halmahera Selatan Regency	101,42	-	-	-	-
Lebak Regency	-	-	286,35	-	-
Sambas Regency	-	-	393,38	-	-
Kendari City	-	-	-	166,68	-
Sorong City	106,26	-	-	-	-
Ternate City	-	-	-	-	165,03

Cost Origin-Destination (OD) Matrix from Integrated Marine and Fisheries Centre to Consumer

To get an indication of origin and destination route from Integrated and Fisheries Center to Customer, the result of simulation can be seen in figure 4.

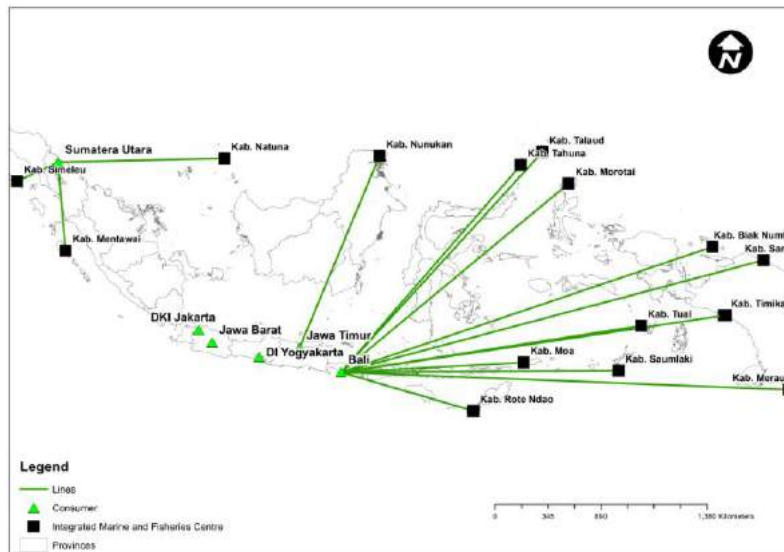


Figure 4. Cost OD Matrix Map from Integrated Marine and Fisheries Centres to Consumer Location, Finding Optimal Destination

From Table 4, it can be concluded that for the destination-destination route with destination rank = 1 indicates the option of the most optimal route of movement (the optimum level of optimization). The analysis shows that the majority of Integrated Marine and Fisheries Centres go to Bali as the center of consumer industry. It is shows that from the total 11 Integrated Marine and Fisheries Centres distributing commodities to Bali as presented in full on the Origin-Target Matrix of fish commodities from the Integrated Marine and Fisheries Centres location to the industrial consumption centers (see Table 4).

Table 4. Origin-Destination Matrix for fishery commodities from Integrated Marine and Fisheries Centre to Consumer Site Based on the highest level of optimization

Origin \ Destination	Bali Province	East Java Province	North Sumatra Province
Biak Numfor	253,38	-	-
Mentawai	-	-	313,67
Merauke	306,77	-	-
Moa	877,9	-	-
Morotai	1088,02	-	-
Natuna	-	-	125,78
Nunukan	-	139,25	-
Rote Ndao	244,9	-	-
Sarmi	311,91	-	-
Saumlaki	255,14	-	-
Simeleu	-	-	30,66
Tahuna	658,45	-	-
Talaud	849,08	-	-
Timika	284,18	-	-
Tual	315,45	-	-

Optimal Location for Integrated Marine and Fisheries Centre for Producer

In this analysis, the optimum location of Integrated Marine and Fisheries Centres are determined based on the distribution of the location of the fish producers, and the analysis setting that will be determined as the table 5.

Table 5. Analysis Setting for Integrated Marine and Fisheries Centres' Location Allocation Model to Producer Centres.

No	Facilities	Demand	Travel From
1	Integrated Marine and Fisheries Centre	Producer	Demand to Facilities

From the analysis of location model of allocation for the determination of the optimal location of Integrated Marine and Fisheries Centres to the existing producer centres, the most optimal are Integrated Marine and Fisheries Centres in Natuna Regency, Nunukan Regency, Saumlaki Regency, and Biak Numfor Regency. See Figure 5 below.

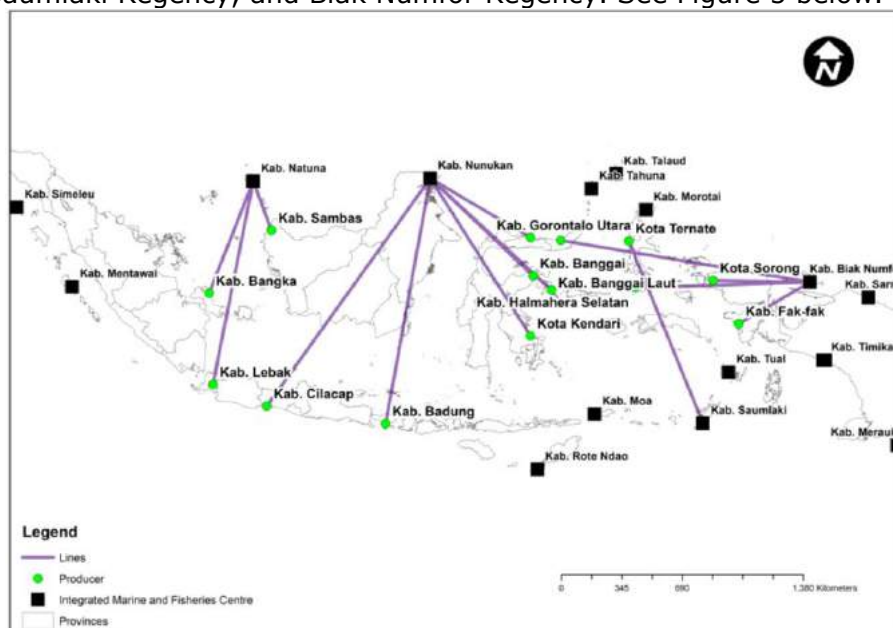


Figure 5. Optimal Location of Integrated Marine and Fisheries Centres to Producer Centres

Table 5 below shows the selected optimal location of Integrated Marine and Fisheries Centres to the Producer's location (Demand to Facility), with the travel time of each Integrated Marine and Fisheries Centre the location to of the producer locations.

Table 5. Optimal Location Chosen for Integrated Marine and Fisheries Centres in Indonesia from Producer Location

No	Integrated Marine and Fisheries Centres	Facility Type	Demand Count	Total Minutes
1	Biak Numfor Regency	Chosen	4	608.57
2	Mentawai Regency	Candidate	0	-
3	Merauke Regency	Candidate	0	-
4	Timika Regency	Candidate	0	-
5	Moa Regency	Candidate	0	-
6	Morotai Regency	Candidate	0	-
7	Natuna Regency	Chosen	3	815.54
8	Nunukan Regency	Chosen	6	1,519.89
9	Rote Ndao Regency	Candidate	0	-
10	Sarmi Regency	Candidate	0	-

No	Integrated Marine and Fisheries Centres	Facility Type	Demand Count	Total Minutes
11	Saumlaki Regency	Chosen	1	165.03
12	Simeleu Regency	Candidate	0	-
13	Tahuna Regency	Candidate	0	-
14	Talau Regency	Candidate	0	-
15	Tual Regency	Candidate	0	-

CONCLUSION

Simulation results using Location Allocation Model gives the following conclusions:

- For 15 of Integrated Marine and Fisheries Centre in Indonesia development locations, there are 4 locations that indicated as optimal locations for distribution nodes of fish commodities. The locations are: (a) Biak Numfor, (b) Natuna, (c) Nunukan, and (d) Saumlaki.
- From the fish supplier to the four Integrated Marine and Fisheries Centre locations, comes from 6 regencies/cities of producer centres from 14 selected regencies/municipalities. This is due to the factor of network connectivity support and existing transportation infrastructure services.
- Other Integrated Marine and Fisheries Centre locations, which are not included in the 4 most optimal locations, are indicated to still have limitations in terms of network connectivity and infrastructure services, so the level of optimization indicated is still low.
- If it is assumed that all Integrated Marine and Fisheries Centre has the same potential in distributing fish commodities to consumer industry centres (in Java, Sumatera and Bali), so Bali, North Sumatra and East Java Provinces have the opportunity to obtain the fish supply from Integrated Marine and Fisheries Centre that in developing, where Bali Province is indicated to get the most supply from 11 Integrated Marine and Fisheries Centres.

ACKNOWLEDGMENTS

We gratefully thank for Ministry of Marine Affairs and Fisheries Republic of Indonesia for supporting the data's.

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VOLUME FLEXIBILITY FOR DYNAMIC FACILITY LOCATION PROBLEM IN PRODUCTION DISTRIBUTION NETWORK

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Abstract— This paper investigates the problem of designing an integrated production-distribution system which supports strategic, tactical, and operational structures in supply chain management. The problem considers a three-layer supply chain consisting of one plant, multiple distribution centers, and multiple customer zones in a multiple period perspective with multiple commodities. An important aspect of this problem is consideration of volume flexibility to increase the system ability to change the level of aggregated output. The problem is modeled using a linear mixed integer programming formulation. The objective function is to minimize the total cost of manufacturing, location of DCs, transportation, inventory holding and backorders while satisfying all customer demands and the facility constraints for all planning horizons simultaneously. The proposed model determines location of DCs, quantity of products produced in plant, inventory level of products in each DC, and quantity of backorders in each period. Computational experiments are presented to demonstrate the model by solving a numerical example. The results show the efficient effects of backorder consideration in model.

Keywords- *Supply Chain; Production-Distribution System; Facility Location, Mathematical Programming*

I. INTRODUCTION

Supply chain management (SCM) is the process of planning, implementing and controlling the operations of the supply chain in an efficient way. SCM spans all movements and storage of raw materials, work-in-process inventory, and finished goods from the point-of-origin to the point-of-consumption [1]. In SCM, three planning levels are usually distinguished depending on the time horizon: strategic, tactical and operational [2,3]. The strategic level deals with decisions that have a long-lasting effect on the plant. These include decisions regarding the number of Distribution Centers (DCs), location and capacities of DCs and manufacturing plants, or the flow of material through the logistic networks. The tactical level refers to both long and short term planning horizons such as production and distribution planning, assigning production and transportation capacities, inventories and managing safety inventories. Finally, at the operational level, the variable time is introduced, and it is classified replenishment and delivery operations [4,5].

A critical review carried out by [6] measures the relationships between supply chain (SC) integration and performance: a high level of integration has a positive impact on corporate and SC performance. Therefore, according to [6], we can say an effective optimization of supply chain is achieved by integrating strategic, tactical, and operational decision making in terms of the design, management and control of activities.

In spite of the need to integrate SC components into a single SC, Only a few studies propose useful operational models and methods enabling managers and practitioners to optimize SCs by focusing on the effectiveness of the whole system [7].

In this paper we demonstrate an integrated production-distribution model for location-allocation problem in a multiple period perspective with multiple commodities. The model is formulated as a linear mixed integer programming supporting strategic, tactical, and operational choices of decision makers in the field of facility location, level of inventory, production management and system flexibility.

Integrated systems in SC which have considered facility location in their models are categorized according to certain features. Numbers of SC layers, single/dual location layers, number of

commodities, single/multiple period(s) and deterministic/stochastic parameters are the most important aspects which have been taken into account in comprehensive reviews. For instance [8,9,10,11] surveyed single layer, single commodity and single period system with deterministic parameters, and [12,13,14] considered dual layers system, dual location layers, multiple commodities and multiple periods in deterministic area.

Melo et al. [1] presented a comprehensive review in SCM which analyzed application of facility location in SC. They provided a perfect classification which categorized a large number of papers based on SC structures. They suggested extending a SC system in 3 layers, multiple commodities and multiple periods. According to this review, this system is not considered so far. Besides they concluded that different aspects to decrease the risk of system have not received much attention in the literature. By means of attention to the risk of system, Decision maker (DM) can prevent of supply chain disruption. Investing in system flexibility, excess inventory and purchasing large insurance policies are common ways to protect supply chains against such risks [1].

In this way, we desire to formulate 3 layers, multiple commodities and multiple periods SC system considering facility location and adding a new concept to SC models called volume flexibility which have been introduced by [15].

Volume flexibility is the ability to change the level of aggregated output. Nowadays, supply chain systems face to unpredictable and variable circumstances. If these systems want to be able to adjust or respond quickly and smoothly to changes with low investment, they should be considered more flexible than a system which can only achieve the same change at great cost and/or organizational disruption. This issue is more important in case of volume flexibility because this is concern with capability to change the output level and there is a straight proportion between output level and customer responsibility. The ϵ -constraint method, which introduced by [16], is selected to determine the efficient value of flexibility because this method don't require specific conditions to achieve the solutions.

Another important aspect that should be considered in model to increase the efficiency of the system is backorder in customer demands. According to [1], only Liang and cheng [17] have used backorders in their model. Through Backorders, the DCs can postpone some of their orders to the next periods that may lead to increase the flexibility of system.

Moreover, every product in each period can be held in DCs. Therefore, inventory holding costs are also considered in the model. In addition, integer decision variables are used to determine every product in each period is produced or not. This decision is made based on the production-line set up costs, variable production costs, inventory costs and transportation costs.

II. PROBLEM FORMULATION

In this section, a linear mixed integer model is developed to extend a SC system considering 3 layers: a plant, Multiple DCs and multiple customer zones in multiple periods perspective with multiple commodities. Likewise, specified capacities for plant and each DC are determined in the model, and demand of each customer zone can be satisfied from multiple DCs in the same time. The model is developed to determine optimum number of DCs, location of DCs, assignment of each customer zone to DCs, quantity of each product produced in each period, inventory level of products which is held in each DC, Quantity of products delivered to DCs and Customer zones, and quantity of backorders in each period. Moreover, in order to increase the ability of responding to changes, volume flexibility is considered in the system.

The objective function of the model is to minimize fixed charge DCs costs, transportation costs between plant to DCs and DCs to customer zones, inventory holding costs and backorder costs while satisfying all customer demands, plant capacity and DCs capacity. The mathematical model describing the characteristic of the problem can be formulated based on following variables and parameters:

A. Notation

A.1. Parameters

B : Time unit available for production in any given period

U_p : Processing time for producing one unit of product p
 F_w : Fixed charge of DC_w
 SC_{pt} : Set up cost for producing product p during period t
 PC_{pt} : Cost to produce a unit of product p
 HC_{pw} : Inventory holding cost per unit of product p at DC_w
 TC_{pw} : Cost of travel from plant to DC_w per unit of product p
 TC_{pwt} : Cost of travel from DC_w to customer zone i per unit of product p
 λ_{pt} : Backorder cost of product p in period t
 H_w : Holding capacity at DC_w
 V_p : Volume of product p
 D_{pit} : Demand of product p at customer zone i in period t
 M : A sufficient large positive number
 FL_t : Volume flexibility in period t
 ε : Volume flexibility performance index
 α_1, α_2 : Weight factor for capacity utilization [0,1]

A.2. Decision Variables

$x_{pt} : \begin{cases} 1 & \text{if the plant should be set up for product } p \text{ in period } t \\ 0 & \text{otherwise} \end{cases}$

$Y_w : \begin{cases} 1 & \text{if } DC_w \text{ should be set up} \\ 0 & \text{otherwise} \end{cases}$

q_{pt} : Quantity of product p produced in period t

l_{pwt} : Inventory level of product p at DC_w in period t

f_{pwt} : Quantity of product p delivered from plant to DC_w in period t

g_{pwit} : Quantity of product p delivered from DC_w to customer zone i in period t

B_{pit} : Backorder quantity of product p for Customer zone i in period t

B. Mathematical Model

$$\text{Min } Z: \sum_w F_w Y_w \quad (1)$$

$$\sum_t \sum_p SC_{pt} x_{pt} + \sum_t \sum_p PC_{pt} q_{pt} \quad (2)$$

$$+ \sum_t \sum_p \sum_w HC_{pw} l_{pwt} \quad (3)$$

$$+ \sum_t \sum_p \sum_w TC_{pw} f_{pwt} \quad (4)$$

$$+ \sum_t \sum_p \sum_w TC_{pwt} g_{pwt} \quad (5)$$

$$+ \sum_p \sum_t \lambda_{pt} \sum_i B_{pit} \quad (6)$$

Subject to:

$$FL_t = \left(\frac{B}{\sum_p U_p} - q_{pt} \right) \alpha_1 + \left(\sum_w Y_w H_w - \sum_p \sum_w f_{pwt} \right) \alpha \quad \forall t \quad (7)$$

$$FL_t \geq \varepsilon \quad \forall t \quad (8)$$

$$\sum_p U_p q_{pt} \leq B \quad \forall t \quad (9)$$

$$q_{pt} \leq Mx_{pt} \quad \forall t, p \quad (10)$$

$$\sum_p f_{pwt} V_p + \sum_p l_{pw(t-1)} V_p \leq H_w \quad \forall t, w \quad (11)$$

$$l_{pwt} = l_{pw(t-1)} + f_{pwt} - \sum_i g_{pwt} \quad \forall t, p, w \quad (12)$$

$$\sum_w f_{pwt} = q_{pt} \quad \forall t, p \quad (13)$$

$$\sum_w g_{pwt} + B_{pit} - B_{pi(t-1)} = D_{pit} \quad \forall t, p, i \quad (14)$$

$$B_{pi(t=T)} = 0 \quad \forall t=T, p, i \quad (15)$$

$$g_{pwt} \leq MY_w \quad \forall t, p, w, i \quad (16)$$

$$f_{pwt} \leq MY_w \quad \forall t, p, w \quad (17)$$

$$Y_w = 0,1 \quad \forall w \quad (18)$$

$$x_{pt} = 0,1 \quad \forall t, p \quad (19)$$

$$l_{pwt} \geq 0 \quad \forall t, p, w \quad (20)$$

$$f_{pwt} \geq 0 \quad \forall t, p, w \quad (21)$$

$$g_{pwt} \geq 0 \quad \forall t, p, w, i \quad (22)$$

$$B_{pit} \geq 0 \quad \forall t, p, i \quad (23)$$

The Objective function minimizes total costs of system. Alternatively, phrase (1) states fixed charge costs of DCs that are installed. Phrase (2) includes set up costs and variable costs of product p producing in period t . Phrase (3) is total inventory costs in DCs. Phrases (4),(5) state transportation costs from plant to DCs and DCs to customer zones respectively, and finally phrase (6) is the total cost of backorder.

Phrase (7) represents the volume flexibility in each period which is the sum of the following flexibility performance measures:

- Plant volume flexibility, which is measured as the difference between plant capacity and plant capacity utilization and thus represents the available plant capacity.
- Distribution volume flexibility, which is calculated as the difference between the available throughput and demand requirements, and thus represents the available distribution capacity.

Constraints (8) state minimum flexibility level that DM expects to apply it for the system. A DM may need to examine many of non-dominated solutions (with concerning tradeoff) to make a selection, especially in the absence of a specific target. This analysis may be accomplished by varying to generate several non-dominated solutions.

Constraints (9) ensure that the plant capacity is respected. Constraints (10) guarantee that the set up cost will incur if there is production in a given period t . Constraints (11) express the capacity constraints of DCs. Constraints (12) assure that the balance of inventory level in DCs.

Constraints (13) ensure that the total quantity of product p delivered from the plant to DC_w is equal to production quantity in a given period t . Constraints (14) state each customer zone demand is completely satisfied. Constraints (16) assure that quantity of backorder in period T is 0 for each product. Constraints (16) and (17) guarantee the assignment of customers and transportation to open DCs. Finally Constraints (18)-(23) state the types of model decision variables.

III. NUMERICAL ANALISYS

In this section, in order to demonstrate the efficiency of the proposed model, a numerical example with 3 layers, 2 products, 3 periods and 5 customer zones is proposed. The model is coded in LINGO 8.0 Software on a PC including two Intel® CoreTM2 and 2 GB RAM.

In order to determine the performance of model, the value of $\varepsilon=0$ is used initially. It means we don't determine any minimum flexibility for system, hence in this case the model solves the example in common conditions. Experiment results are indicated in Table 1.

According to Table 1, two DCs are needed for satisfying customer demands. DCs have been located at $w=1$ and $w=2$. As can be seen, in period 1 both of products are produced, but in period 2 only product 1 is produced, and demands of product 2 isn't satisfied. Finally in period 3, product 2 is produced in amount of total demands of period 2 and 3. So, previous demands are fulfilled as backorders. Likewise, demands of product 1 are satisfied as holding inventory of previous period. It is to say in order to achieve the efficient quantity of flexibility, although the formulation of ε -constraint method is straightforward, it is not clear how to determine the variation bounds on . One way to calculate this is as follows:

TABLE I. RESULTS OF PROBLEM WITH $\varepsilon = 0$

Period	X_{pt}		q_{pt}		Flexibilit y	Backorder		Y w	Objectiv e
	Produc t 1	Produc t 2	Produc t 1	Produc t 2		Produc t 1	Produc t 2		
Period 1	1	1	505	647.5	147.5	0	0	1	
Period 2	1	0	1263	0	37	0	135.5	1	165281
Period 3	0	1	0	372.5	927.5	0	0	0	

- I. Set the ε bound at 0. Examine the available total flexibility.
- II. Decide either to continue in generating more non-dominated solutions (if the value of W is not sufficient), or to stop if the available flexibility is satisfactory.
- III. Choose an appropriate ε step size and add it to the previous lower bound value.

IV. Go to step 3, unless the best solution has been reached. The best solution is reached when adding additional flexibility results impose large cost increase.

The weights a_1 and a_2 are specified by the DM for each flexibility performance measure. For instance if flexibility of plant be more important than DCs, a_1 should be larger than a_2 . The weight values used in this research are $\alpha_1 = \alpha_2 = 0.5$.

In this way, Table 2 demonstrates value of objective function per different ε . Table 2 indicate efficient quantity of in order to achieve flexibility in backorder case is 350 units. The costs increase slightly from 165281 to 166273 (0.5%) when ε is increased from 0 to 300. This may support management's preference for $\varepsilon=350$ because large increases in flexibility for values between 0 and 350 results in a small cost penalty. Figure 1 shows the results of this sensitivity analysis. This graph illustrates the cost-volume flexibility index tradeoffs and provides evidence to support decisions affecting SC performance.

Also, in order to show the effect of backorder, the model is used to solve the example without consideration of backorder (Table 2). In without backorder case, the results indicate the system imposes more costs rather than backorder case. For instance, in $\varepsilon=0$, the value of objective function with and without backorder are 165281 and 166328, respectively. This comparison indicates that consideration of backorder lead to 1047 units economization.

More specifically, the quantity of flexibility index in with and without backorder is achieved in 350 and 300 quantities, respectively. This shows in backorder case the system can be more flexible than without backorder case. According to Table 2, in without backorder case, when $\varepsilon=350$ the model has to add another DC for satisfying minimum flexibility index; while in backorder case the model has to add another DC in $\varepsilon=400$. It means in backorder case, the system satisfies some of demands as backorder to economize costs.

IV. CONCLUSION

This paper studied an integrated production-distribution system for location-allocation problem in a multiple periods with multiple commodities. Because of the importance of integration in supply chain management, this paper studied an integrated system which supports strategic, tactical, and operational structures. Also, volume flexibility is considered to increase the ability of system against unpredictable conditions.

The problem was modeled as a linear mixed integer programming formulation. The proposed model determines location-allocation of DCs, quantity of products produced in plant, inventory level of products in each DC, and quantity of backorders in each period. The objective function is to minimize cost of location of DCs, transportation, inventory holding and backorders while satisfying all customer demands, plant and DCs capacity.

The linear formulation of model was efficiently solved by LINGO 8.0. Computational experiments show the efficient effects of backorder consideration in objective function value. Also, the results show that in backorder case the system can be more flexible than without backorder case.

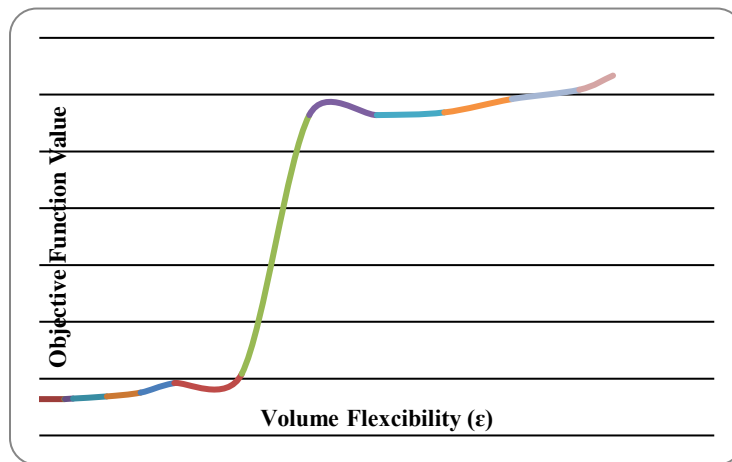
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TABLE II. SUMMARY OF COMPARISONS

ϵ Value	Objective Value	
	With Backorder	Without Backorder
0	165281	166328
50	165300	167023
100	165375	167023
150	165509	167023
200	165844	167023
250	166102	167068
300	166173	167916
350	166673	176172
400	175281	176221
500	175281	176328
600	175375	177023
700	175844	177023
800	176173	177916

FIGURE I. RESULTS OF THIS SENSITIVITY ANALYSIS



FOUNDATIONS FOR AGENT-BASED MODELLING AND SIMULATION OF VALLDAL STRAWBERRY SUPPLY CHAIN

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Abstract

Purpose: The purpose of the paper is to conceptually model the mechanism of individual actors' decision making when it comes to coordination to lay grounds for structural network change of Valldal strawberry supply chain.

Design: The paper applies a published teaching case of end-to-end local supply of Valldal strawberries enhanced by updated information from a recent in-depth interview. Agent-based modelling (ABM) is selected as a modelling approach because it captures decision-making, interactions, and adaptation of autonomous actors in the Valldal strawberry supply chain.

Findings: The Valldal strawberry supply chain is first characterized and followed by modelling decision making and interactions in the supply chain. Then, these two issues are systemized within the existent network structure and presented as a conceptual model using ABM platform. Based on the developed model, alternative network structure is discussed.

Value: This is a new approach in which action research of Valldal strawberry supply chain is visualized into artificial environment using agent-based simulation, and in return, the findings from the simulation is used as bases for improvement.

1. INTRODUCTION

The food supply chain is characterized by a network of heterogeneous actors which have a high degree of autonomy and different objectives. This limited perspective of different actors in the food supply chain results in the need of coordination among actors. Previous case studies of fresh food supplies have revealed industrial particularities that include at core daily coordinating harvest-related uncertainty with uncertain demand constrained by its short time frame. Degree of alignment with respect to coordination (e.g., information sharing) is therefore important to enable smooth operation in order to enhance value and meet required service level. Moreover, nature of competition which has shifted from firm competition to supply competition has made coordination becomes even more critical to achieve supply chain success. Consequently, the food supply chain has changed from open/spot market to vertically coordinated relationship as a response to improving efficiency.

Further, some literatures, e.g., Ng (2008), Krejci and Beamon (2015), have demonstrated that coordination is a source of structural change in food supply chain. Furthermore, coordination-related decision making is motivated by individual actor objectives of increased profit and/or decreased risk. In short, individual actor decision making gives implications for structural network of food supply chain, and hence impacting long-term sustainability and resilience of the food supply chain. This has been evidenced

in then provided Valldal case of strawberry supply chain in which environmental uncertainty (i.e., harsh dan drought winter) has caused the change of contract decision making between Valldal Grønt (farmer-owned cooperative) and BAMA Ålesund (wholesaler), and further the shift of overall structural network. For that reason, behavioural aspect of individual actors' decision making is indeed the essential elements of food supply chain and should be captured to understand the mechanism of structural network change.

Many mathematical models addressing the relationship between inputs (such as crop selection, farm size, weather) and outputs (yields, profits) have been developed to guide individual actor decision making. However, studies on the mechanism of individual actor decision making on structural network are rare. The purpose of the paper is to conceptually model the mechanism of individual actor decision-making to coordinate and thus lay grounds for developing the studied strawberry supply chain.

Agent-based modelling (ABM) is selected as a modelling approach because it captures decision-making, interaction, and adaptation of autonomous actors in the Valldal strawberry supply chain. Following the aforementioned characteristics of food supply chain which involves heterogeneous and autonomous actors who interact each other, ABM is particularly suitable to model food supply chain, in line with that of Utomo *et al.* (2017). The combination of heterogeneity and interaction emerges system properties at macro level. i.e., supply chain performance such as enhanced value, total logistics cost, service level, and network structure. The developed model seeks to understand the mechanism of structural network evolution overtime in order to envisage and explore efficient operations.

Food supply chain studies using agent-based modelling, such as Ng (2008), Krejci and Beamon (2015), were built by abstraction from a social phenomenon, which is not always realistically representing the context. The present study however introduces a new approach in which action research of Valldal strawberry supply chain is visualized into artificial environment through agent-based modelling and simulation. The typical model is usually referred as empirical agent-based model in which the model is built and validated via qualitative and quantitative data. The empirical agent-based model is used to evaluate the existing system and assess structural network change. Additionally, the overall research provides importantly a roadmap for industry to develop supply chain alignment and operations coordination of fresh foods distribution in general and Valldal strawberry supply chain in particular.

The rest of the paper is structured as follows. The next section introduces Valldal strawberry supply chain based on previous study of Engelseth (2015), which is then followed by brief theoretical review of ABM. Section Four describes the proposed agent-based model relevant to Valldal strawberry supply chain. Finally, the application of the proposed model and future research are discussed.

2. VALLDAL STRAWBERRY SUPPLY CHAIN

Valldal is a small township in western Norway which produces strawberry. Farmers in Valldal are small-scale growers which are managed by Valldal Grønt, a small farmer-owned cooperative. Due to the need to increase productivity in strawberry production and distribution, the strawberry growers took an initiative to build a business with the assistance from the municipality. Valldal Grønt AS was then established in 1998 as a private company which is owned exclusively by strawberry growers. The role of Valldal Grønt AS is mainly to secure marketing and sales chain. Annual meetings before, during, and after growing season with farmers are regularly conducted to inform farmers about production and distribution. Valldal Grønt AS not only operates strawberry production but also facilitates terminal and storage facilities.

Strawberry production involves both short-term seasonal strawberry growth (all strawberry in Norway are seasonal and open-air harvested) and long-term farm facility development. Due to typical weather in northern geographical location, the most common strawberry varieties produced in Norway is the Korona cultivar and Polka cultivar. Since the last few years, Florence cultivar has also introduced and represented 10% of fresh strawberry ready for consumption. By introducing the Florence cultivar, the growing season is extended by a few weeks, thus provide opportunity to increase production, and in turn, profits. The rest 90% of fresh strawberries are Polka. Of the total produced volume, Polka

represents 40%, whereas the remainder consists of Senga Sengana cultivar. The Senga Sengana cultivar has been used in Norway since 1960 which was previously used for fresh consumption. Nevertheless, Senga Sengana is currently used as raw material in industrialized food processors. Fresh strawberry is perishable product with limited lifetime of 72 hours after harvested.

Factors influencing quality and quantity of strawberry harvest are weather, soil deterioration, and insect attacks. Among those, a major threat is weather. Colder weather slows plant growth. The winter of 2012-2013 which was extremely cold and drought resulted in significant reduction of the strawberries as shown in Table 1. The expected harvest is normally 1200 kg/da. When rain damage the quality, the harvested strawberries are then directed to for industrial use. The quality of strawberry for industrial use is normally lower than that of fresh consumption. Soil deterioration becomes an issue once the same fields are used for growing strawberries. The fields are then rotated and used to grow grass for animal feed or other soiling enhancing crops. Insect attack could reduce harvests up to 80%. The use of pesticides is the measures to reduce the risk.

Table 1. Harvested strawberries by Valldal Grønt (Engelseth, 2015)

Year	kg/da
2008	1260
2009	1052
2010	842
2011	924
2012	1271
2013	404
2014	670

Demand for both frozen and fresh strawberry is unlimited. This could be due to that Norwegian produced strawberry is cheaper than imported strawberry. Moreover, purchasing power of Norwegian consumers are strong due to high standard of living. It indicates that market opportunities exist. For Valldal, it also means the opportunity to distribute the products into neighbouring production. The main company actors involved in Valldal strawberry supply chain prior to the 2014 season is presented in Figure 1. Valldal strawberry growers through Valldal Grønt sell the strawberries to both BAMA Ålesund and industrial processors. BAMA Ålesund is one of BAMA distribution centers, leading fresh product wholesaler, which operates for the wider Sunnmøre region. Less than 10% of the total harvested volume is frozen strawberry products. Less than 20% of fresh strawberry production is distributed in-season through retailers to consumers, whereas most fresh strawberries are transported daily to the wholesaler. Communication flow among actors are updated daily online through webpage.

Prior to the 2014 season, Valldal Grønt and BAMA Ålesund had a fixed price contract. However, in 2014 season, BAMA Ålesund refused to have a contract with Valldal Grønt because BAMA Ålesund expected large supplies whereas Valldal Grønt had significant reduction of production due to the harsh winter. The discontinued contract made Valldal Grønt sell fresh strawberry directly to the supermarkets themselves. The market gradually expanded as retailers found out from word-of-mouth that Valldal Grønt distributed the products directly to the markets. The market had also increased because the price of Valldal Grønt was lower than that of BAMA. This, in turn, made BAMA Ålesund lost its customers and struggled to find alternative customers. In 2015 season, BAMA Ålesund has agreed to have a contract with Valldal Grønt. The Valldal case has illustrated that the harsh winter influenced actors' decision making for collaboration, which has then impacted the structural network, and thus the resilience of the Valldal supply chain.

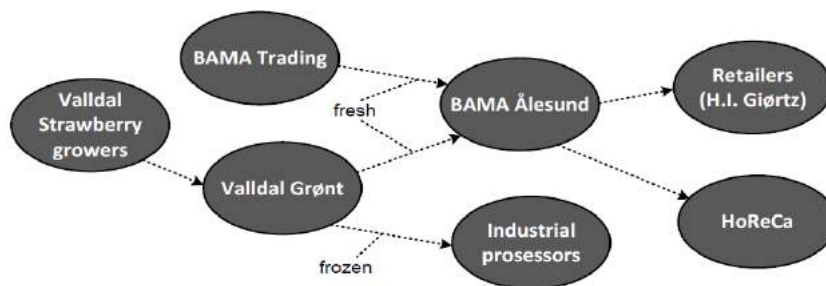


Figure 1. Valldal strawberry supply chain network before 2014 season (Engelseth, 2015)

3. APPROACH

Literature has indicated that long-term collaboration seems to be the option when uncertainty of external factors exists. It is argued that long-term partnership enables communication between firms, which in return reduce cost, and hence increase profit. However, some literatures, e.g., Sun and Debo (2014), demonstrate that long-term partnership may lead to supply chain failure because single sourcing does not encourage suppliers to improve their performance. On the other hand, competition may encourage better value and enhance innovation. Given the characteristics of Valldal strawberry supply chain, ABMS could be used to explore collaboration/coordination which supports sustaining and efficient operations.

Agent-based Modelling and Simulation (ABMS) is a typical bottom-up approach in which individual decision making at micro level is modelled and simulated to produce system performances at macro level. ABMS has been widely used in various application domain due to its capability to represent complex adaptive system (Sopha *et al.*, 2017). Other possible approaches to model food supply chain are discrete-event simulation (DES) and system dynamics (SD). Although DES addresses stochasticity aspect, agents (so-called entity in DES) is passive and non-autonomous agents. The behaviour of the agents is triggered by processes which capture the agents, whereas agents in ABM is active and autonomous when it comes to decision making. Another modelling approach, system dynamics, which is top-down approach, differs from ABMS in which system dynamics models a system at macro level using equation based modelling. Moreover, system dynamics assumes that agents are homogeneous. Hence, system dynamics is appropriate to model food supply chain when it is not necessary to model individual decision making at micro level.

Despite the suitability of ABMS, studies using ABMS to model food supply chain are still very few. Utomo *et al.* (2017) has indicated that ABMS gained acceptance as a promising tool to model food supply chain. The ability of ABMS to represent the important elements of food supply chain such as stochasticity, dynamics aspect, and social processes, are among the reasons. Additionally, current literature of food supply chains using ABMS rarely model food processors and final customers because most existing models are dominated by single echelon supply chain.

Although ABMS has an ability to realistically capture the important elements of food supply chain, ABMS is rather data intensive. Because ABMS models individual decision making and captures multi-faceted elements, ABMS requires good quality quantitative and qualitative data. Krejci (2012) detailed the required data for modelling food supply chain may include natural environment, decision making processes, interaction among actors in food supply chain, economic processes, and political & social environment. Moreover, validating ABMS also entails other independent data which is previously not used when developing the model.

According to the best knowledge of the authors, food supply chain studies using ABMS have focused on coordination (Krejci, 2015) and network structure (Ng, 2008). Those models used theoretical model when modelling behavioural rules of agents. The present study complements the previous studies in a way that the study models

coordination decision making based on empirical evidence acquired from action research. Moreover, the present study deals with multi echelon supply chain.

4. CONCEPTUAL MODEL

The proposed conceptual model was built to mimic the operation environment of Valldal strawberry supply chain in order to explore the effective coordination as it is argued that the appropriate coordination mechanism should match with the operating environment. ABMS has four components that should be specified in the model, i.e., purpose of the model, agents (with their attributes and behaviours), interactions among agents, and emergent properties (Wilensky and Rand, 2015).

The purpose of the model is to understand the mechanism of external factors (such as weather, demand uncertainty) influencing agents' behaviours on the network structure of Valldal strawberry supply chain, and thus resilience of the supply chain. The model focuses on agents' coordination responding to uncertainty particularly related to weather condition and demand, which then affects the network structure of strawberry supply chain. The model is used as a tool to understand the dynamic structural change of Valldal supply chain.

Following the main actors involved in Valldal strawberry supply chain network (Figure 1), agents in the proposed model consists of farmers/growers, Valldal Grønt, wholesaler, industrial processors, retailers and HoReCa (Hotel, Restaurant, Catering). Depending on the role in the supply network, each agent has its own attributes and behaviours. Table 2 details the agents' attributes and behaviours.

Table 2. Agent types, attributes and behaviours

Agents	Attribute	Behavior	Parameters
Strawberry farmers/growers	<ul style="list-style-type: none"> • Location • Farm size • Yield • Composition of strawberry variant • Coordination (independent vs Valldal grønt owned?) • Soil replenishment? 	<ul style="list-style-type: none"> • Grow strawberry • Harvest strawberry • Report yield 	<ul style="list-style-type: none"> • External factors influence (Weather factor and • Insect attack probability)
Valldal Grønt	<ul style="list-style-type: none"> • Location • Farmer member • Contract with wholesaler? • Profit 	<ul style="list-style-type: none"> • Receive estimated strawberry harvest • Inform to BAMA Ålesund • Receive order • Transport order 	<ul style="list-style-type: none"> • Composition of selected strawberry variant types • Operation cost unit • Transportation cost unit
Wholesaler (BAMA Ålesund)	<ul style="list-style-type: none"> • Location • Inventory • Service level • Contract Threshold 	<ul style="list-style-type: none"> • Receive estimated strawberry supply • Receive estimated strawberry demand • Evaluate balance • Decide to make a contract with wholesaler 	
Industrial processors	<ul style="list-style-type: none"> • Location • Demand • Unmet demand 	<ul style="list-style-type: none"> • Generate demand for frozen strawberry 	<ul style="list-style-type: none"> • Demand distribution function
Retailers	<ul style="list-style-type: none"> • Location • Demand • Unmet demand 	<ul style="list-style-type: none"> • Generate demand for fresh strawberry 	<ul style="list-style-type: none"> • Demand distribution function
HoReCa (Hotel, Restaurant, Catering)	<ul style="list-style-type: none"> • Location • Demand • Unmet demand 	<ul style="list-style-type: none"> • Generate demand for fresh strawberry 	<ul style="list-style-type: none"> • Demand distribution function

Heterogeneity is represented by various agent types in the model. Each agent type is also different from each other, indicated by different values of its attributes.

Coordination decision making in the model involves coordination with other agents with respect to whether, with whom, and how to coordinate. Two approaches, i.e., optimization and heuristics, could be used to model the coordination decision. The present study uses heuristics, rather than optimization, to present agent coordination behaviour because it is argued that firms rarely perform rational decision-making, rather they apply bounded rational decision-making such as heuristics. Moreover, heuristics allows social learning in which agents interact with others and internalize adapting behaviour. Figure 2 shows the decision making and interaction among agents in the model.

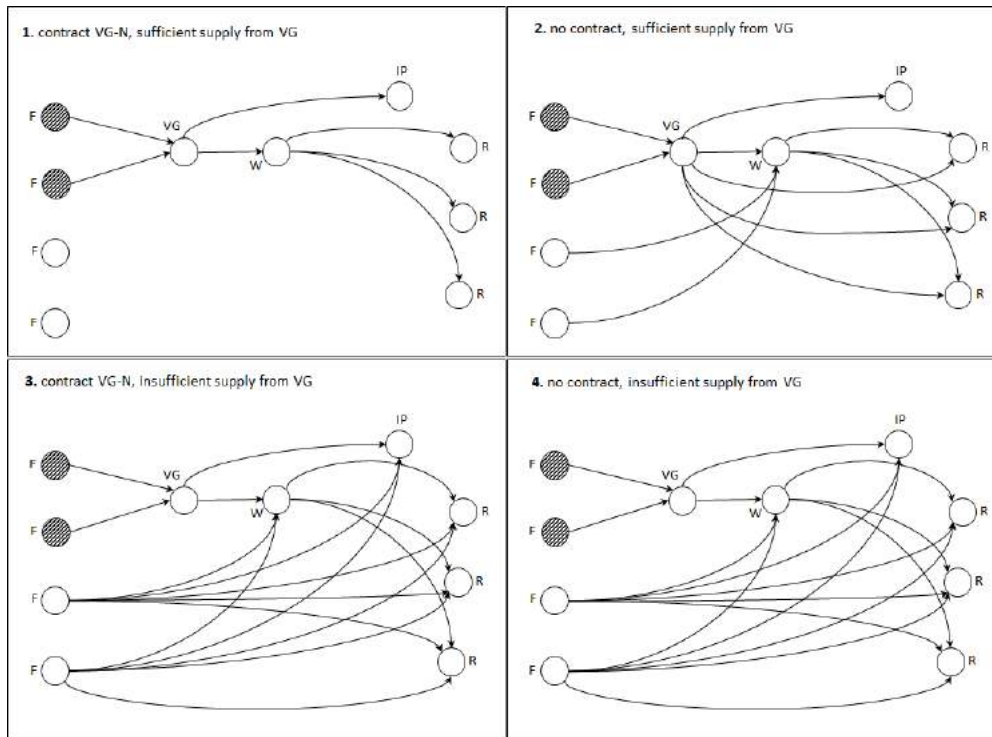


Figure 2. Potential emergent structural network of Valldal supply chain (Note: F = farmers, VG = Valldal Grønt, W = Wholesaler, IP = Industrial Processors, R = Retailers)

Figure 3 on the following page models actors' decision making in Valldal strawberry supply chain network.

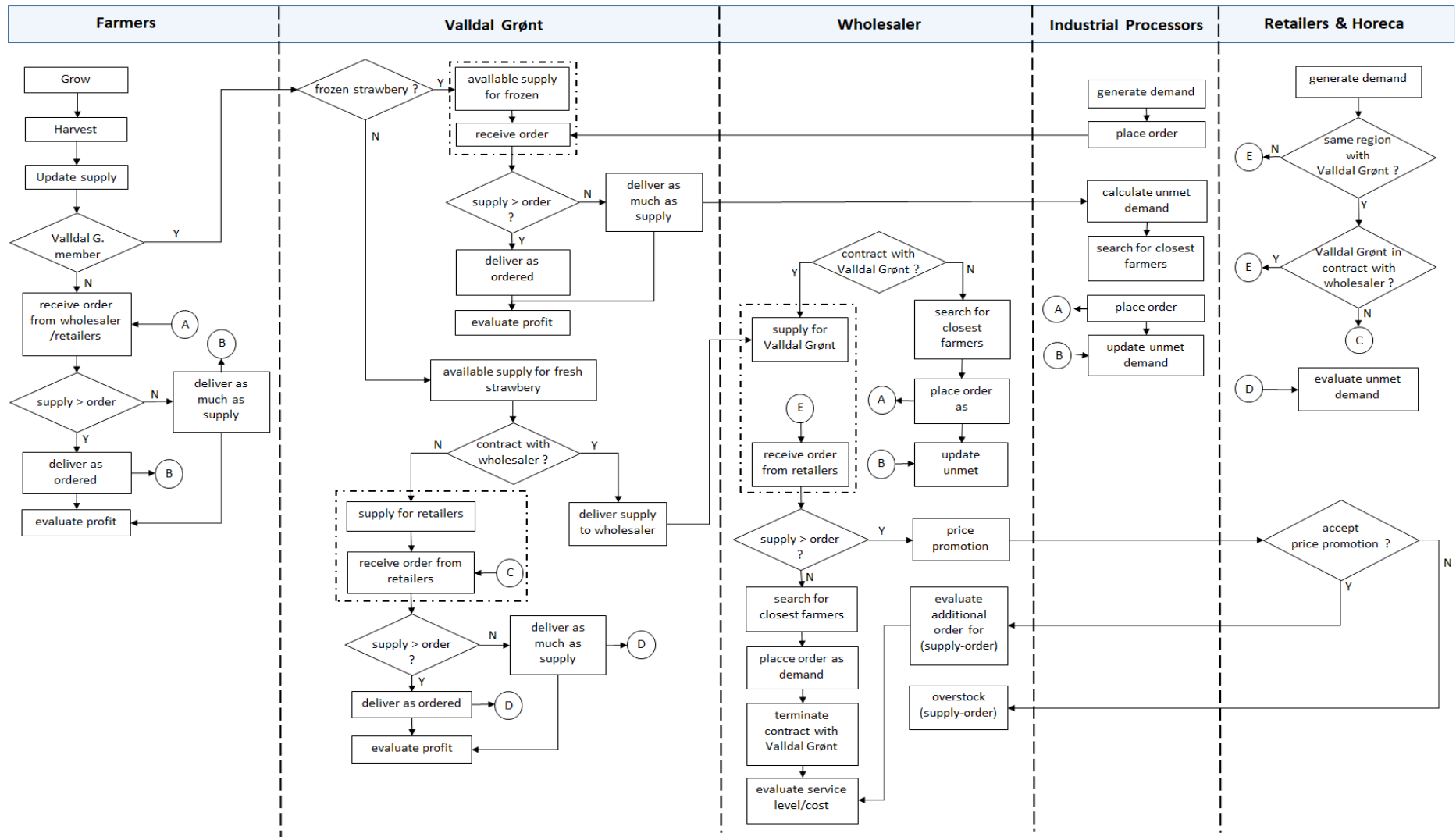


Figure 3. Actors' decision making in Valldal strawberry supply chain network

The aforementioned decision making of agents/actors shown in Figure 3 lead to complex implications for structural emergence of Valldal strawberry supply chain. The emergent properties of the model are therefore network structure of strawberry supply chain. Figure 3 shows the possibilities of emerging network of strawberry supply chain for various settings (whether or not collaboration between Valldal Grønt and wholesaler exists, sufficient or insufficient supply from Valldal Grønt), which may change over time depending on external factors. In addition, logistics performances such as total logistics cost, profits, and/or service level are other emergent properties of the system.

The proposed conceptual model will then be validated either qualitatively or quantitatively. Once the conceptual model is validated, the model is then implemented in simulation model which is parameterized with empirical data from action research. The results of simulation are then compared with another independent data to build model confidence. After passing through some tests, the simulation model could be used to facilitate communication between business practice and academia for continuous improvement ("kaizen") toward efficient operations of Valldal strawberry supply chain.

5. CONCLUSION

The present paper has developed a conceptual model of actors' coordination decision making as foundations for implementing agent-based simulation of Valldal strawberry supply chain. Agent-based modelling and simulation is selected as a modelling platform due to its capability to realistically represent actors' decision making, interactions among actors, uncertainty and dynamic aspect. The model aims at evaluating the existing Valldal strawberry supply chain and its resilience given uncertainty of external factors as well as to explore collaboration/coordination to support efficient operations. The present paper contributes to the development of empirical agent-based modelling which is combined with action research.

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Session 3: Customer-Supplier Relationships

THIRD PARTY PURCHASE BUYER-SUPPLIER RELATIONSHIPS: A CASE STUDY FROM CHINESE AUTOMOTIVE INDUSTRY

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Purpose of this paper:

To analyse the effect third party purchases (3PP) have on supply chain relationships. To explore the value and shortcomings of 3PP in practice.

Design/methodology/approach:

A Chinese case study is conducted on an automotive 3PP and its associated customers and suppliers. 33 interviews are conducted within the 3PP and 32 interviews with supply chain partners.

Findings:

3PP service providers not only help to improve operational efficiency, they also insure purchase prices are kept to a minimum. Supplier-3PP relationships can become strained at times and often adversarial due to a lack of direct contact with the customer.

Value:

The paper provides pilot research into the implementation of a 3PP in China's automotive industry. Based on a selected case, it comprehensively describes the role of a 3PP service provider and highlighting the benefits for using such service.

Practical implications:

3PP are best employed in situations of standard product procurement and transnational relationships. Efficiency gains are more prominent for large homogeneous companies. Effectively and fairly measuring performance of suppliers is required to build up a satisfactory 3PP-supplier relationship.

INTRODUCTION

Procurement and logistics are closely relevant business functions. However, in the face of increasingly frequent global sourcing, they are often defined as value-reduced project (Ramsay, 1994). In 2016, Chinese GDP had reached 74.71 trillion RMB, and the total logistics annual costs exceeded more than 200 trillion RMB (The National Bureau of Statistics of China, 2016). Shi et al. (2016a, b) has pointed out that third-party purchase (3PP), a value-added service, has become another potential profitable source for Chinese firms. Unfortunately, a real 3PP service provider that can step in the whole supply chain management for customers is extremely rare. The fundamental cause is that most third-party logistics (3PL) users have raised a concern of leaking core business confidential and 3PL providers are lack of understanding the entire supply chain knowledge and practical experience (Xu, 2005).

3PP, as a value-added service, refers to outsource a firm's purchase function to a third party (Sun et al., 2011). The scarcity of resources (Pralhad, 2000) results in increase of market competition. Outsourcing purchase function is a crucial decision faced by many firms as they are able to maintain their core competitiveness through transferring the purchase function of non-critical items to a third-party service provider. The topic of 3PP has emerged in the current literatures (Bowersox, 2010), and little past literatures focus on how a 3PP service provider develops closely relationships with suppliers (Adobora et al., 2014). In application to 3PP in China's automotive industry, automotive manufacturers have to deal with many suppliers for different components. Presently, the outsourcing procurement function for the automotive industry in China has achieved over 70 percent,

and this trend will continuously increase in future. Therefore, the primary objective of this research is to explore a possible method to improve relationships between third-party purchasers and suppliers in China's automotive industry.

This study mainly addresses three research questions: 1) how can third-party purchasers effectively maintain good relationships with suppliers? 2) What factors influence on the level of satisfaction for third-party purchasers and suppliers? And 3) how does a firm increase the satisfaction of third-party purchasers and suppliers?

LITERATURE REVIEW

It is crucial to establish well purchaser-supplier relationship management in a whole business process (Sjoerdsma, 2015). Many factors, such as trust, rights, transaction frequency and complexity of transaction, influence relationships between firms (Rajendran, 2012). The perspective of inter-personal communication plays an important role in managing purchaser-supplier relationships, such as 'guanxi' in the Chinese business environment (Large, 2005). It is hard to re-construct a cooperative relationship once the relationship is failed (Gattorna, 2009). Cooperation, coordination, collaboration (3C behaviour) and trust are crucial to influence on building a win-win relationship (Gattorna, 2009).

Using 3PP helps firms significantly reduce purchase cost, improve quality, and enhance procurement convenience through aggregating purchase orders by 3PP professional organizations. 3PP is based on horizontal cooperation, focusing on increasing firms' productivity for core activities (Gruijssen et al., 2007). The horizontal cooperative structure requires to put two or more purchasing firms at the same level in order to increase purchasing volume. However, 3PP is not widely implemented in the current business context (Shi et al., 2016a, b). According to Zhou and Cheng (2002), among 3PL services, inventory costs are about 3% of sales revenue, while transportation accounts for 3% as well. Cost of procurement comprises much more than other items, about 40%-60%. From the perspective of supply chain, the link of procurement can create a huge space for customer value. The transformation of traditional supply chain to innovative one including 3PP is a challenge faced by many firms.

China has become one of leading automotive markets in the globe (Ma et al., 2003). The automotive industry plays an important role contributing the development of China's economy (CFLP, 2012). In fact, the procurement cost accounts for around 60% to 70% of the total costs in the industry. It is important to use the purchasing leverage to increase profitability in the automotive industry (Wang, 2013).

However, the Chinese firms face challenges of lacking necessary skills, knowledge, and infrastructure condition in the process of supplier selection, purchasing implementation, and supply management (Xie et al., 2007). Complicated procurement processes and unreasonable procurement expenditure result in low purchasing operational efficiency, so firms have to suffer huge economic wastes (Tian et al., 2008). It is crucial for the automotive manufacturers to improve procurement management. One of viable option is to seek a professional purchasing service provider to manage their procurement activities (Shi et al., 2016b).

Procurement function plays an important role in enterprise operation (Ramsay, 1994). Outsourcing non-critical purchasing activities to a third-party is a viable option. The fast development of outsourcing business makes 3PP become popular in the contemporary business context (Yang, 2016). The advantage of 3PP helps firms focus on improving their core competence, reducing purchasing costs, and enhancing customer service level (Brewer et al., 2014). 3PP also faces some challenges, including difficulty in managing supplier/customer relationships, risk of information disclosure, and loss of control negatively impacting on the added value for customers. The level of relationships between suppliers and customers significantly influence on the overall supply chain efficiency (Ellegaard, 2006; Ellram et al., 2002). The factors influencing purchaser-supplier relationships are summarized in Figure 1.

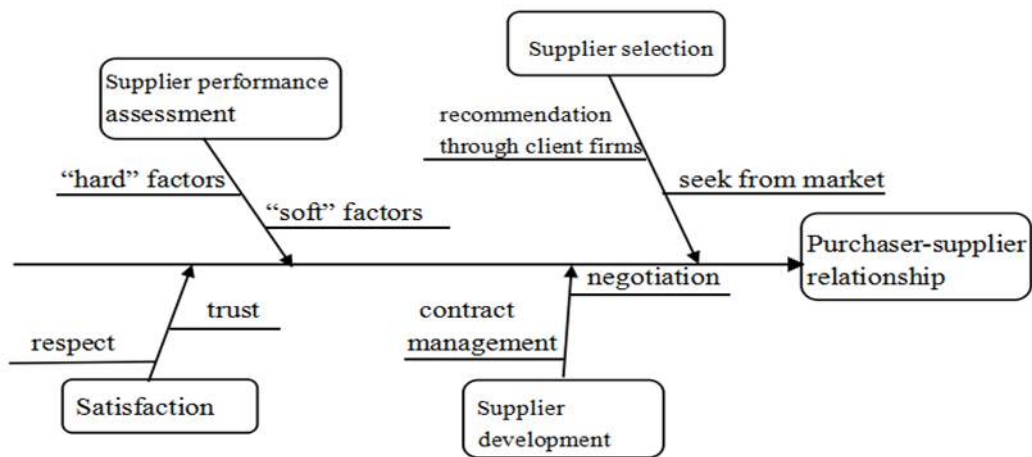


Figure 1. 3PP purchaser-supplier relationships factors (Schotanus et al., 2009)

METHODOLOGY

3PP service is still in the primitive stage in China (Shi et al., 2016a, b). This research is a pilot study focusing on the implementation of 3PP in the Chinese automotive industry. We want to find the real perceptions of 3PP from practitioners through employing the qualitative method – interviews, because the selected participants are able to offer valuable opinions based on their real work experience. It is better to choose a qualitative method for this research because we were able to record the interviewees’ facial expressions, statements, and gestures. The interview questions were adjusted to improve the further communications after completing initial pilot interviews. We adopted one single case, so data was collected among the select participants who are the employees of 3PP service providers and their associated suppliers. It is an advantageous to conduct an in-depth analysis based on a single case. The data was collected by interviews from the internal employees who were dealing with 3PP service and their suppliers at the same time. It is better to give a comprehensive picture in the exploratory study of implementation of 3PP service, such as communicating with suppliers on a phone and negotiating with suppliers. Face-to-face interview was employed in both perspectives of purchasers and suppliers.

DATA ANALYSIS

Company X focuses on offering integrated supply management services for large-scale firms in the automotive industry in China. Its core business includes on-site engineering service, purchase service, and warehousing & distribution services. The purchase service has more potentials to significantly reduce costs, so the company decides to develop the purchase service as the primary service to offer its clients. Its major clients are from top 500 fortune firms, such as Volkswagen and General Motors. The key objective of Company X aims to helps its clients increase their core competitiveness and reduce unnecessary managerial costs.

A key advantageous of Company X attracts automotive manufacturers because of its cost saving programme. Firstly, this programme evaluate the details of clients’ purchasing process, inventory levels, delivery schedule, and on-site workshop to identify a potential of cost saving, produce a report indicating which part of costs can be further reduced. The cost saving programme is set based on the clients’ requirements.

Figure 2 shows a workflow for Company X. In general, an internal purchaser of Company X needs to propose a purchase order requirement (P.O.R) once receiving the orders from its clients. The internal purchaser inputs all required information in the Enterprise Resource Planning (ERP) system, finds a suitable supplier from the database, and generates a purchase order to a supplier. The supplier is responsible for order delivery based on the mutual agreed date. The purchaser needs to check the order and ship it to the clients through the use of its owned transport fleet.

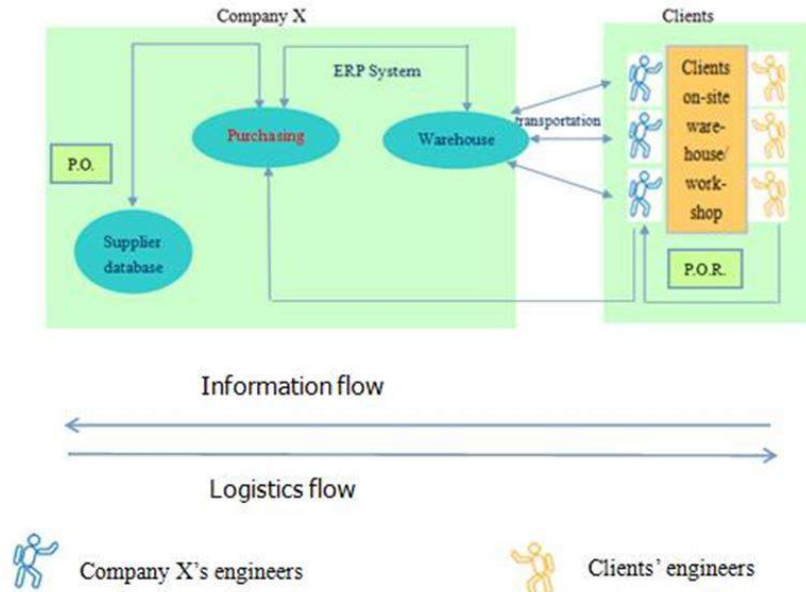


Figure 2: Company X work flows

As 3PP service provider, Company X does not ask extra price to the customers. The price that it offers is the same as that offered by its suppliers. The final price would not be higher than the market price. Otherwise, Company X should negotiate with suppliers downwards on behalf of its clients. The innovative profitable model for Company X is that it charges for the service fee based on the certain percentage of total annual purchase amount. For instance, if it helps client save 5 percent of purchasing cost, the company would receive around 3 percent of the total purchase amount as service fee from its clients. In this scenario, the company and its clients are able to obtain mutual benefits.

The interviews were conducted in two components – purchasers and suppliers. The interviewees from aspect of purchaser are from Company X. 33 participants joined the interviews, and they are all from Company X.

The 32 participants from the perspective of suppliers are randomly selected to cooperate with Company X. Table 1 illustrates the profile of interviewees in terms of year of cooperation, industry types, number of employees, and turnover.

Categories		
Year of cooperation	No.	percentage
<1 year	4	12.50%
1~5 years	15	46.88%
5~10 years	10	31.25%
>10 years	3	9.38%
Industry types		
Manufacturer	5	15.63%
Agent	15	46.88%
Dealer	2	6.25%
Trader	10	31.25%
Number of employees		
<100	13	40.63%
100~500	15	46.88%
>500	4	12.50%
Turnover (RMB million)		
<1	5	15.63%
1~10	10	31.25%
10~100	12	37.50%
>100	5	15.63%
total	32	100.00%

Table 1: The profile of suppliers

There are several key steps for Company X to offer purchase services: 1) receive orders, this is an initial step dealing with the types of purchase orders. Normally, the company classifies the orders in several categories, namely emergency, general, domestic, international, first purchase, or repeat purchased items; 2) select potential suppliers, there are two rules in this step. One is that selecting potential suppliers is from the database of existing suppliers based on the brand of materials. Another is to develop new suppliers when the existing channel is not optimal; 3) sending inquiry, the company has owned Enterprise Resource Planning (ERP) system, the Bill of Materials (BOM) is converted to MS Excel as inquiry sheet. The sheet is sent out within 3 working days after receiving the client's orders. Additionally, the sheet is also sent to a potential supplier by an email, including quotation requirement, price quantity, delivery date & place, and terms of payment. The general due date is 3 working days for domestic orders and 5 working days for international orders; 4) inquiry for tracking, the company normally check the quotation because it makes sure that the quotation meets the requirements of clients. However, if suppliers are unable to send the quotation after the due date, quoted price is invalid and the customer has a right to decide whether to send another inquiry; 5) reject the orders, there are several scenarios that purchasers are able to reject the orders, such as inconsistency of description of materials, the incomplete manufacturing information, and fail to meet minimum order quantity; 6) price comparison and negotiation, it normally have at least twice to negotiate with suppliers regarding the price. The completed price negotiation is within 5 working days in domestic market and 10 working days in international market. In particular, a supplier needs to offer the rational Announcement of Price Adjustment if the previous ordered price cannot be made; 7) choosing final supplier and data submission, the company fills in the Supplier and Price Confirmation Sheet once the quotation is confirmed. All relevant data is loaded into ERP system. In terms of the Principle of Best Price, the company selects a final supplier to meet the requirements of customers. All procurement documents are sent to an auditor for review; 8) receive approval, this is a step after checked by auditors. The internal purchase manager has a right to decide the approval of the order less than RMB 20,000. However, the client firm can make a final decision when the order is over the amount. All processes should be circulated if the final price is not approved; 9) binding a contract, the contract is ready for

further review by an auditor after the order is approved. Then, the contract is sent to the supplier and get it back within 2 working day; 10) delivery tracking, purchasers and suppliers are able to track the status of delivery. Suppliers are responsible for replacement if the materials are not consistent in specified contract.

Company X reviews the performance of suppliers in a regular basis. There are five components: namely, delivery, price, quality, service, and flexibility. The company forms four categories (A, B, C and D) based on a final score for each supplier. The company offers additional bonus to suppliers who are in A category. However, the suppliers who are in D category receive the rectification notice firstly. If they would not significantly improve their performance, the company may terminate the cooperation with them and remove them from the database.

As a 3PP service provider, it requires to have closed relationships with suppliers. As long as one player is not cooperative, the overall performance evaluation is affected. There are two major difficulties mentioned by the company: 1) negotiation with suppliers, negotiation is not only for price, and also related to terms of payment, delivery time and warranty. The major objective for negotiation is to help clients obtain better goods/services in lower price. In addition, the service provider helps clients to receive reasonable compensation when they suffer losses or defaults of orders. It is serious for 3PP service provider to influence on attitudes of suppliers when they are in an asymmetry position; 2) new supplier development, supplier selection is a complicated process since 3PP service provider needs to consider of both 'hard' and 'soft' factors. The 'hard' factors include registered capital, time, and relevant certificate. The 'soft' factors deal with reputation, post-sales service, and quality of service. It is costly and timely for the service provider to collect and compare each merit of suppliers.

Maintaining good relationships is an important aspect in a procurement process. The relationship between a purchaser and supplier impacts on price, quality, terms of payment, and responsiveness (Khuram et al., 2015). The expectation of Company X aims to put the purchase price downwards. An increased raw material, transportation, and labour costs prevent the purchaser with a small purchase volume to get a cheap price. Negotiation with price becomes a major challenge in the process of maintaining relationships between two parties.

Quality assurance is one of key responsibilities for Company X. Normally, the company requires suppliers to strictly meet the requirements of material quality. Their supply channels for purchased materials should be transparent in order to increase visibility across supply chains. Additionally, Company X usually asks its suppliers to accept the term, stating that the payment would be paid after the arrival of orders. Due to the limited cash flow and capital turnover, many suppliers could not expect to make a payment in advance in consideration of financial risk. Some foreign firms are so far as to make a payment by cash before sending out the orders.

Quick response is a crucial indicator to measure the level of purchaser-supplier relationships. Having closed relationships helps Company X efficiently deliver its products to the customers. However, slow to respond the needs of customers may result in significant losses of profits. There are several behaviours to influence on a purchaser-supplier relationship mentioned by Company X: substandard products, transportation delay, ineffectively communicating with clients, and opaque bidding process. Suppliers also point out that lack of respect, unreasonable price reduction, deliberately setting up obstacles, and postponement of payment. These inappropriate behaviours have negative effects on developing effective relationships between purchasers and suppliers.

DISCUSSION

The automotive industry is a fast-growing industry in China, but the procurement is a major obstacle for the industry to increase the overall profitability (Xie et al., 2008). Automotive manufacturers have realized the importance of improving supply chain efficiency and reducing unnecessary costs. It is practical for those firms to consider outsourcing procurement activities to a professional third party. 3PP service providers are able to differentiate purchase processes based on the characteristics of their customers. The results of interviews from Company X illustrate that 3PP is still in the preliminary stage

of development in China (Shi et al., 2016a). Many automotive manufacturers notice the role of 3PP in their supply chains and consider seeking a third party to help them purchase non-critical raw materials at a cheap price.

Automotive manufacturers receive the benefits from outsourcing, including cost saving, focusing on core competence, and improvement of service quality (Goldsmith, 2003). The interviewees from Company X and its suppliers point out that 3PP can bring potential values for both parties, the relevant labour costs are saved and the efficiency of entire supply chains are ameliorated. It is important to comprehensively consider disadvantages of 3PP, such as disclosure of confidential information, difficulty to manage relationships, and loss of control for the purchase process.

From the aspect of suppliers, some of them do not recognize its role in a supply chain because 3PP is a new business model in China. A 3PP service provider timely and costly maintain relationships with its suppliers at the initial stage. Several behaviors identified in the early section reveals that both parties are lack of mutual respect, and the foundation of trust is not well established. Park (2010) reveals that trust can create a 'win-win' relationship, so Company X needs to deeply understand the current situations of its suppliers, such as capability, delivery, quality of materials, and technology, which are able to achieve a desired cooperative relationship with suppliers.

Leenders and Flynn (2006) propose a purchaser-supplier satisfaction model. There are four quadrants: satisfied for two parties, unsatisfied for two parties, satisfied only for each party. Theoretically, purchasers and suppliers have a positive attitude to make the satisfactions. In the scenario of Company X, both parties have realized the importance of 3PP, and are willing to cooperate with each other. Having high levels of satisfaction requires to have more closed business relationships for both parties. One party should continuously help the other increase the maturely satisfaction. Some proposed suggestions on behaviors as followed: From the perspective of suppliers, they should not constantly make same mistakes on a simple issue since purchasers do not expect that their suppliers carelessly offer the orders. Quickly responding to purchasers is an effective method to closely maintain good relationships, so the communication between two parties is transparent in the entire process, such as order quantity, price, quality of materials, and warranty. Suppliers should actively cope with a concern raised by customers, so presenting responsible suppliers is a good channel to build a trust with customers. In terms of the aspect of 3PP service providers, positioning a right attitude in communication with suppliers is a key for them. In a scenario of large consolidated volume, suppliers may not have strong arm's length to have fair negotiation processes with 3PP service providers since those providers with aggregated purchase volume is attractive for suppliers. Most importantly, the service providers have to treat all suppliers in a fair manner although suppliers are sometimes in an asymmetry position. Establishing fairness is a useful 'tool' to build up a trust mechanism for 3PP service providers and their suppliers. Having a long-term and stable collaboration should be relied on mutual understanding and equally support.

It is crucial to establish a well-known reputation across the entire industry because 3PP service providers perceive that they are easily ignored. Many suppliers are not fully aware of the necessity of cooperation with 3PP service providers. Having effective communication with suppliers and establishing trust mechanism are priority for the service providers. In collaboration with the giants of automotive manufacturers can push the suppliers to stay with the cooperation with 3PP service providers.

Price, quality, terms of payment, speed of response, and position of power result in the conflicts of interests between two parties. 3PP service providers need to seek a balance point to mitigate such conflict. Improving bilateral relationships between two parties is a potential to create a cooperative environment for future collaboration (Lewicki, 2015). The stability and enthusiasm of cooperation is influenced when the evaluation of supplier performance is effective. Using both 'hard' and 'soft' factors helps 3PP service providers to rationally assess the overall performance of suppliers. Offering feasible solutions encourage suppliers to work better, which is a pathway to maintain good relationships between two parties.

CONCLUSION

China has become an important country for international sourcing. China's automotive manufacturers are in the imperative position contributing to the national Gross Domestic Productivity (GDP). However, many automotive manufacturers face challenges dealing with multiple relationships with various suppliers, so it is crucial to seek a purchase professional service provider to conduct the purchase function on behalf of those firms. 3PP service is becoming a prevalent business model in the China automotive industry.

This research primarily describes the development of 3PP in the industry, and explore how a 3PP service provider better establish and maintain good relationships with suppliers. Using 3PP service helps China automotive manufacturers reduce relevant purchasing costs and focus on their core competence, such as quality of products and post-sales services. In addition, this study has revealed the 3PP operational process, identified the key factors influencing on satisfaction between 3PP service providers and suppliers, and indicate how 3PP service providers improve satisfaction between two parties. Furthermore, understanding the major conflicts between two parties is useful to seek a balanced point in order to mitigate the negative effects. Effectively and fairly measuring performance of suppliers is a best channel to build up a satisfactory level for 3PP service providers and their suppliers.

The contribution of this paper is a pilot research to examine the implementation of 3PP service in China's automotive industry. Based on a selected case, it deeply and comprehensively describes a 3PP service provider, revealing the importance of implementation of 3PP service in the automotive industry and highlighting the benefits for using such service. Identified factors to influence on relationships between two parties have practical significance to make a rational decision for managers. As an innovative business model, 3PP service providers with consolidated purchase volume from different automotive manufacturers have significantly power to influence negotiations with suppliers and manage the behaviors of suppliers, including quality of products, transparent purchasing process, and tracking delivery. The automotive manufacturers can receive low purchasing cost, enjoy 'one-stop' service, and focus on core competence. Meanwhile, suppliers are keen to maintain good relationships with 3PP service providers due to larger purchase volume.

There are several limitations in this research. First, we only focus on China's automotive industry. The future research may examine the implementation of 3PP service in different industries. Second, this research focuses on one specific company as it is effective to conduct an in-depth of a pioneer study for the implementation of 3PP service in the industry. Increasing the sample size would be another future direction. Third, we mainly use the qualitative method to analyse the current situation of 3PP service, so the further study may consider using a quantitative method to evaluate a possibility of 3PP service in a real business context.

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A STUDY ON THE PASSENGERS' TRAVEL MODES CHOICE BETWEEN TAIWAN AND ITS OFFSHORE ISLANDS

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Abstract

Purpose of this paper:

The cross Taiwan Strait direct shipping link and the three-mini cross strait shipping links via Quemoy and Matsu islands have encouraged many mainland Chinese tourists visit Taiwan and its adjacent offshore islands. Thus, travelling demands by aircrafts and ferries have greatly increased between Taiwan Island and its offshore islands. This research mainly discusses about passengers' travel mode choice behavior, and service quality is found to be one of the important factors influencing passengers' choice behavior.

Design/methodology/approach:

This research firstly reviewed transport mode choice literatures and then designed and distributed questionnaires to passengers who have the experience to travel by both aircraft and ferry to offshore islands. The Binary Logistic Regression technique is employed to analyze factors influence passengers' transport mode choice behavior.

Findings:

Research results indicate the convenience of aviation is the key factor influencing passengers' reveal preference as well as their stated preference to use the air transport mode. On the other hand, safety and reliability are the major factors positively influence travelers' reveal preference and stated preference to select ferries as their vehicle to visit offshore islands.

Value:

Conclusions and suggestions based on the results are provided to ferry carries and air carriers to improve their management strategies.

1. INTRODUCTION

Among many offshore islands of Taiwan, Pescadores Archipelagoes (i.e. Penghu), Quemoy Island, Matsu Island, Green Island, Orchid Island, and Liuqiu Island are six of the most popular tourist spots. Due to each of the six tourist spots has its own geographical location and geological features, thus the natural scenery and social culture in these six spots have their own uniqueness. Furthermore, Taiwan government has also promoted domestic travelling and sightseeing activities, the Taiwanese people are now keen to visit these offshore islands. In the early June 2000, Taiwan government has promulgated the Offshore Islands Development Act which allows three of the abovementioned large offshore islands to be act as a transshipment hub for unlimited tourists between Taiwan and the Mainland China. Thus, the amount of tourists from both Taiwan mainland and the Mainland China are attracted to visit these islands.

Taiwan has allowed the direct across-Taiwan Strait link in 2008, direct shipping and air transportation services are provided by several airlines and ferry operators in both Taiwan and the Mainland China. According to the Tourist Bureau of the Taiwan (2018), most of the visitors to Taiwan are here for sightseeing. It is estimated 71.22% of visitors are tourists. The numbers of tourists visit Taiwan is 7.65 million in 2017 which is 1.63 times and 4.64 times more than the same reported figure in 2012 and 2007. There are 2.73 million Mainland Chinese tourists visit Taiwan in 2017 which is 35.7% of tourist in Taiwan are from Mainland China.

According to the statistics reported by the Tourist Department of Penghu

County and Matsu County, the number of inbound visitors to these islands are summarized in the Table 1.

Table 1. Number of inbound visitors / Visitors arrivals in the three major offshore islands in Taiwan (Unit: pax. trip)

Year	102	103	104	105	106	Total
Matsu	106,413	108,485	105,525	122,783	132,479	575,685
Penghu	951,797	957,384	972,968	1,082,156	1,150,532	5,114,837
Quemoy	1,164,504	1,309,624	1,515,130	1,553,251	1,835,443	7,377,952
Total	2,222,714	2,375,493	2,593,623	2,758,190	3,118,454	13,068,474

Source: Matsu administration information website, Penghu county government tourism department

Ministry of Economic Affairs of Taiwan has announced to promote six emerging industries including medical treatment and care, cultural creativity, biotechnology, refined agriculture, sustainable energy, tourism and travel in 2009. For tourism and travel industry, the government has implemented different development strategies based on different regions to attract more tourists. Thus, Taiwan government has classified its offshore islands into several groups according to their natural resources: Penghu is positioned as "international resort" and "marine ecological journey archipelago", and Matsu and Quemoy are positioned as "battlefield landscape" and "folk culture archipelagoes" respectively.

Due to the geographical constraints, there are only two types of transport modes can be chosen between Taiwan and its three major offshore islands: namely ferries and aircrafts. Thus, passengers between these offshore islands and Taiwan have very limited transport modes choices and the extant researches on offshore island transport service mostly aims at discussing the service quality on one of these two transport modes. In addition, the weather is one of factors affecting passengers while choosing transportation mode. In winter, the ferries roll heavily due to the rough sea condition occurred by the occasional monsoons. Most of the passengers cannot stand the shaking and become seasick during their ferry trips. Thus, the amounts of passengers taking ferries are less than aircrafts. However, the visibility might affect by misty weather while traveling by aircraft and the aircraft would compel to give up its landing plans.

Generally, most of tourists go to offshore islands during peak season (from March to September). As for transportation modes choice, compared to shipping companies, airlines offer comfortable seats and frequent services. However, the air ticket price is twice more expensive than the ferry. For some of the passengers, they might not care about long time traveling by ferry and want to save money by buying cheaper tickets. Although ferry tickets are cheaper and shipping company offer safer voyage, but ferry services are easily affected by heavy weather. Moreover, with limited information accesses, less number of available voyages and the equipment onboard are old, and thus most of the passengers are not keen to take ferries to visit these offshore islands.

Table 2. Transportation modes choice between Taiwan and Penghu, Matsu

Transportation modes choice Offshore islands	Airlines services	Ferries services
Penghu	* Taipei-Taipei Songshan Airport (UNI Air, Mandarin Airlines, Far Eastern Air Transport) * Taichung- Taichung International Airport (UNI Air, Mandarin Airlines) * Chiayi- Chiayi Airport (UNI Air) * Tainan-Tainan Airport (UNI Air) * Kaohsiung-Kaohsiung International Airport (UNI Air, Far Eastern Air Transport)	* Chiayi- Budai Port (M/V All Star No.1, All Star NO.2, Today Star, Kai Shiuan No.3, Pescadores) * Kaohsiung-MaGong Port (M/V Tai Hwa)
Matsu	* Taipei-Taipei Songshan Airport (UNI Air) * Taichung-Taichung International Airport (UNI Air)	* Keelung-Port of Keelung (M/VTAI MA, M/V TAIMA STAR)
Quemoy	* Taipei-Taipei Songshan Airport (UNI Air, Mandarin Airlines, Far Eastern Air Transport) * Taichung- Taichung International Airport (UNI Air, Mandarin Airlines, Far Eastern Air Transport) * Chiayi- Chiayi Airport (UNI Air) * Tainan-Tainan Airport (UNI Air) * Kaohsiung-Kaohsiung International Airport (UNI Air, Far Eastern Air Transport)	NONE

Source: Matsu county tourism administration information website, Penghu county government tourism department

2.METHODS

2.1. Design of the questionnaire

According to SERVQUAL Model (1998, Parasuraman et al.) and Jen et al.(2005), this research sets six service dimensions including : (1) Comfort, (2) Convenience, (3) Safety, (4) Price, (5) Reliability, (6) Service. Also, the authors found 26 service attributes of these six dimensions to find out the factors that might affect passengers' transportation modes choice behavior.

Table 3. Dimensions and service attributes

Dimensions	Service Attributes
Comfort (CB)	(1) This vehicle (including aircraft/ferry) is very steady while navigating. (2) There is enough personal space in this transportation mode. (3) The seat is very comfortable. (4) The environment of this transportation mode and its terminal is clean. (5) The shuttle bus outside the terminal is very clean and comfortable.
Convenience (CN)	(1) There are multiple choices of shuttle outside the terminal. (2) The number of flights/voyages is adequate. (3) Convenient access to the airport/port. (4) Convenient egress to the airport/port. (5) It is convenient to buy the tickets. (6) The direction sign in the airport/port is clear and easy to understand. (7) The information of this transportation mode is clear.
Safety (SF)	(1) There are safety instructions and directions in the aircraft/ferry. (2) The pilot/captain of the flight/voyage is reliable and safe. (3) There is standard emergency equipment in the ferry/airplane. (4) Quarantines inspection in the airport/port is good to prevent disease propagation.
Price (PR)	(1) The ticket price is reasonable. (2) The discount of the ticket is reasonable. (3) The decrease/increase of the ticket price is reasonable.
Reliability (RL)	(1) The aircraft/ferry has punctual departure and arrival schedule. (2) The service interval between the voyages/flights is adequate. (3) The travel time of one voyage/flight is adequate. (4) The waiting time before boarding is adequate.
Staff's Service quality (SQ)	(1) The service attitude of the staff in the terminal is friendly. (2) The service attitude of the staff onboard the aircraft/ferry is friendly. (3) The staff offer wide range of information (e.g. offering different languages, guiding, answering questions)

Additionally, according to revealed preference theory (firstly proposed by American economist Paul Samuelson in 1948), this research collected the responses by distributing questionnaires to the passengers in the airport and ferry terminal directly and recorded the revealed preferences of these passengers in terms of their transportation modes choice in order to make sure the high reliability of their responses. Their responses are then analyzed by the binary logit regression technique offered in the SPSS software. Finally, several model specifications are suggested to predict if passengers want to take the ferry/airplane again or not.

Garvin (1984) identified the eight dimensions of quality. Perceived quality is one of these eight dimensions and suggested that information content is one of the bases of perceived product quality. According to him, "Product will be evaluated less on their objective characteristics than on their images, advertising or brand names." Thus, this research uses Likert 5-point scale, divided the level of

agreement into five, including "1 – Strongly disagree", "2 – Disagree", "3 – Neither agree or disagree", "4 – Agree", "5 – Strongly agree". The higher the score, the more the passengers are satisfied with the service given by that transportation mode.

The general demographic information of passengers has included the following variables: gender, age, occupation, income per month, and the marital status. Furthermore, the aim of taking ferry/airplane, the actual transportation modes choice and passengers' willingness to take ferry/airplane again are asked in the survey as well.

2.2. Research participants and Survey

Questionnaire survey is employed to carry out this study and it has included questions which the participants are expected to respond anonymously. Generally, passengers can travel to Quemoy county only by aircraft except during long vacations period and fog season. Once there is overcapacity for airline companies, the county government is used to arranging extra ferries to help evacuate passengers during these period and season. So, the participants in this study were passengers who have the experiences to travel by both aircraft and ferry only to Matsu and Penghu. In order to get the information, one of the authors have visited the ferry terminals and the airports and distributed the questionnaires in person from January to May in 2014.

Concerning the airplane passengers, this research has chosen passengers in the Taipei, Chiayi and Kaohsiung airports as potential respondents; on the other hand, concerning the ferry passengers, passengers in in the Keelung, Chiayi and Kaohsiung ferry terminal are surveyed.

There are 130 copies of questionnaires issued and collected, twelve copies of them were removed as the incomplete responses and the remaining 118 copies of responses are valid responses. The effective response rate was 90.77% as shown in table 5.

Table 4. Questionnaires distribution

Transportation modes	Questionnaires distributed in the origins (ferry terminals & airports)	Destinations
Aircrafts	Taipei Songshan Airport (Taipei)	Penghu, Matsu
	Chiayi Airport (Chiayi)	Penghu
	Kaohsiung International Airport (Kaohsiung)	Penghu
Ferry	Port of Keelung (Taipei)	Penghu, Matsu
	Budai Port (Chiayi)	Penghu
	Port of Kaohsiung (Kaohsiung)	Penghu

Table 5. Response of the questionnaires survey

Number of questionnaires distributed	130 (pc)
Number of questionnaires responded	130 (pc)
Number of valid questionnaires	118 (pc)
Effective response rate	90.77 (%)

This research employs binary logistic regression technique as the major research methodology and SPSS for windows 19.0 is used to process descriptive statistics and specify the binary logistic regression equation in order to find out the key factors affecting passenger's travel modes choice during their traveling to these groups of offshore islands.

Modeling travel behavior is a key aspect of demand analysis, where aggregate demand is the accumulation of individuals' decisions. The analysis of passengers' behavior is typically disaggregating, meaning that the models represent the choice behavior of a group of individual passengers. Discrete choice analysis is the methodology used to analyze and predict passengers' transport modes choice decisions.

2.3. Discrete Choice Models

The framework for a discrete choice model (Ben-Akiva and Bierlaire, 1999) can be presented by a set of general assumptions. Following elements are required to construct the choice model:

1. Decision-maker -- defining the decision-making entity and its characteristics;
2. Alternatives -- determining the options available to the decision-maker;
3. Attributes -- measuring the benefits and costs of an alternative to the decision-maker; and
4. Decision rule -- describing the process used by the decision-maker to choose an alternative.

Discrete choice models are also referred to as disaggregate models, meaning that the decision-maker is assumed to be an individual. The "individual" can be either a person or an organization. For instance, we may consider that a group of passengers in a company is the decision-maker. In doing so, we may ignore all internal interactions within the group, and consider only the decisions of the group as a whole. To explain the heterogeneity of preferences among decision-makers, a disaggregate model must include their socio-economic variables, including age, gender, education and income, and make sure to include these variables in the questionnaires.

2.4. Binary Logistic Regression

The Logistic Probability Unit, or the Logit Model, was first introduced in the context of binary choice where the logistic distribution is used. This study utilized binary logistic regression, which is a statistical technique used to predict an outcome variable that is dichotomous. In this case, a passenger chooses either ferry or airplane for their transportation modes to go to an offshore island around Taiwan. The dependent variable is that if the passenger wants to take this transportation mode again or not. The 26 independent variables exhibited in Table 3 are further divided into the following six dimensions: Comfort(CB), Convenience(CN), Safety(SF), Price(PR), Reliability(RL), and Staffs' Service Quality(SQ).

3. RESEARCH RESULTS AND DISCUSSION

In order to analyze the data, descriptive statistics is discussed after questionnaires are returned by the respondents. Respondents' demographic data are analyzed in Table 6.

Moreover, this research has also compared passengers' model choice behavior according to different demographic data of these respondents. We found that there are 57 male passengers who take aircraft (78.1%) and 16 male passengers who take ferry (21.9%); 34 female passengers take aircraft (75.6%) and 11 female passengers take ferry (24.4%). Comparing the respondents' monthly income, this research uses \$20,000 NTD as an interval and the majority of passengers (90.6%) with monthly income between \$30,000 and \$50,000 have chosen aircraft as their transport vehicle to these three offshore islands. Interestingly, only 57.1% passengers with their monthly salary above \$70,000 have chosen to use the airline to travel to these offshore islands.

Table 6. Participants' personal data analysis

		Passengers' model choice		Percent
		Aircraft	Ferry	
Gender	Male	57	16	73
		78.1%	21.9%	100.0%
Gender	Female	34	11	45
		75.6%	24.4%	100.0%
Age	Under 20	6	3	9
		66.7%	33.3%	100.0%
	21-30	59	16	75
		78.7%	21.3%	100.0%
	31-40	16	4	20
		80.0%	20.0%	100.0%
Age	41-50	4	2	6
		66.7%	33.3%	100.0%
Age	Over 51	6	2	8
		75.0%	25.0%	100.0%
Education	Without Bachelor degree	20		16.9%
	Bachelor degree	65		55.1%
	Master degree	32		27.1%
	PhD degree	1		0.8%
Residence	Northern Taiwan	55		46.6%
	Central Taiwan	14		11.9%
	Southern Taiwan	33		28.0%
	Eastern Taiwan	0		0.0%
	Offshore islands	16		13.6%
Marital status	Single	70	21	91
		76.9%	23.1%	100.0%
Marital status	Married	21	6	27
		77.8%	22.2%	100.0%
Monthly Income	Under \$10,000 NTD	22	6	28
		78.6%	21.4%	100.0%
	\$10,000-30,000 NTD	33	11	44
		75.0%	25.0%	100.0%
	\$30,000-50,000 NTD	29	3	32
		90.6%	9.4%	100.0%
Monthly Income	\$50,000-70,000 NTD	4	3	7
		57.1%	42.9%	100.0%
Monthly Income	Over \$70,000 NTD	3	4	7
		42.9%	57.1%	100.0%
Occupation	Student	38		32.2%
	Civil servant	16		13.6%
	Manufacturing Industry	7		5.9%
	Self-employed	21		17.8%
	Service Industry	20		16.9%
	Unemployed	8		6.8%
	Others	8		6.8%
Willing to take aircraft again	Yes	114		96.6%
	No	4		3.4%
Willing to take ferry again	Yes	78		66.1%
	No	40		33.9%
Passengers' model choice	Aircraft	91		77.1%

	Ferry	27	22.9%
Purpose of traveling	Work	11	9.3%
	Visit families, Tourism	107	90.7%

3.1 Aspects of service quality analysis

In order to measure the service quality of a transport mode, passengers' satisfaction on the following six service attributes are shown in Table 7 for the airlines and ferry companies.

Table 7. Passengers' satisfaction on the six service attributes

Transport Modes	Service Attributes	Average	Standard deviation	Ranking
Airlines	Comfort (CB)	3.7780	0.66296	3
	Convenience (CN)	3.7179	0.62297	4
	Safety (SF)	4.1059	0.60923	2
	Price (PR)	2.9153	0.89547	6
	Reliability (RL)	3.6292	0.63862	5
	Staff's Service quality (SQ)	4.1497	0.80312	1
Ferry	Comfort (CB)	3.2525	0.82501	5
	Convenience (CN)	3.2143	0.71921	6
	Safety (SF)	3.7500	0.73015	1
	Price (PR)	3.3955	0.95278	3
	Reliability (RL)	3.2627	0.87024	4
	Staff's Service quality (SQ)	3.5565	0.89533	2

In general, passengers are highly satisfied with Staff's service quality(SQ) and Safety(SF) offered by both transport modes. For airlines passengers, they are unsatisfied with the Price(PR). On the other hand, for ferry passengers, Convenience(CN) is ranked as the least satisfied service attribute.

Multicollinearity is a problem in regression analysis that occurs when two independent variables are highly correlated. According to Gujarati (1995), collinearity exists if $|r| > 0.80$. After examining, the correlation coefficient between each variable in this research are all under 0.8 and shown in Table 8. Consequently, collinearity between these service attributes is not existed in this research.

Table 8. Correlation matrix for six service attributes

Transport Modes Choice		Air					Ferry						
Service Attributes		CB	CN	SF	PR	RL	SQ	CB	CN	SF	PR	RL	SQ
CB-air	Pearson Correlation	1											
	Sig. (2-tailed)												
CN-air	Pearson Correlation	.479*	1										
	Sig. (2-tailed)	.000											
SF-air	Pearson Correlation	.466*	.419*	1									
	Sig. (2-tailed)	.000	.000										
PR-air	Pearson Correlation	.404*	.398*	.235*	1								
	Sig. (2-tailed)	.000	.000	.011									
RL-air	Pearson Correlation	.499*	.495*	.560*	.537*	1							
	Sig. (2-tailed)	.000	.000	.000	.000								
SQ-air	Pearson Correlation	.506*	.455*	.612*	.361*	.552*	1						
	Sig. (2-tailed)	.000	.000	.000	.000	.000							
CB-ferry	Pearson Correlation	.586*	.350*	.326*	.233*	.418*	.176	1					
	Sig. (2-tailed)	.000	.000	.000	.011	.000	.057						
CN-ferry	Pearson Correlation	.509*	.607*	.324*	.496*	.608*	.333*	.584*	1				
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000					
SF-ferry	Pearson Correlation	.453*	.292*	.582*	.169	.431*	.362*	.614*	.438*	1			
	Sig. (2-tailed)	.000	.001	.000	.068	.000	.000	.000	.000				
PR-ferry	Pearson Correlation	.501*	.415*	.376*	.652*	.547*	.463*	.329*	.474*	.337*	1		
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	.000	.000			
RL-ferry	Pearson Correlation	.516*	.296*	.241*	.437*	.555*	.285*	.582*	.624*	.418*	.513*	1	
	Sig. (2-tailed)	.000	.001	.009	.000	.000	.002	.000	.000	.000	.000		
SQ-ferry	Pearson Correlation	.504*	.368*	.457*	.311*	.484*	.499*	.575*	.633*	.574*	.403*	.487*	1
	Sig. (2-tailed)	.000	.000	.000	.001	.000	.000	.000	.000	.000	.000	.000	

** . Correlation is significant at the 0.01 level (2-tailed).

* . Correlation is significant at the 0.05 level (2-tailed).

3.2. Discussion between service qualities and willing to take aircraft again

Both the descriptive statistics and the binary logistic regression techniques are employed to analyze the data collected from the survey.

This research sets the collected data of six service attributes of aircraft as independent variables, and their willingness to take aircraft again as dependent variable. The Hosmer-Lemeshow test results are shown in Table 9. The p-value ($p=1$) is above $\alpha = 0.05$, so the null hypothesis that the observed and expected proportions are the same is not rejected which indicates that the model is a good fit.

The classification of passengers' willing to take aircraft again is shown in Table 10 was predicted and the results show that 114 out of 114 passengers who chose "Yes" were correctly classified representing 100%; 4 out of 4 passengers who chose "No" were correctly classified representing 100%. In addition, the overall accuracy

of passengers' willing to take ferry again is 1, which means that the model is estimated to give an 100% of accurate prediction. The classification of passengers' willingness to take ferry again is shown in Table 12.

Table 9. Hosmer and Lemeshow Test- Aircraft

Step	Chi-square	df	Sig.
1	.000	8	1.000

Table 10. Classification table of passengers' willingness to take aircraft again

Observed		Predicted		
		Passengers' willing to take aircraft again		Percentage Correct
		Yes	No	
Passengers' willing to take aircraft again	Yes	114	0	100.0
	No	0	4	100.0
Overall Percentage				100.0

(The cut value is 0.5)

Among 6 aspects, convenience of aircraft ($\beta = 2.229$, $p=0.022 < 0.05$) significantly positively affect the probability of choosing aircraft again as shown in Table 11. Thus, if airline companies can improve their degree of service convenience, the passengers are more likely to choose aircraft again traveling to offshore islands.

Table 11. Variables in the equation of passengers' willing to take aircraft again

	β	S.E.	Wald	df	Sig.	Exp(β)
CN-air	2.229	0.974	5.235	1	0.022*	9.286

3.3. Discussion between service qualities and willing to take ferry again

This research sets the collected data of six service aspects of ferry as covariate, and willing to take ferry again as dependent variable. The Hosmer-Lemeshow test results are shown in Table 12. The p-value ($p=0.577$) is above alpha = 0.05, so the null hypothesis that the observed and expected proportions are the same is not rejected which indicates that the fitness of the model is good.

Table 12. Hosmer and Lemeshow Test- Ferry

Step	Chi-square	df	Sig.
1	6.632	8	.577

The classification of passengers' willing to take ferry again was predicted and the results show that 65 out of 77 passengers who chose "Yes" were correctly classified representing 84.4%; 22 out of 40 passengers who chose "No" were correctly classified representing 45%. In addition, the overall prediction accuracy of passengers' willing to take ferry again in this model is 0.709, which means that the model is estimated to give a 70.9% of accurate prediction. The classification of passengers' willingness to take ferry again is shown in Table 13.

Table 13. Classification table of passengers' willingness to take ferry again

Observed		Predicted		
		Passengers' willing to take ferry again		Percentage Correct
		Yes	No	
Passengers' willing to take ferry again	Yes	65	12	84.4
	No	22	18	45.0
Overall Percentage				70.9

(The threshold of alpha value is 0.5)

Among 6 service attributes, "Safety of ferry" ($\beta = 1.015$, $p=0.012<0.05$) and "Reliability of ferry" ($\beta = 1.454$, $p=0.000<0.001$) have significantly positively affected the probability of passengers' willingness to take ferry again as shown in Table 14. Thus, if shipping companies improve their performance on the safety and reliability service attributes, the passengers are more likely to take ferry again to travel to offshore islands.

Table 14. Variables in the equation of passengers' willing to take ferry again

	β	S.E.	Wald	df	Sig.	Exp(β)
SF-ferry	1.015	0.402	6.361	1	0.0120*	2.759
RL-ferry	1.454	0.415	12.286	1	0.0000**	4.279

3.4. Discussion between service qualities and passengers' modes choice

This research sets the collected data of six service aspects of two transportation modes as covariate, and passengers' model choice as dependent variable. The Hosmer-Lemeshow test results are shown in Table 15. The p-value (0.934) is above alpha = 0.05, so the null hypothesis that the observed and expected proportions are the same is not rejected which indicates that the model has a good fit.

Table 15. Hosmer and Lemeshow Test- Passengers' model choice

Step	Chi-square	df	Sig.
1	3.009	8	.934

The classification of passengers' model choice was predicted and the results show that 84 out of 90 passengers who chose Aircraft were correctly classified representing 93.3% of prediction accuracy; 16 out of 27 passengers who chose Ferry were correctly classified representing 40.7% of prediction accuracy. In addition, the overall accuracy of passengers' model choice is 0.812, which means that the model is estimated to give an 81.2% of accurate prediction. The classification of passengers' willingness to take ferry again is shown in Table 16.

Table 16. Classification table of passengers' model choice

Observed		Predicted		
		Model Choice		Percentage Correct
		Aircraft	Ferry	
Model Choice	Aircraft	84	6	93.3
	Ferry	16	11	40.7
Overall Percentage				81.2

(The cut value is 0.5)

Table 17. Service attributes in the equation of passengers' model choice

Parameters Attributes	β	S.E.	Wald	df	Sig.	Exp(β)
CN-air	1.061	0.454	5.456	1	0.02*	2.889
SF-ferry	0.876	0.422	4.311	1	0.038*	2.4
RL-ferry	1.112	0.369	9.08	1	0.003*	3.039

Among 6 aspects of two transportation modes, Convenient of aircraft ($\beta = 1.016$, $p=0.02<0.05$) and Safety of ferry ($\beta = 0.876$, $p=0.038<0.05$) and Reliability of ferry ($\beta = 1.112$, $p=0.003<0.05$) has significantly positively affected the probability of passengers' model choice as shown in Table 17. Thus, if airline companies improve their performance on the Convenience of services, the passengers are more likely to choose aircraft traveling to offshore islands. On the other hand, if shipping companies improve their performance on the Safety and Reliability services, the passengers are more likely to choose ferry to travel to offshore islands.

4.CONCLUSION

The purpose of this study is to discuss the key factors that affect passengers' transportation modes choice behavior to travel to offshore islands. A wide range of service attributes which might affect passengers' transport modes choice is investigated, and their marginal effects on the passengers' decision-making are estimated. Some key service attributes were discovered. The service attributes could be employed by airlines, ferry operators, airport operators, and ferry terminal operators to improve their services.

4.1. The relationship between service qualities and passengers who take aircrafts

According to the result, among six service quality aspects, a positive correlation exists between only Convenience(CN) and passengers' willingness to take aircraft again which is a good model to predict passengers' model choice behavior. As a result, if the airline companies could upgrade their performance on the Convenience(CN) attribute, passengers are more willing to take aircraft to travel to offshore islands and the probability to correctly predict airlines passengers' transport modes choice would be higher.

4.1.1. Suggestions to airline companies

Airline companies are used to offer convenient, comfortable and quick services, and largely reduce the in-vehicle travelling time. According to Table 7, Convenience(CN) is ranked as the 4th important among 6 investigated service attributes and its average score is 3.72, and its standard deviation value is 0.62, which indicated that only some of responding passengers are satisfied with the Convenience(CN) offered by the airlines.

After interviewing passengers, we suggest airline companies can improve their performance on Convenience(CN) service attribute by simplifying booking systems. With the ever-changing nature of technology, buying tickets online or an application in the mobile phone has become an evitable trend. However, many of old passengers are not familiar with the booking system online and usually buy tickets at the same day before boarding. For example, they can offer more information on how to book a seat and purchase airtickets (such as television ads and flyers). Hopefully it could improve the booking and purchasing inconvenience for old passengers.

Additionally, although Staffs' service quality(SQ) is ranked as the most important service attribute, there are still some passengers did not satisfy with airlines service quality during our in-field survey at the airports. So, the different ways how airlines train their employees and staffs' different personalities or characteristics and the way they solve problems might affect passengers' satisfaction. As a result, we suggest airline companies should evaluate their staffs' performance regularly to understand the current problems they have encountered

to improve the service better and raise passengers' willing to take aircraft traveling to offshore islands.

4.1.2. Suggestions to airports

Nowadays, there are shuttle buses in the terminals for Taipei Songshan Airport, Taichung International Airport and Kaohsiung International Airport. Moreover, it is really convenient for passengers to go to the airports by Mass Rapid Transit (MRT) in Taipei and Kaohsiung, offering passengers more options. However, for Chiayi, there are no public transportation to connect Chiayi airport with Chiayi downtown and has resulted in inconveniences for passengers using this airport. As a result, this research suggests the airline companies to plan adequate routes to build a connection network to offer a convenient access to the Chiayi airport to increase passengers' willingness to take aircraft traveling to offshore islands.

4.2. The relationship between service qualities and passengers who take ferries

According to the research findings, Safety(SF) and Reliable(RL) service attributes have positive effect on passengers' willingness to take ferry again. Thus, if shipping companies can improve their performance on their safety and reliable service attributes, passengers are more willing to take ferry traveling to offshore islands and the probability of passengers' model choice of ferry would be increased.

4.2.1. Suggestions to shipping companies

According to Table 7, Safety(SF) is ranked the most important service attribute for ferry passengers and it also indicates passengers are satisfied with the current Safety services provided by shipping companies. Besides, as one of the authors has interviewed ferry riders at the sea port passenger terminal, this research suggests ferry companies could provide their safety instructions with greater details. For example, playing safety instruction videos in the ferry during the sea passage or before the ferry departures from the passenger terminal, which could make passengers familiar with the safety instructions. Another suggestion is that ferry operators should have their daily maintenance and checking with their ships to enhance their safety performance. And these ferry operators can also exhibit their safety certificates on their official website or at the tickets counter in the passenger terminal to ensure their passengers feel safe during the trip.

Weather condition can seriously interrupt ferry companies' service schedules, so the ferry operators should evaluate the weather conditions carefully before they allow the ferry ships to departure from the terminal. Also, they should ensure the seaworthiness of their ferries. Once the ferries' service schedule is delayed, the ferry companies should notify their passengers in advance to let them know the situation and to notify the passengers how much time they have to wait at the terminal.

4.2.2. Suggestions to Taiwan International Ports Corporation (TIPC)

The peak season for ferry riding is always in the summer and the weather is really warm in Taiwan then. After the interview with ferry passengers at the port, we suggest Taiwan International Ports Corporation to expand its ferry terminal and add more chairs in the waiting areas in its passenger terminals. Additionally, TIPC could provide covers among the corridor from passenger terminal to ferries berth to make passengers feel more comfortable. Finally, these improvements will raise passengers' willingness to choose ferry to travel to offshore islands.

Last, there are decreasing limitations on the traveling between offshore islands and mainland China. The offshore islands are now positioned as intermediating connection stops across the Taiwan Strait. It was found that with the promotion of our previous government officers, there were increasing travelling activities between Taiwan and China. To sum up, airlines, ferry operators, the seaport company and the airport company could use these research suggestions to improve their performances on these important service attributes. In short, these stakeholders can provide excellent and well-organized services to meet different passengers' requirements and finally increase passengers' willingness to choose either aircraft or ferry to travel to these offshore islands.

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OPERATIONAL FRAMEWORK FOR HEALTHCARE SUPPLIER SELECTION UNDER A FUZZY MULTI-CRITERIA ENVIRONMENT

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PURPOSE: This paper studies how a logistics service provider managing the suppliers for several hospitals can innovatively improve the supplier selection process. The paper examines the attribute set for healthcare supplier selection such as response time, reliability, stock quantity, in order to realize optimal cube utilization, cost, and customer satisfaction. This operational framework developed can help a logistics service provider in supplier order management based on the selected criteria set, criteria weight calculation, and supplier ranking under a fuzzy multi-criteria decision making (MCDM) environment.

DESIGN/METHODOLOGY/APPROACH: We adopt a multi-objective decision making approach based on three main criteria of service, cost, and disruption risk. The following modelling approaches are used – (i) the criteria weight are found using fuzzy AHP, and (ii) the ranking of the suppliers are found through fuzzy TOPSIS.

FINDINGS: Sometimes a logistics service provider needs to include multiple suppliers for one product instead of the current single supplier policy, in order to share the risks especially when dealing with public health emergencies and uncertainty in disruptions.

VALUE: This is a practical industrial problem dealing with various facets of MCDM being applied on actual data, so as to bring to bear the actual challenges of using MCDM in dealing with healthcare supplier management.

RESEARCH LIMITATIONS/IMPLICATIONS: Some future extensions and current limitations of this work will include the sole suppliers, namely, suppliers who are exclusive providers of certain unique products mandated by the healthcare regulators, and to include the effects of shelf life and perishability into the products such as the biodegradable sutures.

PRACTICAL IMPLICATIONS: This study can help the healthcare logistics service provider to use data judiciously to select and manage the suppliers optimally, without the unnecessary incurrence of buffer stock at the warehouse, which can lead a high degree of obsolescence.

KEYWORDS: Healthcare, Supplier Selection, MCDM, Fuzzy, AHP, TOPSIS

1. Introduction

The healthcare industry is an important industry especially given the current need for and attention on providing better quality and speedier response to patient care in the hospital. To manage the supply chain of this sector is just as important as the lead time to respond to patient needs at the operating table, and providing quality medical attention depends very much on what happens upstream in the supply chain, invariably beyond the hospital. To ensure quality patient care and service delivery, the choice of suppliers becomes critical in as far as timeliness, quality, reliability, and cost are concerned. Indeed, maintaining a tight control on cost is just as critical given the unwelcome news of price increases on hospital services throughout the world. One common practice used in managing the logistics cost is to practise an outsourcing model whereby the selection, management, and quality assurance of the non-critical medical products is placed under the wings of the logistics service provider as part of the value added service operating regime. In short, the logistics service provider now has to perform over and above the traditional functions of delivery, warehousing, stock control, to include supplier selection, supplier certification, and vendor managed inventory at the hospital on behalf of the suppliers. The reasons for doing so is clearly obvious when viewed through the lenses of the resource based view (Barney 1991) and transaction cost economics (Williamson, 1981). Hospitals simply do not have the expertise to manage and select suppliers for all the products needed for use in a hospital. As highlighted by Prahalad and Hamel (1990), it is simply not their core competence. At the same time, outsourcing to a seasoned hand, the logistics service provider, seems the obvious route to take as the latter would have sufficient economics of scale in warehousing, delivery, operations to lower the cost of transactions at each point of the supply chain. Supplier selection is no exception.

While scholars such as Milgrom and Roberts (1992) have argued that there are many ways to structure an organization innovatively and efficiently through a better coordination of their activities such as that of outsourcing, little is offered by way of prescribing an implementable framework for doing so, especially in Asia where much of the selection is relationship driven.

Therefore, this paper focuses on providing an operational framework for healthcare supplier selection under a multi-criteria decision making (MCDM) setup, operating in a fuzzy environment. In particular, this case study paper looks at the state and practice of healthcare management in Singapore through the lens of a logistics service provider, using the traditional approach of MCDM. For the purpose of this study, we will consider the case of the medical examination gloves, the latex and nitriles.

We discuss the following. One of the tasks for the operational framework is to establish a criteria set for supplier selection unique to the healthcare sector, namely, with an overall consideration to the response time, reliability and risk of the suppliers, stock quantity to be maintained at each echelon so as to realize the optimal cube utilization, logistics cost, and customer satisfaction. The literature is replete with theoretical models for doing so, for example, Mendoza and Ventura (2012).

This paper is structured as follows. Section 1 provides the necessary introduction and background to our problem at hand. Section 2 highlights the prevailing practice used by the case firm, STL, when evaluating the suppliers of the medical examination gloves. At the same time, we provide a streamlined and improved criteria selection set. Section 3 then develops the operational framework for supplier selection when operating under a multi-criteria, fuzzy environment. Section 4 discusses how the decision results can be obtained using the closeness

coefficients and highlights some practical realities or limitations in the framework and concludes with some suggestions for future work.

2. Practice of STL in Supplier Selection

The prevailing practice of the STL is to use the following criteria found in Figure 1 to evaluate their suppliers on determining which supplier to provide the medical examination gloves for both the latex and nitrile types. It can be seen that apart from the four mandatory critical criteria (compliance to tender, supplier recognized by the Health Ministry, appropriately certified, supply to specifications), there are also four non-critical criteria (price, product quality, product shelf life, and track record of the supplier).

TYPE	GLOVES, MEDICAL EXAMINATION	Weightage	Vendor A	Vendor B	Vendor C	Vendor D	Vendor E
Critical Compliance	1. Full compliance with Instructions to Tenderers and Conditions of Contract. The Tenderer shall not change the text of the Invitation to Tender, including but not limited to the Instructions to Tenderers and Conditions of Contract.		Comply / Non Comply/	Comply / Non Comply/	Comply / Non Comply/	Comply / Non Comply/	Comply / Non Comply/
	2. Must not be suspended or debarred by the Standing Committee on Debarment, c/o Ministry of Finance, from participating in Government Invitations to Tender.		Comply / Non Comply/	Comply / Non Comply/	Comply / Non Comply/	Comply / Non Comply/	Comply / Non Comply/
	3. Comply with Health Products Act (Cap 122D) Health Products (Medical Devices) Regulations 2010, any licensing conditions and any applicable legislative requirements.		Comply / Non Comply/ Not Applicable	Comply / Non Comply/ Not Applicable	Comply / Non Comply/ Not Applicable	Comply / Non Comply/ Not Applicable	Comply / Non Comply/ Not Applicable
	4. Mandatory requirements of the specifications (1 to 12)		Comply / Non Comply/	Comply / Non Comply/	Comply / Non Comply/	Comply / Non Comply/	Comply / Non Comply/
Non-Critical Compliance	1. Price : Tender Price plus Storage Cost	X %					
	2. Non-Price : (30%)						
	2a. Users' evaluation scores on comfort, fit, product quality.	Y %					
	2b. Product Shelf Life at delivery >= 57 months - 3% >= 54 months - 2% >= 48 months - 1% < 48 months - 0%	Y1 %					
	2c. Track record >= 3 years - 2% >= 2 years - 1% < 2 years - 0%	Y2%					
TOTAL							
Remarks							

Figure 1: Criteria for evaluating suppliers of medical examination gloves

Clearly, some criteria overlap. From the current critical compliance and non-critical compliance of the product list of the medical examination gloves maintained by STL, as well as drawing from the related literature review, we proceed to improve and construct a decision hierarchy structure for STL's supplier selection, in which we establish a criteria set containing 3 main criteria and 11 sub-criteria. Doing so will help the decision maker to better prioritize the weightage based on service attributes rather than mere technical specifications, and draw performance indicators from a logistics angle. Table 1 provides a description of the list of criteria and their sub-criteria.

Table 1: Criteria set for selecting STL's suppliers

Main criteria	Sub-criteria	Description
Service (S)	Compliance with tender (S ₁)	Degree of compliance to the specification and requirement in the Invitation To Tender (ITT). It is high when the supplier has less non-compliance on the terms of the tender.
	Product quality (S ₂)	Percentage of products which meet STL's expectations on quality. It can be measured by the amount of damaged and deteriorated products, and customer experience of comfort and perceived ease of use of products.
	Product shelf life (S ₃)	Length of the product shelf life on delivery.
	Past performance (S ₄)	Track record of the supplier, position/reputation in the market either in terms of customer or transaction volume, and the evidence of undamaged deliveries, on time and in full loads in the healthcare industry if possible.
	Response time (S ₅)	Lead time taken by supplier to process STL's order request, arrange for production and shipment, and provide after-sales service.
Cost (C)	Price (C ₁)	Holding cost + purchase cost. Supplier who can consolidate stock for disposal, help monitor to the cost of the product, or actively choose to streamline cost on behalf of STL has higher priority.
	Investment in R&D (C ₂)	Percentage of supplier's investment dedicated to R&D activities such as product design, prototype development and the use of new technologies.
Risk (R)	Output flexibility (R ₁)	The manufacture and dispatch flexibility level of products in case of demand surges due to public health emergencies.
	Buffer capacity (R ₂)	Percentage/quantity of the buffer inventory of the supplier to cope with emergency orders so as to reduce the risk of stockouts.
	Political & economic stability (R ₃)	Political stability of the supplier's country and its attitude to business policies may affect long term relationship between STL and potential supplier.
	Geographical location (R ₄)	Supplier location, physical and social status. The origin country of the supplier, the location of plant, the nature of natural calamities and other risk factors should be checked.

Based on the criteria set, we then develop the following decision hierarchy structure in Figure 2 to help STL to select the medical examination gloves suppliers. It can be seen that the first level is the goal/ objective of the tender exercise. The second level is the criteria set encompassing the 11 detailed criteria. The third level is the set of potential suppliers Sp_i who will be assessed by the 11 criteria and the decision-makers can then choose one or several suppliers based on the results obtained from the supplier evaluation process. The template was designed specifically to ensure that all the decision criteria can be readily measured using the transactional data obtained by STL from the tender exercise. However, in reality, some of the data are provided in qualitative response form such as criteria S_2 (product quality) which can be stated as excellent, good, average, or okay. This immediately introduces the notion of fuzziness and calls for the need to introduce fuzzy MCDM into the supplier evaluation process.

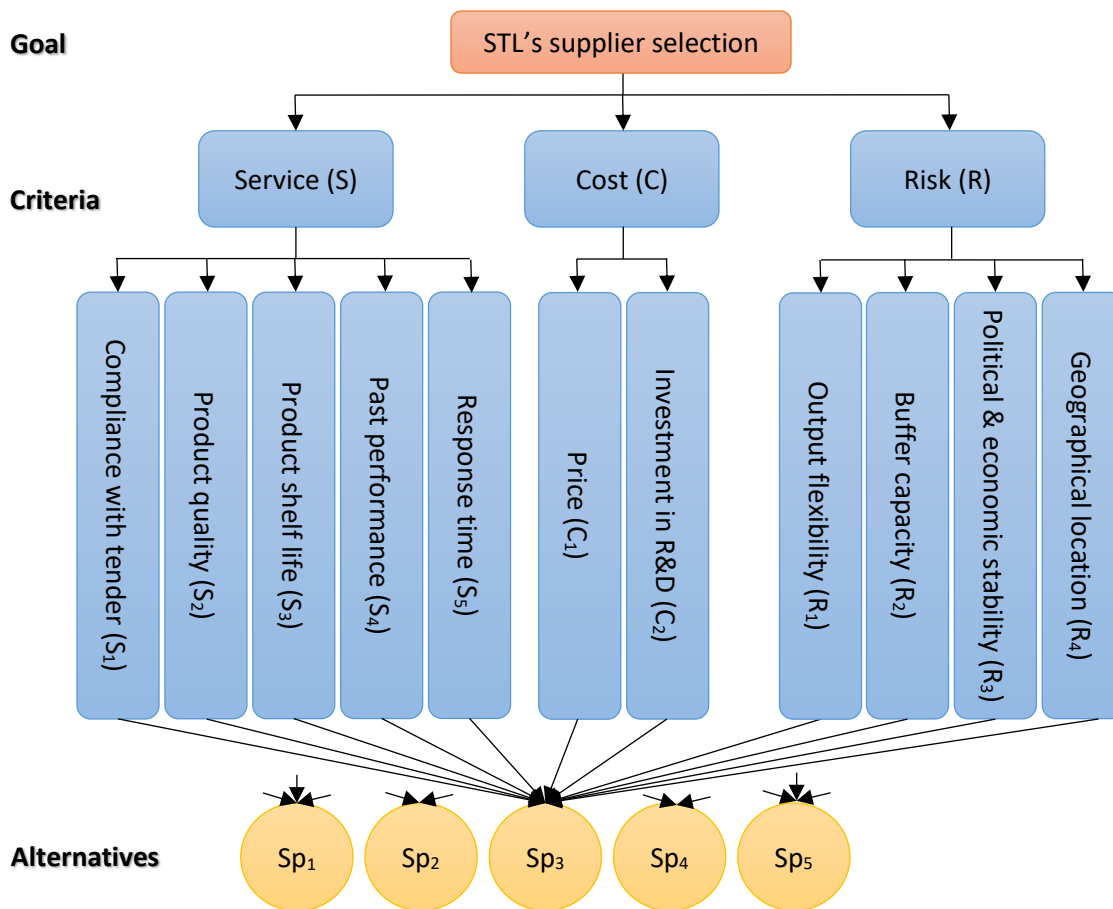


Figure 2: Decision hierarchy structure for STL's supplier evaluation

3. Operational framework for supplier selection and order management

Next, we present the proposed 4-stage operational framework (see Figure 3). There are several phases in this framework, structured as follows. Phase I deals with the criteria set formulation (which was previously presented in Section 2), Phase II concerns computing the weightage of the criteria using fuzzy AHP. Phase III involves the supplier rank determination

through fuzzy TOPSIS, so as to help the decision makers to choose the “best” supplier(s). We will briefly mention each of the phases.



Figure 3: Phased operational framework for supplier selection

Phase I. Criteria set formulation

As STL had to choose from 5 potential suppliers, an expert panel of decision makers comprising two senior managers, operations specialist, and hospital user were selected. The criteria set was identified and formulated by the decision group, and the decision hierarchy structure was developed through Figure 2. The decision hierarchy structure is the output of this phase and serves as the input for the next phase.

Phase II. Criteria weight computation using fuzzy AHP

After forming the decision hierarchy, the weights of the criteria are found through the fuzzy AHP method, and they are the output of this phase and the input of the next phase. Analytical hierarchy process (AHP) first introduced by Saaty (1980) is a quantitative technique that structures a multi-criteria, multi-person, multi-period problem hierarchically so that realistic solutions are facilitated. Fuzzy AHP extends Saaty’s AHP by combining AHP with fuzzy set theory to solve practical industry relevant hierarchical fuzzy problems. Fuzzy AHP can capture the subjective imprecise judgment of the experts by handling the linguistic variables (see Junior et al. (2014), and Patil and Kant (2014) for more details). The steps for fuzzy AHP in this phase are as follows.

Step 1. The decision group defines the scale of relative importance used in the pairwise comparison matrices.

Step 2. Construct fuzzy comparison matrices.

By using a linguistic scale, the decision group can then make pairwise comparisons for main criteria and sub-criteria. For example, from our interaction with STL, the cost criterion is moderately more important than the risk criterion, and strongly more important than the service criterion, while the risk criterion is equally important with the service criterion. Then the consistency ratio (CR) for each matrix is found. If the value of the CR is no more than 0.2, then consistency of the comparison matrix is considered as acceptable, otherwise the decision group would need to revise the original comparison values in the pairwise comparison matrix until the consistency check is met. While this rule can upset the objectivity of the decision made, it also allows for the decision makers to tweak their judgement until consensus is reached.

Step 3. For each pairwise comparison matrix found in Step 2, the fuzzy synthetic extent is computed using a rigorous mathematical formula.

Step 4. The degree of possibility between two fuzzy synthetic extents is found.

Step 5. The degree of possibility over all other fuzzy synthetic extents is computed.

Step 6. The weight vector of the fuzzy comparison matrices is found.

After normalizing the local weights of the sub-criteria, the global weight can be obtained as shown in Table 2.

Table 2: Weights of criteria for supplier evaluation (criterion importance)

Main criteria	Weight of main criteria	Sub-criteria	Local weight of sub-criteria	Global weight of sub-criteria	Weight rank
Service (S)	0.030956	Compliance with contract (S_1)	0.585155	0.018114	6
		Product quality (S_2)	0.349624	0.010823	7
		Product shelf life (S_3)	0.064051	0.001983	8
		Past performance (S_4)	0.000585	0.000018	10
		Response time (S_5)	0.000585	0.000018	10
Cost (C)	0.691166	Pricing (C_1)	0.999001	0.690475	1
		Investment in R&D (C_2)	0.000999	0.00069	9
Risk (R)	0.277878	Output flexibility (R_1)	0.345761	0.096079	2
		Buffer capacity (R_2)	0.307825	0.085538	3
		Political & economic stability (R_3)	0.196295	0.054546	4
		Geographical location (R_4)	0.150119	0.041715	5

Phase III. Supplier rank determination by fuzzy TOPSIS

After getting the weights of all of the 11 criteria (Table 2, column 5), the fuzzy TOPSIS method is used to rank the potential suppliers. TOPSIS, or the technique for order performance by similarity to ideal solution, is a traditional MCDM method first developed by Hwang and Yoon (1981). In the TOPSIS approach, personal judgments are expressed as deterministic values. In reality, any measurement taken using crisp values is not always possible. A better approach is to utilize the linguistic variables rather than deterministic ones. In this regard, fuzzy set theory can be used to represent the linguistic value. For this reason, the fuzzy TOPSIS method is very suitable for solving real life application problems under a fuzzy environment. The detailed steps for the fuzzy TOPSIS method can be found in Patil and Kant (2014), and Junior et al. (2014). We will leave it to the reader to follow-up on this detail.

4. Discussion and conclusion

To determine the ranking of the potential suppliers to choose from for the medical examination gloves, we compute the closeness coefficient (CC_i) of each alternative, and rank the values in descending order. It can be seen from Table 3 that the different potential suppliers are ranked according to the CC_i in decreasing order. The preference degree of the potential suppliers is also calculated according to the CC_i . The decision group can now determine the number of suppliers to choose for STL based on the obtained supplier ranking. The top three suppliers (Sp_1 , Sp_2 and Sp_5) are marked in red.

Table 3: Final ranking of potential suppliers using fuzzy TOPSIS

Supplier	Closeness coefficient	Rank	Preference degree
Sp ₁	0.189756	1	1
Sp ₂	0.189162	2	0.957790
Sp ₃	0.185891	4	0.725322
Sp ₄	0.175684	5	0
Sp ₅	0.187844	3	0.864158

This operational framework for selecting suppliers can be digitally mounted using software such as Matlab 7.0b, allowing for easy future evaluations. Putting the framework onto a digital platform allows the next available supplier to be readily chosen, and share the risks especially when dealing with public health emergencies and uncertain supplier disruptions.

In conclusion, this paper has helped a logistics service provider to operationalize the selection process of suppliers systematically, using a fuzzy AHP approach to provide suitable values for the weights and applying fuzzy TOPSIS to determine the best ranking of the suppliers under investigation. Finally, we coded the framework on a Matlab platform so that future selection evaluations can be managed expediently. In terms of the limitations, several come to mind. First, the use of the 5-point linguistic scale can be given further granularity as Table 3 suggests that the values of the closeness coefficients for suppliers Sp₁ and Sp₂ lie fairly close to each other, with a very small margin of error. The computational errors or rounding off errors in the earlier steps for instance in the computation of the weights using fuzzy AHP can potentially sway the selection decision. Further, supplier ranking ties have not been properly attributed. There is a need for a better understanding of how to choose between ties. Future work can study the supplier order allocation using a multi-objective program to minimize the total cost and disruption risk (due to the suppliers), and to maximize customer service (for the hospitals).

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LEGITIMACY MECHANISMS IN THE PURCHASING FUNCTION: THE CASE OF INDIRECT ITEMS

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Abstract

Purpose of the paper:

This article focuses on the internal legitimacy of purchasing function particularly regarding the indirect items. More specifically, it is a question of studying the various legitimation mechanisms in place to manage the relations between indirect items purchasing (IIP) function and its internal clients.

Design/Methodology:

Based on a qualitative study of twenty-one purchasing managers and documents from their companies.

Findings:

Beyond the normative mechanisms related to procedures and expenses monitoring, the results show that the IIP function would benefit from developing related mechanisms: Internal communication, management of the relationship with internal customers, and improvement of the service offered.

Value:

A reading grid is proposed to companies wishing to analyze and develop the legitimacy level of their purchasing function.

Research limitations/ implications:

This study used the buyer's point only. Future studies should take into account internal clients perspective.

Key words:

Legitimacy, buyer, internal clients, relationships, indirect purchase

1 Introduction

By studying published research on purchasing over the last fifty years, Shneider and Wallenburg (2013) have emphasized the need to study the interaction of this function with the increasing demands of stakeholder management. The purchasing department has to define a purchasing policy and needs to ensure that it is respected through various mechanisms that can influence the behavior of the internal customer. However, beyond studies showing the positive impact of purchasing maturity on cost reduction and financial performance, Foerstl et al. (2013) as well as Ellegaard and Koch (2012) highlight the lack of studies on the internal integration of the purchasing function. If the buyer has to be with a constant interaction with other employees from different functions and hierarchical levels (Bichon et al., 2010), the management of internal customers can be complicated and influenced both by the purchasing policy and tools and by the relationship between the buyer and the internal customers. The internal service of the purchasing function thus becomes a critical element for the function (Cousins et al., 2006). Today, the internal environment of buyers has become more complex.

As part of this research, our focus will be on indirect items purchasing (IIP) also called non production items, which accounts for nearly two-thirds of overall business expenses. This type of purchase is often neglected in companies although it has a high potential for reducing expenses. However, today its looking legitimacy in several companies. Without doubt, IIPs are more difficult to manage than direct purchases (Boghos et al., 2012) because they are not always covered by formalized tools and procedures.

This IIP was historically managed by the different internal users in a decentralized way and without a real purchasing strategy. The IIP function has thus been considered as a service in its own right only recently (Boghos et al., 2012). This can be explained by the recognition of their potential to reduce costs and create value. Since the buyer does not have a hierarchical relationship with the internal customers, he has to ensure that the purchasing

rules are applied. Thus, managing relationships with internal customers becomes a key success factor.

The question is therefore no longer about the legitimacy of the IIP function as such, but more about how to ensure this legitimacy near the different actors of the company. Based on a qualitative study conducted within 21 companies (semi-structured interviews, reports and internal documents), the interest of this research will be to study the mechanisms that can set up an organization. The goal is to enhance the internal legitimacy of the IIP function. The results show that, in addition to the normative mechanisms related to procedures and expenses monitoring, the IIP function would benefit from developing mechanisms related to the management of the relationship with the internal client, internal communication as well as the improvement of the service to internal customers. Following these results, a reading grid is proposed to companies wishing to analyze and develop legitimacy of their IIP function.

This paper is structured as follows: First, a literature review on indirect items purchasing function will be presented, highlighting its legitimization process, specifically the management of its relationships with internal customers. Then, the empirical investigation will be described. Finally, the main results will be presented in this first version.

2 Literature review

2.1. Non Item Purchasing looking for legitimacy

The most commonly definition used for legitimacy is probably from Suchman (1995) (Alves and Frih, 2014): "legitimacy is a generalized perception or presumption that the actions of an entity are desirable, appropriate, or appropriate within a socially constructed system of norms, values, beliefs and definitions" (Suchman, 1995, p. 574). Legitimacy would thus be a representation of a concordance of behaviors and shared beliefs within social groups. These social groups are multiple and can involve external stakeholders (customers, suppliers, local residents, etc.) as well as internal stakeholders (employees, members of the company) (Buisson, 2009).

In addition, much research has been devoted to the study of organizational legitimacy (Buisson, 2005; Michel, 2015); few studies have focused on the study of the legitimacy of functions or managerial practices (Buisson, 2009, Alves and Frih, 2014, Tchokogué et al., 2014).

According to Boghos (2012), "In the industrial companies, IIPs cover all purchases that are **not directly integrated into the production** of the final product and contribute to the operation of the various departments of the company." According to the same author, these purchases usually cover the following categories: building construction and property management; energy and other utilities; maintenance of sites and industrial supplies; computer; general Services; human resources (temporary employment, recruitment, training); intellectual services (consulting, engineering, marketing), travel...

Indirect items purchases are increasingly considered as **strategic** due to their **complexity**, related to the wide variety of internal clients and needs. Indeed, indirect purchases cover a very broad scope ranging, for example, simple products (office supplies) to highly technical products and services (IT, intellectual services ...). Although **less strategic** than direct purchases, Tuteja (2004) explains that "**direct purchases are easier to manage than indirect purchases**, as large companies such as General Motors, tend to negotiate agreements with suppliers, with commitments specific volumes even before the launch of new vehicles". They are also considered as strategic due to their potential of **cost saving**.

2.2. Relationship between buyer and internal customers

Extant literature uses different concepts in this context, both with regards to the buying department (purchase, supply management¹, buying managers) and internal customers (users, user departments, internal stakeholders, internal advocates²). During the transition from traditional buying to the development of modern and mature purchase processes, it is important to manage well these internal customers. They (traditionally) determine the need for equipment, determine the general characteristics of the equipment needed, determine final specifications and also the post-purchase implementation of the equipment (Leigh and Rethans, 1985).

All these concepts seem to be close to each other, definitions are not uniform yet, and many overlaps exist. **Several approaches** can be distinguished when it comes to the question of **how buying managers can influence, convince internal customers and negotiate** with them:

- The **satisfaction** concept stemming from marketing is widespread in this context. It now applies to **internal customers** or internal customer service (Farner et al., 2001) and might simply express "good management" of internal customers, via "restructuring the organization" and "empowerment" (Farner et al., 2001, p. 358). It seems important to satisfy internal customers or users, because it contributes to external customer service (reliability, responsiveness, assurance, empathy) as performance output (Farner et al., 2001). In the same manner, Marshall's et al. (1998) approach strives for satisfaction of internal customers, by the means of adequate internal service quality (reliability, responsiveness). In line with our assumption of **diversity** characterizing internal customers, Marshall et al. (1998) propose a **segmentation** of internal customers, as "people differ in their service quality requirements" (Marshall et al. 1998, p. 390).
- Still borrowed from the marketing literature, **internal communication** seems to be a major element (if not *the* element or role, cf. Quirke, 1995) when striving for influencing employees such as internal customers in the desired direction. Several authors have highlighted the vital role of communication in this context, especially during **change management**, one example being the development of a modern and structured purchase processes with regards to our research issue. Proctor and Doukakis (2003, p. 276) take up once again the variable of **internal customer satisfaction**, in order to optimize employees' trust, and consecutively, **commitment and loyalty**. Internal customer orientation, staff flexibility and high quality service operations are necessary in order to achieve employee satisfaction, empowerment, acceptance and high motivation when it comes to managing important changes within the organization. In the same context of (revolutionary) change, Kitchen and Daly (2002), propose a model of organizational communication which includes explicitly **controlling, leading, motivating, negotiating** and **bargaining** as communication activities. These latter are considered as vital, influencing organizational change and development such as developing new purchase processes. Messages (content, symbols, codes) and modalities of communication (channels, media and technologies) are other characteristics to be studied when designing the adequate model of organizational communication which should be **tailored** (i.e. the idea of segmentation once again), according to the company's context (e.g. technology and processes), because such factors influence relationships within the organization, and typically with internal customers.
- Other authors stress upon **skills and competences** necessary for purchasing managers. Besides the technical and job-related skills for the purchase function that has evolved from "clerical" or tactical to strategic importance (Giunipero and Percy 2000, p. 12; Kraljic 1983), specific competences are important to manage relationships with internal customers or users. Among the most important skills in this context, Giunipero and Percy (2000) find **team skills**, and particularly the constitutive items **leadership, managing change** and **managing internal customers**. In the same study, **negotiation skills** - amongst them the

¹ Cousins et al. (2006).

² Krapfel (1985).

constitutive item **influencing and persuasion** - are found to be another important category of competences in order to manage the interface with internal customers. Skills are considered to be important for "organizational effectiveness" (Giunipero and Percy 2000, p. 12), which is close to our performance dimensions. Skills appear via "talent management" in the article Foerstl et al. (2013). Even though these authors adopt a function- and process- and alignment-related approach, via cross-functional integration and functional coordination, they do not renounce the relationship or "political" aspect between e.g. purchase managers and internal customers (cf. Van Echtelt et al. 2007 who consider virtual team leadership and relationship management of purchase employees as important soft skills), we will develop this aspect just below. According to their findings, both variables (cross-functional integration and functional coordination) reflect the maturity or sophistication of purchase or supply processes, functions and departments, contributing – together with performance management - to the company's competitive position, via purchasing performance and, consecutively, firm performance. Our research issue's interface between the purchase department and internal customers appears via cross-functional integration, including **purchasing managers' leadership towards other internal actors**, through Foerstl's et al. (2013) lenses. The authors link together skills and (internal) communication, by considering **communication skills** as major antecedent for **strategic purchasing (performance)**.

3 Methodology

Data collection

A sample of heterogeneous firms with different maturity levels of purchasing function is used. These data were collected between 2015 and 2016 through two sources:

a. Interviews

The first source concerns twenty-one semi-structured interviews with purchasing directors and managers in fourteen companies.

We conducted these interviews based on an interview guide organized around the following themes:

- The specificities of IIP (definitions, characteristics);
- The role of the buyer (department organization, attachment and responsibilities);
- The relationship with internal customers (purchase process requisitions, tools used to manage requests, communication tools, rules and procedures);
- The company's purchasing strategy (expectations of top management and levers put in place, centralization / decentralization of purchases);
- Monitoring and evaluation procedures (performance objectives, expenses monitoring, assessment of internal customer behavior and satisfaction).

During the interviews, we let our interviewee's free speech to let other concepts emerge.

b. Internal documents

The second source of data concerns the collection of internal corporate documents on indirect items purchases. Several respondents agreed to send us documents following our meeting. We have had access to documents such as: the process of managing purchase requests, customer satisfaction surveys, action plans, and procedural manuals, reporting and internal of information.

Data analysis

The data were coded according to the methodology recommended by Gioia (2004). Performed according to three levels, it is a progressive abstraction starting from the first order data coming from the field, to build second order themes and finally to bring out an aggregate dimension. This method makes it possible to highlight the way in which the interviewees interpret the changes they introduce and manage (Langley and Abdallah, 2011).

4 Results

Through the data analysis, two main categories of legitimation mechanisms have been identified, namely normative mechanisms and discursive mechanisms.

The normative mechanisms of legitimation

a. Procurement procedures and control mechanisms

The pragmatic dimension of the internal legitimacy of the AHP function results particularly from the establishment of a purchasing procedure and control mechanisms. Boghos et al. (2012) define purchasing procedures as: "The list of rules regulating the purchasing activity and the corresponding documents: ethical code, purchasing procedures and other procedures that a buyer must know". The IIP buyer is responsible for the application of the various procedures (when defined) by internal customers: *"If it makes sense to globalize, to standardize the need that's why we are paid and if it takes time to set up a process, it must be applied"* (C).

The existence of procedures leads to a more efficient management of the purchasing function by allowing, for example, to reduce the number of new accounts receivable opening, the control of the supplier panel, the control of the setting up of new contracts or a better control of operations in relation to supplies. It also helps to create value and economy, as one respondent explains: *"if we make synergies, if we massify and show added value (when everyone comes to the same supplier, or in any case we buy together), we find ourselves financially"* (D). The procedures also save time in the purchasing process: *"the best it is that allows to generate the most important needs through existing framework contracts that continue. It avoids treating each request separately. So our goal is, when there are topics that are recurrent, to unite them through framework contracts"* (G).

To do this, for example in companies B, C, D, E and H, all purchases must be validated by the IIP buyer (mandatory signature or validation via a computerized tool). This makes possible to avoid duplicating contracts but also to avoid signing contracts that do not match the needs of the user or the purchase policy. This procedure allows the buyer to check the terms of the contract, control expenses and seize any savings opportunities. Procurement procedures can also provide a framework for calculating and deferring savings. These procedures also serve to guide internal clients in their work, in line with the expectations of the purchasing management.

b. Performance objectives and expenditure tracking

Another legitimation mechanism widely used in companies characterized by a high level of centralization remains the definition of performance objectives and the measurement of savings (often called "savings"), through monitoring tools such as scorecards and reporting. Expenses relating to IIP purchases are regularly monitored when their evolution does not fit to the defined objectives. An additional check is carried out either via an analysis of the data transmitted in the systems, or via an exchange with the internal customer.

Our respondents often mentioned the reporting sent to top management according to defined periods: *"We make a report that we transmit to the global purchasing department. But internally we also have a system where each buyer will put their tender in progress, saying what level it is in his tender and he said I made such saving. That's how we can have the reporting data and our data checked to see if there is any big gaps at the end of the month"* (K³) or *"Monthly, a reporting is requested to IIP buyers to anticipate potential savings and set budgets for the next year. The goal is to get an accurate budget definition"* (H). The figure 1 gives the example of a tool for monitoring and tracking expenses. In this performance-checking snippet, the purchasing department controls all order details, including the desired savings. Monitoring is also achieved through the evolution of supplier turnover in the absence of a monitoring tool.

However, it is important to note that in companies where a cost reduction target is set, it is not always a question of reducing purchase prices, but also of improving the use of

resources. *"It's not just price negotiation, it can be consumed less, completely eliminate the need, change it, or offer an alternative to meet the goal"* (H).

Performance targets, expense tracking tools and cost estimates therefore encourage internal customers to comply with established standards. Thus, our interviews suggest that the evaluation of results, in all its forms, acts as a disciplinary mechanism that can influence and transform the behavior of internal clients, sometimes in a coercive way, sometimes persuasively. However, *"The procedures are simple to set up (inexpensive) but the main difficulty is to enforce them"*. For this purpose, communication seems to be the major element when the purchasing department wishes to enforce the purchase rules.

4.2. The discursive mechanisms

a. The skills of the IIP buyer and the management of internal customers

The buyer works with internal clients from different departments: logistics, finance, IT and communication. He is constantly forced to adapt to these customers, who are at the heart of the indirect-items buyer's work: the respondents unanimously underlined the importance of the collaboration with internal clients. However, the quality of this collaboration differs according to the companies considered. Thus, in some companies in the category "bad students", the buyer may find himself obliged to solicit internal customers to obtain the information necessary for the implementation of his projects. This can be explained by the reluctance of the internal customer to collaborate or simply to work with the buyer. *"In the case of IIP, you create service to people; you create something new that is like entering their lives. Somehow, you may be annoying them with the constraints imposed on you and you impose on yourself"* (C). The buyer may be perceived as a brake on the purchase of the product and the negotiation with the internal customer may prove to be sometimes more difficult than the negotiation with the supplier.

The adaptation of the buyer and the analysis of the needs of his internal client make it possible to legitimize the AHP by the development of a relationship of trust, based on conviction and persuasion.

Internal customers are affected transversally by the actions of the Indirect-item buyer: *"the buyers I hire have to synthesize the needs in each market, you have internal customers who have prescribed something and you, you have earned their trust in matching their need to something economically acceptable"* (C). This is very important especially in the case of IIP, according to the respondent, totally different people (project teams for example) that must be brought to work together and that these people *"do not have necessarily want to do what the buyer wants them to do."* Moreover, faced with the diversity of IIP purchases, the buyer must constantly develop solutions, or even new management processes, because the topics are varied and rarely recurrent: *"Once you have attacked the strategic topics, you develop others. So the idea is to continue to grow and follow the group's policy"* (G). Demonstrating interest and being available to gain the trust of internal customers is a difficult exercise. However, once earned, this trust can reduce complexity or other forms of negotiation more quickly, resulting in significant savings.

b. Communication

Internal communication is a key mechanism for the internal legitimization of AHP: *"Good communication will enable the purchasing department to facilitate the management of projects, improve the image of the purchasing department, create synergies through better sharing of information and thus promote the adoption of internal purchasing processes"* (G). Regularly informing the internal customer of purchase projects and validating them together allow him to influence him and to get him to accept the purchase act as desired by the buyer. Several levers, specific to the job of the buyer, can be used to convince the most reluctant internal clients. Formal communication is thus often used. It is based on procedures manuals, internal purchasing processes and the development of framework contracts, which are subsequently communicated to the entities. The interest of formal communication through various media (information systems, display, or meetings) is to be able to structure, organize, sort and synthesize data automatically but also to share them more easily. However, the establishment of communication support may be insufficient if

the purchasing department does not follow up. As one interviewee points out, "*the purchasing department has put in place various communication media. However, it has never communicated in the continuity (...)*" (G), which adds: "the purchasing department decided to communicate only when it seemed really necessary, that is to say when the conclusion of group contracts or during radical changes in purchasing procedures ". The internal customer, at the origin of the needs, must therefore be in regular contact with the purchasing department and be involved in the purchasing process so as not to feel excluded.

The most virtuous companies but especially the progressives (H, I and J) tend to use the communication on the savings made in the purchases as an instrument to promote the image, the reputation and to reinforce the role of the purchasing department. This strategy of achievements communication, based on the explanation and sometimes the exchange, is more convincing, in the eyes of the internal customers, than simple general affirmations by the purchasing department. This communication of results is described as being able to transform the practices of internal customers. It is also a means of valuing and recognizing the function vis-à-vis internal customers.

c. Assessment of internal customer satisfaction

Through our study, it appears that measuring the satisfaction of internal customers with the purchasing department is also a mechanism for legitimizing the function. It involves questioning internal customers, often through questionnaires, about their relationship with the purchasing department.

The questionnaire makes possible to identify the shortcomings of the purchasing process. The notion of internal customer satisfaction being particularly widespread among companies seeking legitimacy, it encompasses here the reliability of the responses provided by the IIP department, the nature of the relationship with it, as well as the responsiveness to requests from Purchases made by internal customer. For the respondents, the satisfaction and interest that the other stakeholders of the company grant him make it possible to measure the quality of the service offered to the internal customers. One respondent confirms that: "Beyond the number of responses received, the feedback from the various prescribers has allowed us to get an idea of the current situation. For us, the time invested by the prescriber vis-à-vis this questionnaire alone represents an indicator of the level of consideration and interest for the purchasing function.

In addition, internal customer satisfaction can even be used as an indicator of the performance of the purchasing department. "*After analyzing the feedback from the internal specifiers, we find that there is still work to improve the service rendered. With around 23.5% satisfaction on the overall level of communication and 17.6% on the degree of responsiveness, it is clear that the path is still long before it can reach a satisfactory level*" (K). The search for the satisfaction of internal customers can lead to legitimization through the establishment of a climate of trust between the two parties. Indeed, the more the indirect-items buyer and the technical managers work in a collaborative way, the more the needs anticipation process is facilitated. This collaboration also makes buyers aware of the need to communicate more with internal customers in order to keep them informed of delivery times and the processing of their orders, for example.

The analysis of legitimation mechanisms led us to identify three categories of companies based on their IIP actions: the best in class, the progressives and the worst in class. These three categories were defined according to the level of development of the purchasing department and the organization of the function. These results are consistent with the classification of Paulraj et al. (2006) who defined three levels of development of the strategic role of purchasing according to the strategic orientation of purchases, its involvement in the organization and its visibility or status.

Thus, the first category includes companies characterized by a strong development of the purchasing function (maturity of the function and its recognition within the organization). In this category, purchases are often centralized. The second category includes companies engaged in a procurement improvement process supported by top management and clearly quantified savings objectives. The last category consists of companies with a low level of development of the purchasing function, frequently involving optimization difficulties and conflicting relationships with internal customers.

Both types of normative and discursive mechanisms were then put forward. Normative mechanisms consist of the definition of relevant procedures and indicators to facilitate the control of the actions of internal customers. They make it possible to correlate the overall performance of the function with the objectives defined by the hierarchy, in order to be able to react effectively, to define action plans and to ensure the correct application of the different processes.

For each category, the level of legitimacy mechanism was appreciated. Table 3 summarizes these results.

Table 3: Business Categories and Levels of Use of AHP Legitimate Mechanisms

Category	Category A «Best in class»	Category B « progressives »	Category C « worst in class »
Company	ABCD	FGHIJ	KLM
Characteristics	Strong purchase maturity, centralized purchasing for all entities and subsidiaries	Decentralized purchasing, 40-60% IIP purchases vs. global purchases, management involvement, savings objectives	Low AHP maturity, value of non-estimated AHP, purchases decentralized, power of internal customers
Normative mechanisms			
Proc. & Control Mec	High	Medium	Absent
Performance objectives	High	Medium	Low
Discursive mechanisms			
Buyer skills	Medium	High	Low
Communication	High	High	Very low
Ass.I.C Satisfaction	Low	High	Absent

Conclusion

The role of the purchasing department, particularly with respect to IIP, can often be tested without being supported by a system of clear objectives supported by management and maintained by examples of success (savings, profitability), time and value creation. Purchasing and procurement managers could therefore highlight this study in order to claim their complementary role, alongside the internal customer, in strategic supply projects (Tate et al., 2010). The results can also justify and trigger an organizational change through the implementation of standards and procurement process.

If the IIP function wishes to be involved in the different phases of procurement and supply projects without the risk of being sidelined, it must assert its internal legitimacy both in the early phases, as the search for suppliers and the definition of specifications in downstream phases, such as the processing of purchase requisitions and logistical follow-up. The function thus requires buyers to develop interpersonal skills that are complementary to their technical skills.

Last, this study emphasizes that the development of such skills is not enough: the internal legitimacy of IIP can indeed find a limit within the organization if internal customers reject to be involved in this relationship with buyers, restricting the extent of the initiatives mentioned here. It would therefore be interesting, in the context of future research, to identify the factors that could hinder the motivation of internal clients to adhere to these new collaborative forms.

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Session 4: Globalisation and Supply Chain Performance

ORGANIZATIONAL SUCCESS FACTORS OF LEAD PLANT/SISTER PLANT RELATIONSHIPS IN GLOBAL PRODUCTION NETWORKS

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ABSTRACT

Purpose of this paper:

In a global production network, a lead plant can be defined as the global hub of knowledge with respect to the design and manufacturing of a specific product. The purpose of this paper is to identify the organizational success factors in the relationship between a lead plant and its sister plants in a company's global production network (GPN).

Design/methodology/approach:

Eight cases, all centered at the automotive division of a multinational company and featuring lead plant/sister plant relationships for different products, were researched. Cases were selected for providing various contexts in terms of the age/maturity of the GPN and its forecasted development with respect to production volume. A literature review and initial interviews suggested to focus the research on four areas related to the knowledge flows in the network: (1) level of expertise in the lead plant, (2) knowledge transfer to sister plants, (3) organization of day-to-day operations and staff involved on either side, and (4) the perception of the relationship on either side. Information for the cases was obtained by in-depth interviews with those responsible for the relationship in both lead plant and sister plant.

Findings:

Two focal issues of a firm's internal GPN have been identified in the research: (1) How the lead plant shapes the role assigned to it and (2) How knowledge is transferred within the GPN. The factual role of the lead plant depends on how sister plants not only take technical support and accept strategical guidance but also actively support the lead plants role by sharing their own knowledge. It is important for the lead plant that the business unit allows enough room to maneuver. The cases suggest that the life cycle of the GPN is a key influencing factor. The lead plant's role should be established in the GPN's formation phase. Even though the lead plant might initially prioritize technical support, it should not neglect strategic guidance early on because this function is hard to establish in an already mature GPN. Also, the mechanisms and standards of knowledge transfer must be established early in the GPN's life cycle as in later stages both entrenched behavioral patterns and cost pressure might stand in the way.

Value:

Much research has been conducted on the different roles plants can assume in GPNs (cf. Ferdows, 1997; Vereecke et al., 2006; Feldmann and Olhager, 2013). This paper adds insight into how lead plants should organize and maintain their relationships with both business unit and sister plants in the GPN and shows the strong influence of GPN maturity.

INTRODUCTION

In a globalized economy a key management issue is how to set-up and both effectively and efficiently operate global production networks (GPNs). Two perspectives prevail:

- the logistics perspective focusing on the flow of goods and order-related information;
- the organizational perspective discussing the role of the members of the GPN, their relationships and respective responsibilities.

As early as 1964, Skinner had requested to “*sharpen the management of international manufacturing operation*” and to develop a framework for the better management of GPNs. At that time, the typical set-up of a firm’s internal GPN resembled a hub-and-spoke system, with the “home office” as the network’s focal plant (Skinner, 1964). Ferdows (1997) defined six strategic roles for foreign factories based on (1) the strategic reason for the existence of the plant and (2) the scope of its activities: lead plant, source plant, contributor plant, offshore plant, server plant, and outpost plant. In more recent years, the focus of analyzing factory roles in GPNs changed to organizational issues, e.g. the knowledge flows between plants (Vereecke *et al.*, 2006) or site competence (Feldmann and Olhager, 2013).

In this paper, the organizational perspective on GPNs is adopted and narrowed down to the special situation of a firm’s internal GPN with a lead plant as the GPN’s central plant. Many companies, for instance Japanese Original Equipment Manufacturers (Deflorin *et al.*, 2012), Otis and Thyssen-Krupp (Kuhn, 2007) or Bosch Rexroth (Deflorin *et al.*, 2010), have adopted this type of GPN organization.

The purpose of the paper is to identify organizational success factors in the relationship between a lead plant and its sister plants. The rest of the paper is organized as follows: The literature review puts this topic into the context of ambidexterity theory and reviews extant research. Then, it is explained how the multiple-case study is designed. The results are presented in concise within-case analyses and discussed in a cross-case analysis. Finally, the results are summarized, and further research directions are presented.

LITERATURE REVIEW

With respect to manufacturing, the key responsibilities of a lead factory are to develop manufacturing technologies and processes, transfer mature and stable manufacturing processes to sister plants, support continuous development of the sister plants’ product and process-related knowledge, and to provide a central intra-firm interface for all manufacturing-related communication (Ferdows, 1997; Tykal, 2009, p. 88f.) whereas it is mainly manufacturing at utmost efficiency for the sister plant. Hence, a GPN centered around a lead plant is one approach to implement organizational ambidexterity (Duncan, 1976), with the lead plant’s focus being more on exploration, against exploitation for the spatially separated sister plants (March, 2009). The additional complexity and costs associated with the lead plant approach are justified if the sister plants have not yet reached a comparable degree of maturity with respect to both product and process-related knowledge (Deflorin *et al.*, 2010).

Acting as a mediator in the GPN (Deflorin *et al.*, 2010), the lead plant, in addition to creating and transferring knowledge, has both a coordination and communication task in internal, to R&D for instance, as well as external relations, e.g. to customers and suppliers. Internally, this mediating role is most evident in the knowledge flow from the lead plant to the sister plants (Vereecke *et al.*, 2006), also channeling information from central departments like R&D (Deflorin *et al.*, 2010).

The lead plant is the “Center of Competence” (Simon *et al.*, 2008, p. 357) for its products and the respective manufacturing technology and production processes, hosting pilot production and ramping-up production of new products (Vereecke *et al.*, 2006; Tykal, 2009, p. 88). A part of the knowledge available at the lead plant can be made explicit, for

instance in form of manuals or training materials, other more tacit knowledge can only be transferred indirectly (Ernst and Kim, 2002) by, for example, sending a task force to the sister plant or by inviting staff of the sister plant to learn by observation and practice when working with the lead plant team.

The evolution of factories in the GPN is the result of four dynamics: products transferred to sister plants, plant capabilities, conditions under which the plant operates, and corporate strategic decisions on the GPN (Cheng *et al.*, 2011). This development, though, is not straightforward as Feldmann *et al.* (2013) found that site competence is not necessarily reflected in the responsibility officially assigned to a plant, i.e. a sister plant might have ambitions beyond its assigned role.

Transferring knowledge in the GPN should not be limited to a one-way process because the lead plant requires detailed insight into the experiences made in volume production at each sister plant (Simon *et al.*, 2008, p. 357). However, it cannot be unconditionally assumed that the sister plants follow suit. The knowledge flow back to the lead plant is shaped by managerial decisions for the GPN, like incentives (Wang *et al.*, 2009), as well as by local management decisions to retain or share knowledge.

RESEARCH METHODOLOGY AND DESIGN

Case study research was adopted for studying the phenomenon in its real-life context. As a multiple case study across different companies would have required evaluating organizational success factors against the background of various market environments and strategic frameworks, a multiple-case study with eight cases, all centered at the automotive division of a multinational company and featuring lead plant/sister plants relationships for different products, was conducted (*figure 1*). Cases were selected for providing different contexts in terms of the age/maturity of the GPN and its forecasted development with respect to production volume (decreasing, stable, increasing).

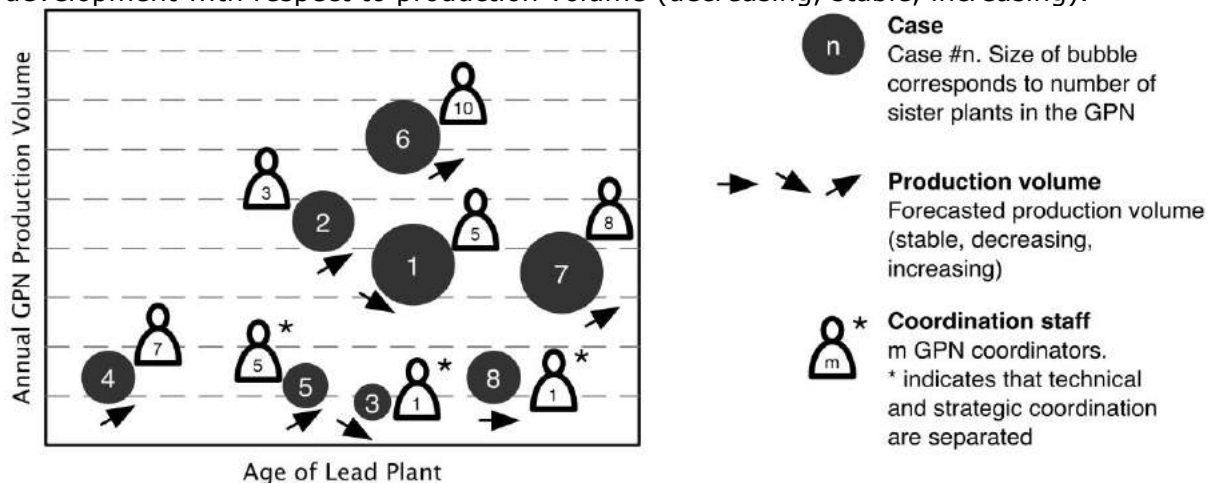


Figure 1: Cases

Construct validity (Yin, 2018, p. 43f.) of the research design was addressed by interviewing people on various hierarchical levels in both the lead plant and the sister plant, external validity (Yin, 2018, p. 45f.) by contrasting findings against the literature. To maintain the reliability of the case research design (Yin, 2018, p. 46.), in-depth interviews followed a common field manual. As in-depth interviews were used as the main source of information, the quality of the field manual is crucial for the quality of the case research. The field manual, therefore, was designed following four guiding principles (Hopf, 1978): scope (leave room for the interviewee to discuss topics in a multi-faceted way rather than to confirm or decline pre-fabricated opinions), specificity (ask questions with respect to the interviewees' field of experience), depth (focus inquiries on the personal involvement of

the interviewee), and personal context (record the personal and social context of the statements). Interviews were audio-recorded, transcribed and evaluated using qualitative content analysis (Mayring, 2000). Cross-case patterns were used as the basis for theory building on success factors (Eisenhardt, 1989).

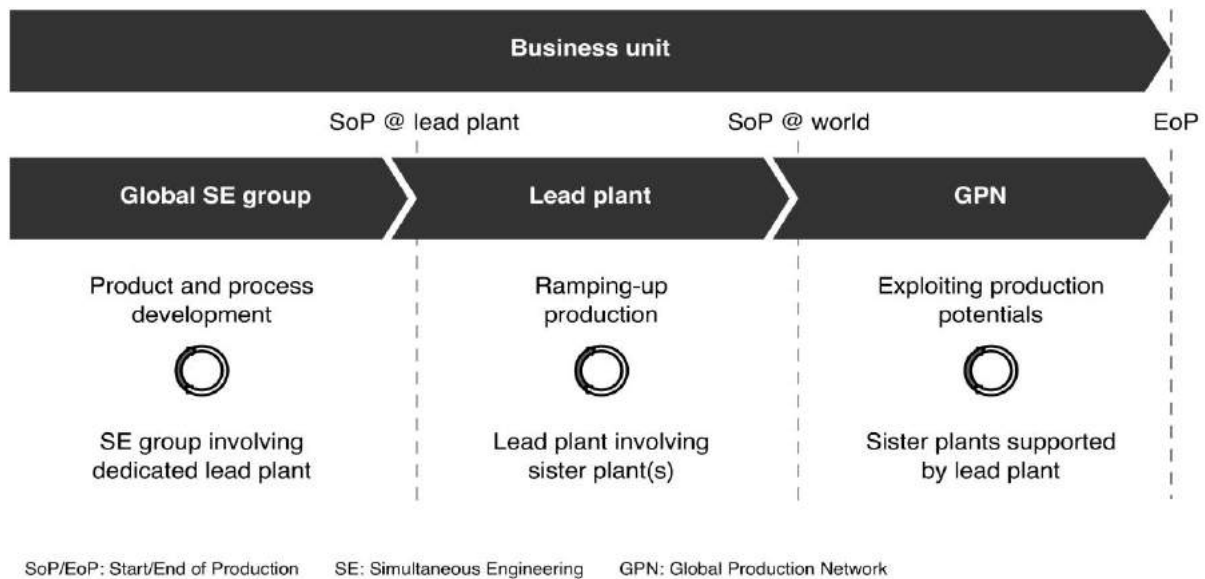


Figure 2: Product life cycle

ANALYSIS OF CASES

The common context of the eight cases is a German automotive supplier which has adopted a GPN organization with a lead plant in the focal position of each of its manufacturing networks. The product life cycle consists of three major phases (*figure 2*), all governed by the business unit: (1) Product development, in which R&D transfers new products to the company's global simultaneous engineering (SE) group. Already involving specialists from the dedicated lead plant, the SE group develops production technology and processes, (2) Production at lead plant. The product is transferred to the lead plant once pre-series production has established statistically reliable product quality. The lead plant is responsible for the product from the first samples manufactured on series-production equipment to a stable state of production allowing the product to be transferred to sister plants, and (3) Production in GPN. The lead plant transfers (the main part of) the production to sister plants but assumes GPN-wide coordination of capacity and investment planning, quality management, supply chain management, and controlling. Main competencies in the GPN (Feldmann and Olhager, 2013) are allocated as follows: development-related competencies to central and business unit R&D, supply chain-related competencies to business unit and lead plant, and production-related competencies to lead plant and sister plants.

Case 1

The lead plant team still sees room for improvement in a more proactive and better coordination of activities across the GPN but due to tight resources is limited to an unwanted reactive mode of operation. Standardization of equipment is relatively low because the transfer of production volume was based on already existing production equipment in sister plants. However, the lead plant is constantly working on improving its own knowledge base (equipment-related and process-related data), knowledge transfer and establishing personal relations by temporarily delegating team members to sister plants and running joint expert workshops. Although good personal relations at staff level support knowledge transfer and the lead plant's product competence is not questioned, two sister plants openly communicate their ambitions to become lead plants themselves. The lead plant, then, struggles with conflicts arising from divergent targets sister plants

set for themselves, i.e. additional investments in automation against a more restrictive budgeting for the GPN. Considering decreasing production volume, the business unit every now and then addresses plants directly which undercuts the coordination and mediation role of the lead plant.

Case 2

Collaboration in the GPN is often compromised by the dual burden of running the own operations and supporting the GPN. Case by case, the teams on either side need to decide which priority to assign to GPN requests against other scheduled activities. In particular, the limited resources of the lead plant are critical if technical changes need to be analyzed and released for implementation. As tight resources are the main inhibitor for ideation and GPN improvement the GPN management suggests splitting the lead plant function: The technical support function, closely connected to but not involved in manufacturing at the lead plant, should be able to fully dedicate its resources to the support of sister plants, while the strategic support function is moved to the business unit. The lead plant promotes standardization: By establishing standardized processes and equipment in all sister plants and, in terms of communication, monthly telephone conferences. A project had been started to externalize GPN knowledge (in the form of a collection of GPN process and manufacturing concepts) but was stopped as maintaining the knowledge base required too much effort. Hence, the knowledge base of the lead plant is mainly internalized (demanding both a well-balanced team and careful succession planning, which already proved to be critical due to personnel turnover). The GPN management actively promotes the GPN vision but expects sister plants to work on their own responsibility to unfold positive effect on the GPN. Competition among sister plants is seen as a positive stimulus as long as thinking in silos can be contained.

Case 3

The GPN management emphasizes the mediating role of the lead plant in communication between sister plants and business unit. This strategic role is strictly separated from the technical support function. In its strategic role, the lead plant was able, to a large extent, to convince the business unit to consent and sister plants to accept. As production volumes are decreasing sister plants more and more try detaching themselves from standards set by the lead plant, hoping to gain a better position in GPN-internal competition. The lead plant has to invest additional effort to maintain the required GPN-wide quality level. It opens up further potential for conflict in the GPN that the business unit frequently purports changes in manufacturing concepts and processes in order to reduce costs, even though projected costs savings not always compensate for investment. While the GPN management appreciates its staff's high motivation and creativity in problem solving, sister plants complain that personal contact in technical issues is strictly limited to the lead plant's business hours and the communication approach is very often not focused on collaboration but on top-down specifications, resulting in the emergence of parallel functions in the sister plants which consume even more of the tight resources on either side and further complicates coordination in the GPN.

Case 4

The youngest GPN is still, to some extent, "under construction" as yet not all sister plants have formally agreed to the GPN mission and standards. Due to market pressure, the lead plant is mainly operating a "one-way" support function: The lead plant has prioritized establishing the technical support function against its strategic coordination function. Likewise, sister plants are happy to accept technical support from the lead plant but are less supportive in sharing their own improvement ideas. However, having direct access to operational performance data of each sister plant the lead plant team has deep insight into the GPN operations. Long-term exchange of staff between lead plant and sister plants has already established a close collaboration on technical issues. The lead plant builds on that asset by using on-site meetings to promote more strategic targets like process and equipment standardization. Human resources in the GPN team are sufficient albeit not excessive which can be seen in the fact that it was not possible to externalize the GPN

knowledge. Even though the GPN team is relieved from the dual burden of supporting manufacturing in both lead plant and the GPN, the resources might become tight when the full load of strategic coordination builds up.

Case 5

The lead plant team sees the business unit's emphasis on KPI-reporting critical as it increases competition in the GPN and counteracts the idea of unity laid down in the GPN mission statement. However, the business unit also plays a supportive role in developing the GPN which is visible in monthly meetings to discuss project progress. The sister plants have developed a sound product expertise, so that the lead plant team can focus on supporting the start of production for new products. The lead plant announces workshops and meetings with the sister plants in its annual GPN schedule to steer clear collaboration with sister plants of "fire-fighting" as far as possible. The GPN team has clearly allocated responsibilities: A group of specialists is only focusing on technical changes and production releases; another group is going to be established to centralize the procurement of production equipment instead of just checking requirement specifications drawn up by the sister plants.

Case 6

The lead plant team, responsible for the largest GPN by production volume, puts emphasis on unity and sharing knowledge openly. The GPN management, though, had first to overcome resistance in its own team, originating from a general fear of offshoring production volume. Today, sharing knowledge with the sister plants and offering a platform for discussion on a biweekly basis is amicably used to develop sister plants' expertise. Only if necessary, the lead plant helps with technical problems but even in this case tries to support the sister plant's autonomy by only assuming project coordination instead of dipping into technical details. The GPN team has real-time access to performance indicators of each sister plant.

Case 7

This GPN has the longest history among the cases. The cooperative collaboration with the business unit is a key asset. The sister plants feed operational performance data, on production line level, into a database, which gives the lead plant a very deep, real-time insight into the GPN. The lead plant has achieved a coherent technical standard throughout the GPN. Having fully standardized the production equipment, coordination effort is low and the transfer of knowledge smooth, even to the extent that the lead plant sometimes is no longer needed as a mediator between the global SE group and the sister plants. The GPN team can fully concentrate on managing the GPN as no dual burden (no responsibility for manufacturing at the lead plant) has to be carried.

Case 8

Separating technical support and strategic coordination is not helpful for transferring knowledge proactively: The lead plant supports the sister plants when asked for help but does not have a clear agenda of qualification for the sister plants. This, at least partly, may also be a consequence of tight resources in the GPN team. Setting priorities means that, even with a high level of technical expertise in the sister plants, some requests are postponed, leaving a vacuum of strategic guidance. Consequently, the GPN management sees the GPN as a cooperation rather than as a managed and coordinated network.

FINDINGS

While the literature mostly focuses on the transfer of new products (Simon *et al.*, 2008, p. 357) (Deflorin *et al.*, 2012) a cross-case analysis shows that the later stage of volume production at the sister plants is equally important but different in many ways. Whereas it is mainly technical support in the earlier stages, it is the full set of operative support, strategic coordination and mediation with respect to the request of the business unit that is required in the later stages of the life cycle.

Role of the lead plant

The cross-case analysis shows that the hierarchical accentuation of the lead plant in the company's organizational structure is not as important as the design of the lead plant's role. Beyond routine technical support, the lead plant must provide strategic guidance and assume leadership of the GPN. Competition in the GPN is helpful as a motivating factor to improve overall performance but can as well cause adverse effects like thinking in silos or withholding information. This is noticeable in cases 1 and 3, where improving the own competitive position against peers is seen as a strategy for surviving decreasing production volumes. In both cases, the business unit's relation to the lead plants is ambivalent: Relying on the lead plants activities in general, a shrinking market leads the business unit every now and then to exert direct influence on critical cost reduction projects. At least, the business unit should focus more on discussing strategic projects instead of KPI's reflecting daily operations (case 5). A lead plant well integrated with the business unit and endowed with the business unit's authority can properly govern internal competition and improve the GPN. Also, a strong internal position (based on sister plants appreciating the expertise shared by the lead plant team) is helpful to further develop the GPN by addressing the sister plants' direct responsibility for technical issues (case 6). Tykal (2009, p. 132f.) has described this as balancing centralization and decentralization forces.

Knowledge transfer and GPN visibility

A main responsibility of the lead plant is to transfer knowledge for the start of production (Deflorin *et al.*, 2012; Scherrer-Rathje *et al.*, 2010). This task should be strategically positioned as a joint interface with the global SE group to R&D (cases 4 to 7). It is not enough to provide sufficient human resources for this task (cases 1 and 2), as considering knowledge transfer a mere reactive service does not meet the requirements (cases 1 and 8). As knowledge transfer in the GPN is multilateral (Vereecke *et al.*, 2006), the lead plant also retrieves knowledge from volume production in the sister plants and makes it available in the GPN. The strategies for knowledge transfer vary from relying on internalized knowledge (cases 1 and 3), joint workshops (cases 1, 4, and 5) and at least trying to externalize process-related knowledge (case 2) to having direct access to process performance information (case 4, 6 and 7). If sister plants provide this information manually (cases 1 to 3), lead plants have to put a great deal into verifying this information. Investments into standardizing knowledge transfer are more justified during the GPN's formation, as in mature GPN's this effort would run contrary to the focus on cost savings. The more standardized manufacturing process and equipment are in the GPN, the smaller is the effort to implement technical changes and adapt to local requirements. This leverage effect stands out in larger GPN's (cases 6 and 7) and helps to run a GPN efficiently even with tight resources (case 2). Again, enforcing standardization is easier in the formation phase of a GPN than in a mature GPN, where updating existing production equipment is the method of choice. It is neither the individual technical expertise provided by the lead plant team nor a strict hierarchical management imposed on the sister plants but the ability to create an environment in which the sister plants are able to develop their own expertise within the GPN's scope, share their own knowledge with peers and trustfully provide open access to performance data.

SUMMARY AND FUTURE RESEARCH DIRECTIONS

Two focal issues of a firm's internal GPN have been identified in the research: (1) The role assigned to the lead plant and how the lead plant shapes this role and (2) How knowledge is transferred within the GPN. These issues are interrelated: The factual role of the lead plant depends on how much room to maneuver the business unit allows as well as on how sister plants not only take technical support and accept strategical guidance but also actively support the lead plants role by sharing their own knowledge. The cases suggest that the life cycle of the GPN is a key influencing factor. The lead plant's role should be established in the GPN's formation phase. Even though the lead plant might need to prioritize technical support at the start of production in a sister plant, it should not neglect strategic guidance early on because this function is hard to establish in an already mature

GPN. Also, the mechanisms and standards of knowledge transfer must be established early in the GPN's life cycle as in later stages both entrenched behavioral patterns and cost pressure might stand in the way. This suggests that the lead plant team should feature an adequate number of quality staff from the beginning.

As in the present cases the strategic framework was identical, future research could investigate how corporate strategy shapes a firm's GPNs. In a more practical approach, a GPN reference model could be developed that describes organizational parameters and processes of the GPN based on both external influences like market pressure and GPN life cycle.

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JAPANESE AUTOMOBILE MANUFACTURERS' EFFORTS TO DEVELOP PARTS LOGISTICS SYSTEMS IN INDIA

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ABSTRACT

Purpose of this paper

Japanese automobile manufacturers have developed parts logistics systems based on the principle of just in time (JIT) not only in Japan but also globally. In the rapidly growing Indian automobile market, they have been trying to establish efficient parts logistics systems to cope with completely different business environment. Their efforts are good cases to explain the development of the JIT principle globally. The purpose of this paper is to analyse their experiences in India and to discuss some issues for further development.

Design/methodology/approach

By surveying existing literatures and statistics, the development of production and procurement of Japanese automobile manufacturers in India is analysed. Then, the actual situation is complemented by the interviews with major automobile manufacturers, such as Suzuki, Honda, Toyota, and Nissan.

Findings

Although the JIT principle is consistent, the actual situation of parts logistics systems in India is different from that in Japan. They have introduced various parts logistics systems, such as direct deliveries by suppliers, procurements by milk-run method, consolidations at logistics centres from remote locations, international procurements, and so on to cope with the business environment. To reduce inventory of parts and to streamline the procurement, the JIT principle is evaluated highly of even in Indian market. In order to keep the JIT principle, their parts logistics systems seem to have evolved to adapt to the environment. However, some issues, such as under-developed logistics infrastructures, not enough domestic suppliers, complicated procedures for customs clearance and transport, and so on are remained for further development.

Value

This paper adds value to the literature accumulation in the fields of logistics from the somewhat different point of view, by focusing the efforts by Japanese automobile manufacturers.

INTRODUCTION

Many Japanese automobile manufacturers have established their factories in India where economic growth continues. Among them, Suzuki established its factory near Delhi by a joint venture with a local company as early as 1980s. Maruti Suzuki India Limited (hereinafter referred to as Maruti) occupies an overwhelming market share mainly in compact cars.

Toyota, one of the world's largest automobile manufacturers, has established Toyota Kirloskar Motor (TKM) in Bengaluru. Nissan Motor has established Renault Nissan Automotive India (RNAIPL) in Chennai through alliances with Renault. Honda Cars India Limited (HCIL) established its factories in Greater Noida and Tapukara.

Basically, Japanese automobile manufacturers try to procure parts and components from adjacent or nearby suppliers. However, they often obliged to procure concentrated

production parts such as electronic devices from remote suppliers. Manufacturers with limited production volume tend to increase procurement from remote areas. Poor Logistics infrastructure such as roads and railroads, complex procedures in logistics have been serious obstacles to procure parts. They have been trying to establish efficient logistics systems to overcome the obstacles. Such efforts by Japanese automobile manufacturers for parts logistics include important implications in the field of logistics study.

For Indian automobile industry in general, Tiwari and Herstatt (2014) shows the detail of the market. Fourin (2016) and Fourin (2017) provide recent movement and statistics on the market. Bhattacharya et. al. (2014) is conducting general considerations on the complexity and issues of the supply chain in the Indian automobile industry. Tomozawa (2011) and Tomozawa (2014) analyzed the space structure of the location of the automobile factories and parts suppliers. Motoahashi (2013) showed the detailed development of Maruti and importance of its supply chain. Nakajo (2011) studied the strategy of Innovative International Multi-Purpose Vehicle (IMV) and TKM. Nemoto et. al. (2016) and Hayashi et. al. (2017) focused on parts logistics of Japanese automobile manufacturers in India. Based on the last two references, complemented by recent statistics and referring to these literatures, this paper tries to discuss Japanese automobile manufacturers' efforts to streamline parts procurement logistics.

OVERVIEW OF THE INDIAN AUTOMOBILE MARKET

Development of the Market

Along with the rapid economic growth, domestic sales of the automobile (passenger and commercial) have increased to reach the record high of 4.14 million in fiscal 2017. The domestic market size has surpassed Germany and ranked fourth in the world following China, the United States and Japan.

By utilizing cost competitiveness and geographical advantage of India, movement to become an automobile export base is becoming active. The export volume continues to increase, reaching 840,000 in fiscal 2017. Destinations include Asia, Africa / Middle East, Mexico etc., and export to Japan has also increased. Due to the increase in domestic sales and exports, the number of units produced in fiscal 2017 reached a record high of 4.91 million units.



Note: Number of passenger and commercial car. Fiscal year starts April and ends March.
Source: Society of Indian Automobile Manufacturers

Fig. 1 Indian Automobile Market

In addition to domestic automobile manufacturers, major global automobile manufacturers have entered into the market. They compete fiercely to gain market share in fast-growing market. More than twenty automobile manufacturers compete with each other, but in recent years Maruti has overwhelming share. According to Fourin (2017), the Maruti's market share reaches to 33.3% in the total number of production in 2016, followed by Hyundai Motor India (HMI) (14.7%), Tata Motors (11.7%), Mahindra & Mahindra (9.9%), Ford (5.3%), Nissan (3.7%), Honda (3.6%), Toyota (3.2%).

In the domestic market, compact cars are quite popular because of low price and road condition. Compact cars with an engine displacement of less than 1,500cc and full length of less than 4.0meters occupy nearly 80% of the production volume.

Automobile Cluster

The location of the Indian automobile industry has been greatly influenced by policy changes (Tomozawa (2011)). Indian government used to regulate factory location near large cities and to lead to locate underdeveloped areas. However, the government deregulated the factory location laws in 1990s, and three automotive clusters have developed since then. Maruti and Honda locate in the northern cluster around Delhi. Local manufacturers such as Mahindra & Mahindra and Tata are in the western cluster, and HMI, Nissan, Toyota are in the southern cluster.

As many parts and components manufacturers locate near major automobile manufacturers, it is easy to procure parts within the same cluster. However, some parts are made in concentrated large factory to be more efficient. In the case of such parts, it may be inevitable to procure from different clusters or even from abroad. This is especially likely for car manufacturers with small production scale.

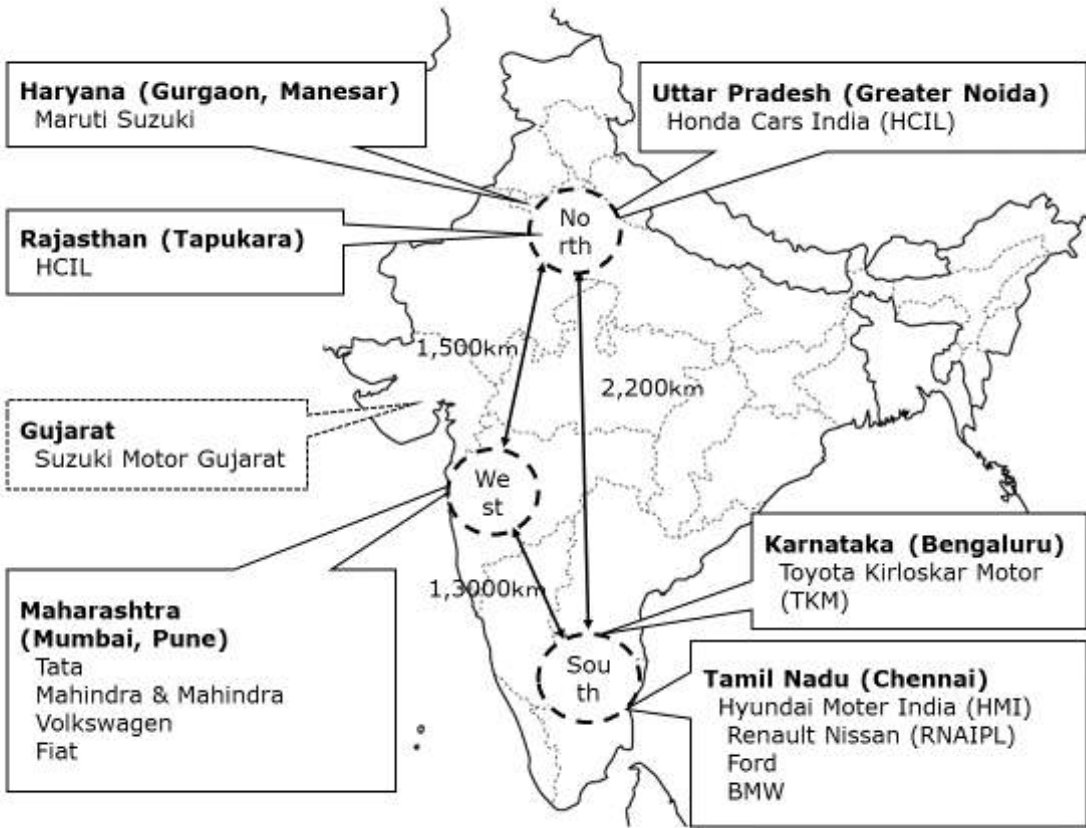


Figure 2. Automobile clusters in India

Logistics conditions

Logistics infrastructure such as road and rail have not been well developed in such a vast country land. The length of expressway remains only 200km, and the maintenance level of the main road is delayed. The railway network is also becoming obsolete and passenger trains have priority to use tracks, thus container train takes long time to transport even in main corridors. According to India Nippon Express, the most important Delhi - Mumbai route it will take about 72 hours by train and 100 hours by truck transport. In addition, the passage of trucks in many urban areas during the daytime is often prohibited to cope with chronic road congestion and air pollution in large cities.

The logistics industry has not yet developed sufficiently, and only a limited number of operators can provide comprehensive logistics services. The size of trucking carriers is very small, and many of them are owner operators. Moreover, labour disputes and strikes sometimes affect logistics services.

The government has imposed high tariffs on finished vehicles and parts to protect domestic automobile industry. Thus, foreign automobile manufacturers have established factories in India and have expanded domestic production. Along with that, the number of foreign parts manufacturers to enter India has increased, and the domestic parts industry has been rapidly growing. However, there are still many parts that are difficult to procure in India, mainly electronic parts.

Basically, 10% of import duties and 10% additional duties are imposed on automotive parts. However, due to the entry into force of the Japan-India Comprehensive Economic Partnership Agreement in 2011, tariff rates on major auto parts have been reduced. For the time being, Japanese manufacturers need to utilize these mitigation measures for importing parts.

Table 1. Transport distance and time between major cities

	Delhi / Mumbai	Delhi / Bengaluru	Bengaluru / Mumbai	Chennai / Bengaluru
Road distance (km)	1,540	2,088	1,238	325
Transport time by truck (hour)	100	110	60	12
Railway distance (km)	1,382	2,457	1,204	362
Transport time by rail (hour)	72	96	48	24

Source: India Nippon Express

NORTHERN CLUSTER

Maruti Suzuki

Maruti established assemble factories in Gurugaon and Manesar. The number of production reached 1.51 million and 33.3% of total production in 2016. To cope with growing domestic and export volume, Suzuki established Suzuki Motor Gujarat, an automobile production subsidiary in the province of Gujarat and started operation in 2017.

Regarding domestic parts procurement, eleven suppliers of large parts such as seats, mats, engine parts, fuel tanks, etc. currently locate in the supplier park adjacent to the Manesar factory. According to the assembly plan, suppliers deliver directly to the truck bay near the designated assembly line. Such parts procurement system contributes to reduce distribution costs and shorten lead time.

Apart from procurement from supplier park, it procures parts from about 150 suppliers. Most of them locate in the Delhi-Gurgaon area in the range of about two hours from the assembly plant. As the amount of parts delivered increases, delivery frequency does not decrease even when parts are loaded full of trucks. Thus, each supplier delivers its parts directly to the factory without using milk run operation. The number of trucks that deliver parts to the Manesar factory exceeds 1,900 vehicles a day.

Trucks are prohibited to operate on the national road No. 8 leading to the factory during designated time in the morning and evening. It is necessary to wait at the parking lot around the factory, which leads to increase the inventory. Maruti monitors the GPS (Global Positioning System) information of the truck to manage the delivery schedule linked with the assembly plan.

In case of procurement from distant locations such as western and southern cluster, it is difficult to be delivered JIT basis due to inadequate transportation infrastructure. For this reason, intermediate warehouse for parts set up adjacent to the factory. About 10% of parts and components are imported mainly from Japan. Import parts are unloaded mainly at Nhava Sheva Port, then transported to the factory by truck. Rail transport is advantageous in terms of costs. But lead time of rail transport is so unstable due to cargo stagnation at ports that Maruti cannot use rail.

Honda Cars India Limited (HCIL)

HCIL has established the first factory in Greater Noida and the second factory in Tapukara. Parts are procured mainly from the suppliers in northern cluster. At the first factory, suppliers directly deliver to the factory. Labour union of the truck driver is strongly opposed to the introduction of milk run, which leads to driver's job reduction.

At the second factory, suppliers that have enough volume for truckload delivers to the factory directly by trucks chartered by themselves. Other suppliers deliver by milk run method once a day. By introducing milk run, HCIL have achieved reductions of the number of required trucks and transport costs. HCIL selected the trucking companies that are not against milk run or that unions are not organised.

The volume of parts procured from the southern cluster has increased as many suppliers are locating there. Although the distance from southern cluster to the factory is about 2,200km, mode of transport is truck, because of costs and delays.

The ratio of parts from overseas is about 30%, mainly from Japan, Thailand, Indonesia. Parts from Japan are unloaded at Pipavav Port, which is about 1,300km away from the factory, transported to the Inland Container Depot (ICD) near the factory by rail, and then clear customs. The average lead time is 22 days from Japan to Pipavav Port, 7 days by rail transport, 3 days at ICD for customs clearance.

SOUTHERN CLUSTER

Toyota Kirloskar Motor (TKM)

In 1997, Toyota established Toyota Kirloskar Motor (TKM) in Bengaluru by a joint venture with local company. The first factory assembles multi-purpose vehicles with a frame structure and the second factory assembles passenger cars. To assemble many models efficiently, TKM introduced mixed assemble line and SPS (Set Parts Supply) system to supply parts sequentially in synchronism with movement of the line. The procured parts are sorted into SPS shelves that move synchronously with the line.

In addition to select local suppliers, TKM encouraged foreign parts manufacturers to enter India. Toyota Techno Park India (TTPI) was established to invite these suppliers in the Bidadi industrial park where the TKM factory is located.

There are about 120 domestic suppliers procured by TKM, of which 40% are local companies, about 40% Japanese companies including the Toyota group, and about 20% global companies. About geographical distribution, 67% of suppliers locates in the southern clusters mainly in Bengaluru and Chennai, 20% in the northern cluster and 13% from the western cluster.

TKM procures important and large parts such as engines, transmissions, axles, transmissions, seats, trims, coils and instrument panels from onsite suppliers and suppliers in Toyota Technopark (including TKAP) adjacent to the factory. Suppliers deliver bulky components of truck load in the order of assembly based on JIT principle. Other parts from Bengaluru and Chennai are procured by milk run method to reduce inventory.

From the northern cluster 2,000 km away and the west cluster 800 km away from the factory, parts are collected by milk run method in each cluster and then transported to the factory by large trucks. The procurement logistics including milk run is operated by Transystem Logistics International (subsidiary of Japanese trading company). It introduces GPS (Global Positioning System) on all trucks to track and trace all trucks and parts in real time.

As to assemble IMV, parts and components are concentratedly produced in each country and mutually supplied. The diesel engine for IMV is manufactured in Thailand, the gasoline engine in Indonesia, the transmission in Philippines and India. Imported parts are unloaded at the Chennai port, then transported by trucks to the factory.

Renault Nissan Automotive India (RNAIPL)

Nissan established a joint venture assembly company RNAIPL with Renault and built a factory in Oragadam near Chennai in 2010. RNAIPL assembles cars for both Renault and Nissan, and Renault and Nissan sell them independently. Nissan Motor India (NMIPL) is in charge of marketing and sales.

Renault Nissan Alliance is promoting the introduction of Common Module Family (CMF) as a new development method. At RNAIPL, CMF was first adopted in small cars and will be adopted to larger models.

RNAIPL makes assembly plans based on sales information of NMIPL and Renault and assembles according to the plan. In the factory, cars of both Nissan and Renault brands are assembled on the same assembly line. Since the assembling cars flowing on the line are different one by one, parts supply should be synchronized with the order of assembly. Necessary parts are picked and put in a shelf for each car, which are supplied to the line. It is called kit system, which is almost same for SPS by Toyota.

Renault Nissan Alliance has introduced joint purchasing program for cost reduction. Besides cutting unit prices by mass purchasing, this program can decrease logistics cost by collectively transporting. As parts prices and delivery costs are separated, frequent milk run procurement are used.

Eleven companies, mainly large-sized suppliers, are located in the supplier park adjacent to the factory. RNAIPL procures from over 300 suppliers including these suppliers. As for the location of the suppliers, about half of them are in Tamil Nadu province where the factory is located, about 10% in Bengaluru. Other than these, most are procured through long-distance transport from northern cluster and western cluster.

RNAIPL tries to increase local procurement rate in order to reduce costs, and the rate achieved about 90% in compact cars. Furthermore, for the model adopting CMF, it aims to improve the local procurement rate. Overseas procurement parts are imported via Chennai port.

Logistics operations for parts procurement are entrusted to Indian subsidiaries of Japanese logistics companies. They manage milk run operations and long distance transport. Furthermore, they convey sorted shelves to the assembly line in the factory site.

CONCLUSION

In this research, it was confirmed that Japanese automobile manufacturers have developed a parts procurement logistics system corresponding to India's special business environment through case studies.

Maruti, boasting an overwhelming production scale in India, shortens lead time and reduces transport costs through installation of supplier parks and joint inventory management with parts suppliers, to meet challenges such as bad transport situations. HCIL is also trying to improve transport efficiency by implementing milk run methods. TKM, RNAIPL, which entered Indian market later than Maruti, still has a smaller production scale compared with Maruti. For this reason, they are trying to introduce efficient multi-model with small-volume assembly systems by mixed flow line using SPS or kit. In order to support such a production system, the two companies have streamlined parts procurement by introducing milk runs, consolidation at departure place, and so on. Furthermore, Toyota, a global company, intends to concentrate production of parts and vehicles by introducing IMV and to establish an international mutual supply system. In addition, the Renault Nissan Alliance is pursuing optimum location production on a global scale with CMF.

In India, due to delays in infrastructure development, various practices, traffic restrictions, and so on, it is sometimes impossible to introduce an efficient logistics system. Particularly, to procure parts from distant suppliers there are obstacles such as complicated boundary passing procedures as well as underdeveloped infrastructure. Furthermore, in international parts procurement, the port congestion and complexity and uncertainty of customs clearance procedures are big problems.

Some of the issues such as provincial border crossing procedures and customs system are expected to be improved by the recent reform of Prime Minister Modi. However, India's business environment is highly uncertain, as seen in the recent abolition of large bills and the occurrence of large-scale strikes. The recent expansion of nationalism also has the possibility of adversely affecting trade. In the business environment with high uncertainty, it is noteworthy how Japanese automobile manufacturers and logistics companies in India will respond to the change.

ACKNOWLEDGMENTS

I would like to express my gratitude to everyone concerned for their cooperation in the interview survey in India.

This work was supported by JSPS KAKENHI Grant Number Basic Research (C) 16K03936.

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INTELLIGENT DECISION SUPPORT SYSTEM FOR SUPPLIER MANAGEMENT IN SMALL APPLIANCE MANUFACTURING COMPANY

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ABSTRACT

Purpose of this paper:

The cost competitiveness in appliance industry is a key sustainable factor for a small appliance manufacturing company. How to select and allocate the order for a commodity item to get an optimal decision balance over supply risk, quality stability and cost is the core interest for every manufacturer. This case study integrates Artificial Intelligent (AI) modelling technique and results of supplier ranking and consolidation to the Decision Support System (DSS) to facilitate management decision making in supplier management in Small Appliance Manufacturing Company.

Design/methodology/approach:

Supplier Consolidation is a multi-criteria decision making problem and after the inferior suppliers are eliminated, the continuous supplier performance monitoring and supplier information updating for management decision comes next for management challenge. A hybrid intelligent modelling approach using Analytic Hierarchy Process (AHP) first for pair wise comparison and Genetic Algorithm (GA) to find near to optimal output which then be used as input to Artificial Neural Network (ANN) and generate the ranking result of the selected commodity suppliers. The modelling database is then integrated to the Decision Support module to provide base for management decision making on order allocation and business strategy. Other necessary information such as supplier performance on cost, quality, and delivery etc. together with the supplier risk and supplier information update are continuous captured for the DSS and data analysis tools and utilizing a private cloud for dissemination of information.

Findings:

The hybrid approach can give a better suggestion for the supplier ranking and consolidation by just using AHP or subjective management judgement. The result varies by the weighting factor on the various supplier performance considerations. Cloud computing can reduce cost in acquiring hardware for information storage and facilitate dissemination of information. Data analysis tool will enable speedy analysis of massive information of different formats and continuous updating. The integration of the model base vendor consolidation support system, the supplier database, the material requirements planning and the knowledge base provide necessary data and information to the DSS.

Value:

The hybrid intelligent approach for supplier ranking and consolidation is simple but provides objective ranking approach over traditional management judgement approach. The use of this approach for many generic commodities with control prices by the company can be extended for practical application. The development of Intelligent Decision Support System can enhance the cost efficiency, effectiveness, quality and accuracy of the management decision making process on supplier management.

Research limitations/implications (if applicable):

The case study limits to a common commodity which is an off-the-shelf item with several equivalent substitutes. Other complicated commodities like custom made or items require joint development between the company and the supplier will require different consideration of the supplier selection and order allocation strategy.

1. INTRODUCTION

With the slowdown in world economic growth, the small appliance manufacturing industry in Hong Kong faced a hard time in the past few years. Due to the increase in competition, increase in labour cost and material cost and decrease in profit margin; the small appliance industry has to improve its performance and strengthen its competence in order to survive and stay in the industry. One alternative is to reduce operating cost such as purchase price and reduce loss due to sub-quality products, late delivery etc. by improving its supplier's performance. Hence, supplier management is an important aspect which may affect the company's profit and overall performance. Supplier management includes various aspects such as supplier price and quality control, on-going supplier performance monitoring, supplier consolidation and order allocation etc.

Speedy capture of supplier performance and analysis of supplier performance can assist management to make timely and appropriate decision on supplier control and management. The conventional approach of decision support system on supplier management is not sufficient and effective due to extensively use of qualitative information and heavy rely on human judgement of supplier performance. Therefore, in this research, an Artificial Intelligent based vendor consolidation system is proposed to set up to form the intelligent decision support to enhance the existing management decision system of supplier management for the small appliance company. Also cloud computing is incorporated to improve cost and efficiency. With this, the cost effectiveness, efficiency, quality and reliability of the supplier management system will be enhanced.

2. LITERATURE REVIEW

2.1 Intelligent Decision Support System

An intelligent decision support system (IDSS) is a decision support system that makes extensive use of artificial intelligence (AI) techniques. IDSSs are interactive computer-based systems that use data, expert knowledge and models for supporting decision-makers in organization to solve complex, imprecise and ill-structured problems by incorporating AI techniques (Ribeiro, 2006). The use of AI tools and models provides direct access to expertise, and their flexibility makes them capable of supporting learning and decision making processes. IDSS includes domain knowledge, modelling and analysis systems to provide users the capability of intelligent assistance which significantly improves the quality, accuracy, reliability and utility of decision making (Tariq, 2012). In addition to the three fundamental components of a DSS that is: Database Management Subsystem, Model Management Subsystem, and User Interface Subsystem, an IDSS has a Knowledge Management System that filters and transforms the information/knowledge via Data Mining, OLAP, Machine Learning and AI application.

2.2 Vendor Consolidation

According to Sarkar and Mohapatra (2006), the concept of supplier base reduction refers to the downsizing of the number of existing suppliers within the supplier base. Sollish & Semanik (2011) stated that company needs to identify criteria to determine which vendors should be targeted for elimination. Sarkar and Mohapatra (2006) pointed out performance, as an important criterion when selecting suppliers for elimination and Ogden & Carter (2008), mentioned that a systematic elimination of inferior vendors can be based on poor cost performance, quality, delivery performance etc. After the elimination criteria had been determined, it will be necessary to rank the vendor based on the elimination criteria.

2.3 Modelling for Vendor Ranking

Artificial intelligence (AI) - based models are based on computer-aided systems that in one way or another can be 'trained' by a purchasing expert or historic data. A hybrid method using AHP and ANN for supplier selection was provided by Ariffin et al. (2013) and Lakshmanpriya et al. (2013), where AHP is used to determine the weights of criteria,

and the ANN to select the supplier. An AHP methodology based on a combined AHP and GA was also developed by Venkata (2007). Another approach on applications of GA to ANN involves optimization of the ANN using GA for the weights computation (Asthana and Gupta, 2015).

2.4 Cloud Computing for User Interface and Output Management

Cloud computing is a kind of computing system in which various hardware, software and applications share their facilities over the internet (Darak and Pawar, 2014). Customers access cloud-based applications through a web browser while the software and data are stored either on in-house servers or on servers at a remote location. The cost of using public cloud is lowest but if lower risk and higher security is a concern, private cloud may be more appropriate. The choice between private and public cloud depicts a trade-off between security and flexibility respectively (Schramm et al., 2010). The cloud based DSS reduces the deployment and processing time, ameliorates the communication and the cooperation between the decision makers, facilitates the accessibility and decrease the cost (Imena et al., 2016)

3. PROPOSED ARCHITECTURE OF IDSS FOR SUPPLIER MANAGEMENT

The proposed system architecture of IDSS is shown in Figure 1. The IDSS integrating the necessary modules will provide information for management decision making. All the necessary information on supplier performance such as after sales service data, vendor surveillance record, vendor cost update, production schedule, delays of delivery, defect rates, quality control records, client orders etc. are fed to IDSS and for computing.

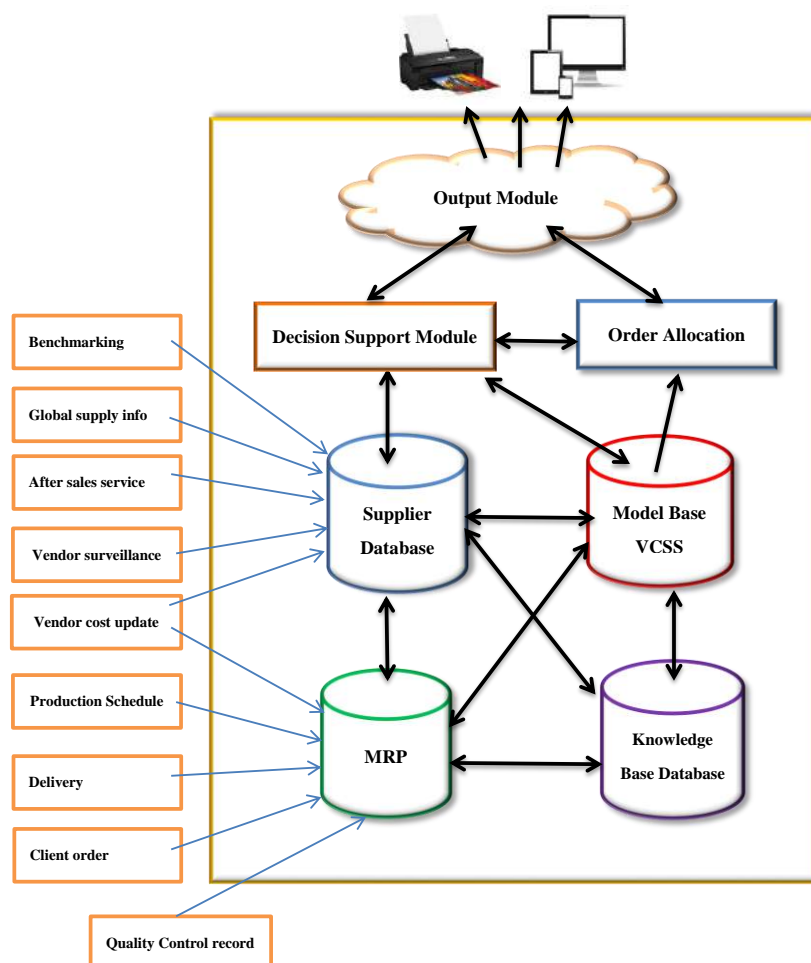


Figure 1. Proposed Architecture of IDSS

3.1 Model Base Vendor Consolidation Support System (VCSS)

The analysis aims at development of a VCSS that will provide a reference and foundation for the IDSS. The VCSS will adopt a hybrid approach instead of traditional single modelling method to ensure optimization and improve accuracy of result. The VCSS will utilize AHP to evaluate vendor performance criteria and apply AI technique including GA and ANN to optimize result on final ranking of vendor performance. Details depicted in Figure 2.

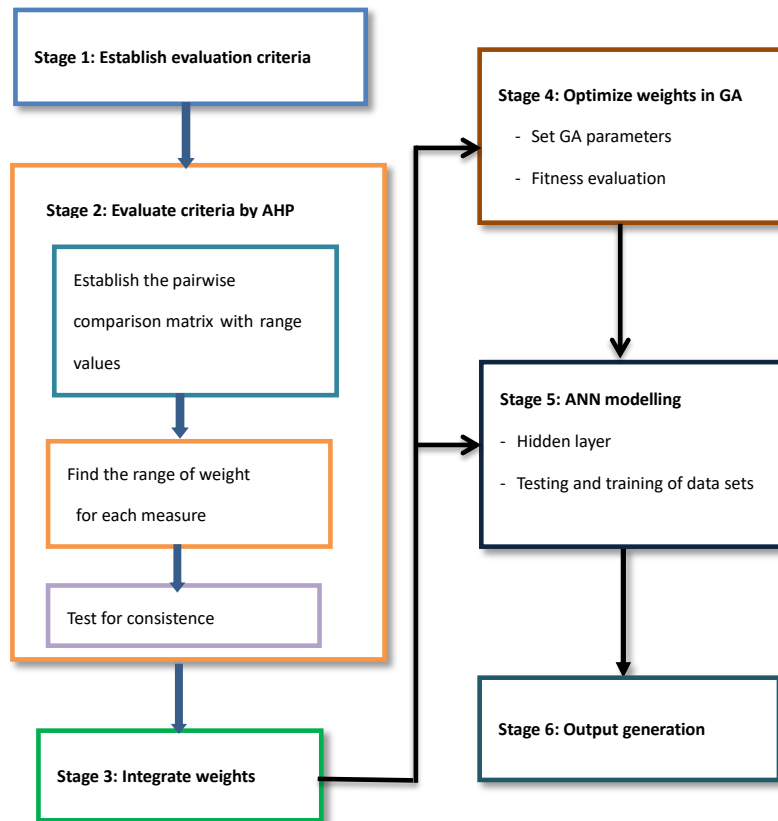


Figure 2. Model base VCSS

3.2 Supplier Database

Supplier database contains all the supplier information such as price history, defect rates, incoming and in process quality record from production line, late delivery records, technical competence, response rate, after sales services, supplier base by product, supplier capability, supplier reputation, supplier surveillance record, rating on supplier, supplier by category, world sourcing records, supplier bidding result, supplier factory visits etc. that are required for the on-going analysis and processing in IDSS.

3.3 Material Requirements Planning (MRP)

The MRP contains information on client order requirements, Bill of Materials (BOM) by product, production schedule, delivery schedule, quality control records, customer complaints, after sales repair records, defect rate, work in progress, stock on hand, shelf life of stock and parts etc. for computing and updating in IDSS, details are shown in Figure 3.

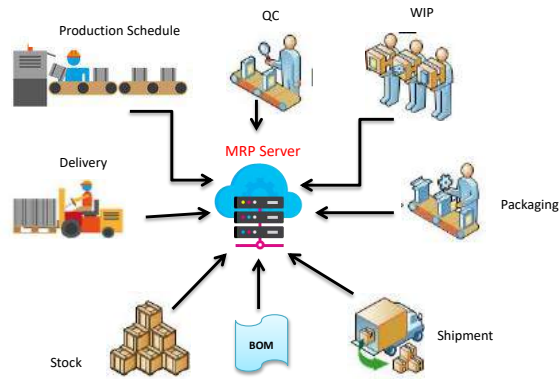


Figure 3. MRP Information Source

3.4 Knowledge Base

The knowledge base contains information on competence suppliers in market, latest trends on product, latest trends on technology, world trends on supplier management, past decisions on supplier management, possible problems arise in supplier management and the supply chain, and how supplier management may contribute to and assist the product design and development.

3.5 Decision Support Module

The Decision Support Module incorporates and utilizes latest information on vendor performance, consolidated vendor list, competent vendors, vendor surveillance, supplier risk and health assessments, supplier capacity assessments, material review support, technical surveillance and engineering liaison support, supplier price history, order-to-delivery cycle times, traceability of parts performance, competitor pricing, supplier collaboration and relationship, integrated business planning, operation planning and demand driven operations etc. All these required information are input from the supplier database, model base VCSS, MRP and knowledge base and aim to minimize human judgment and effort while improve the efficiency and accuracy of decision making in supplier management and order allocation.

3.6 Order Allocation

Order allocation to the appropriate vendors can be achieved after vendor consolidation for quantity discount. Also order award to vendors with higher ranking and performance can ultimately improve the quality and delivery performance while minimizing human input in order processing.

3.7 Cloud Based Output Module for Remote Access

The output and remote access module utilizes a private cloud for information distribution and sharing with its regional users, remote users and remote major clients. The output and remote access module has real time and multi-user capability. Details of the output and remote access module are as figure 4.

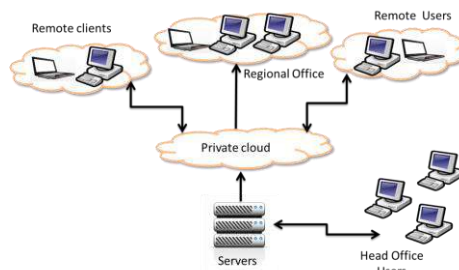


Figure 4. Cloud Based Output Module

4. CASE STUDY

The Small Appliance Company A produces household electrical appliance on OEM basis for US, EU and Japanese brands. It has four manufacturing plants set up in mainland China and employs around 20,000 workers. Like typical manufacturing companies in South China, it is highly vertical integrated to produce finished products and emphasis on cost competitiveness. It is equipped with manufacturing capabilities of plastic injection moulding, electronic assembly of PCBA, die-casting, metal stamping, painting and final assembly.

4.1 Existing Challenges Faced by the Case Company

While Company A strives hard to improve its performance, its major customers become more demanding and request Company A to further reduce product prices and order delivery lead time. This further trims down the profit margin for Company A and demands Company A to further improve its already agile and speedy sourcing and procurement process. On the other hand, with the growing concern on environmental protection, China has tightened its environmental protection regulations. This imposes adverse effect on the pricing of raw materials. The unit price of some materials, such as metal parts and packaging materials, are surging due to fade out of non-compliance producers and the more costly processes to meet the environmental requirements. So Company A is facing the challenges of lowering product prices while increase in raw material and direct manufacturing cost.

4.2 Implementation of IDSS

Modelling of VCSS had been completed with satisfactory results and proved to be more reliable and accurate than manual system. A comparison of the results of different method is depicted in Table 1. It is observed that different methods generated different ranking result. The manual system could not discriminate vendor v3 and v5, while AHP alone did not produce optimum result. Reason for the deviation was vendor 4 scored very high marks on delivery and service which contributed to the higher total marks for vendor 4 even though vendor 4 scored the lowest mark on Quality. Since quality is a very important aspect and carries highest weights, taken this into account, it should affect the final weight of vendor 4 and thus vendor 4 should have a lower ranking in compared to vendor 3 and 4. Hence the result of AHP+GA+ANN could reflect this hidden aspect which the manual system and AHP alone could not take this account. Therefore, the hybrid approach can best discriminate and rank the vendors according to their performance after the optimization of the final weighting is done.

Table 1. Comparison of different ranking method

	Manual System	AHP	AHP+GA+ANN
v1	1	1	1
v2	2	2	2
v3	4	5	3
v4	3	3	5
v5	4	4	4

Next stage will be the database construction and integration, the required data input and output requirements for the IDSS had been defined for future linkage and construction of the system. Update information and data will be fed from the supplier database, order allocation module, model base VCSS and knowledge base to the decision support module for management decision making. Details of which are depicted in Figure 5.

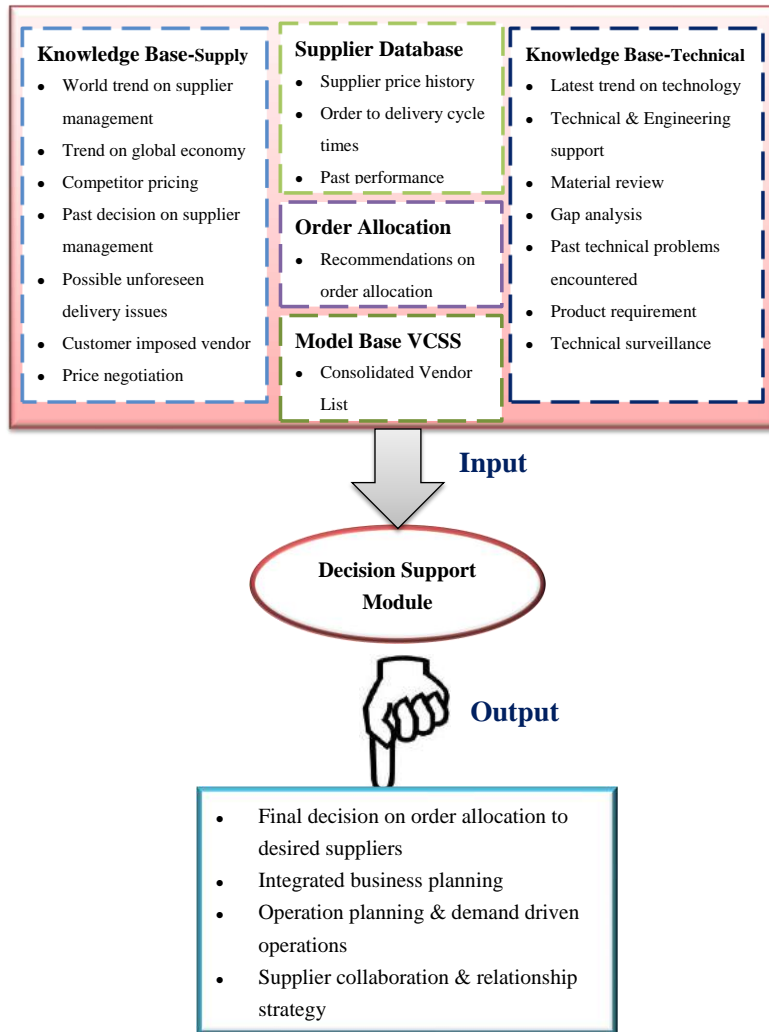


Figure 5. Data In/Out for Decision Support Module

5. RESULTS AND DISCUSSION

The model derived generated result with better discrimination than the result obtained from the existing manual system of the company and thus can be incorporated in the decision support system of the company to provide valuable information to the senior management for timely and efficient decision making on vendor selection and consolidation. With the proposed system architecture, manual efforts and judgements involved in calculation and derive of the best vendor for order placing will inevitable be minimize and more accurate results can be obtained. By applying the VCSS model, several commodity categories were tested with results applied for ranking of suppliers for vendor consolidation; such as Gift Box, Carton Box, Plastic Bags, Screw and Nuts etc. Numbers of suppliers for these categories are trimmed down from 6-8 suppliers to 3-4 suppliers. Of course there are other issues such as variation in market demand and change in objectives of management of the company that this model may not be able to cope with, and there are issues to be ascertained and visited in the future research, further development of the model together with new knowledge and information will enhance the model and technique to make it more mature. Detail data input and output requirements for each module of the IDSS will be defined and fine-tuned for the construction of the integrated IDSS for supplier management.

6. CONCLUSION

One of the small appliance manufacturing company's objectives is to improve its existing supplier management process. Though this is a preliminary study, it offers some proof that modelling integrated with IDSS is a technique which is reliable and can be used to ease management's effort in decision making with better quality, higher accuracy and reliability. Moreover, the implementation of IDSS through application of AI modelling; the process of vendor consolidation will be streamlined and the most appropriate vendors will be selected for order allocation. The application of cloud based computing to IDSS can provide a cost effective means of data sharing and knowledge base management in supplier performance. All these together will contribute to the improvement in quality, efficiency and effectiveness of the supplier management and decision making process.

ACKNOWLEDGEMENTS

The authors would like to thank the Engineering Doctorate Programme, Faculty of Engineering of The Hong Kong Polytechnic University for inspiring the development of this project.

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THE LINKAGE OF LEAN-SOCIAL PRACTICES, LEAN-TECHNICAL PRACTICES, AND OPERATIONAL PERFORMANCE IN CONTAINER SHIPPING

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Abstract

Maritime transport is very important for international trade. However, several business environmental changes reasons lead to the serious imbalance between supply and demand. In the light of this, shipping carriers try to reduce costs, often by reducing units, operational cost to achieve economies of scales. Using data acquired from 198 respondents in container shipping companies in Taiwan, exploratory factor analysis was conducted to identify the crucial dimensions underlying lean social practices and lean technical practices. Furthermore, structural equation modelling (SEM) was used to test the research hypotheses. The research findings revealed that both lean social practices and lean technical practices positively influenced organizational performance. The theoretical and practical implications from the research findings are discussed.

Key words: Lean Social Practices, Lean Technical Practices, STS Theory, Container Shipping

1. Introduction

Maritime transport is at the core of cross-border transport networks that support globalized international trade. The total volume of containerized trade increased by 2.4 per cent to reach 175 million TEUs in 2015 (UNCTAD, 2016). However, several changes in the business environment have led to a serious imbalance between supply and demand, including ship overcapacity, the structure of strategic alliances, and significant fluctuation in bunker prices. (UNCTAD, 2016). For example, the idle container ship fleet stood at 1.6 million TEUs in March 2016. Hanjin Shipping, which was the 7th largest container shipping company in the world in 2015, filed for court receivership in August 2016. This was the largest bankruptcy ever to take place in container shipping (Alphaliner, 2016). The result of past investment decisions and slower-than-expected demand growth caused an oversupply of tonnage. The outlook for seaborne trade remains uncertain. Downside risks include weak global investment, weak demand and political uncertainties, all of which will continue to impact the shipping market. In the light of this, lean management has been one area of focus, with the potential to improve effectiveness and efficiency and eliminate waste.

Lean concepts have been widely applied in management practice and studies because they offer an approach that combines higher performance with continuous improvement (Marley and Ward, 2013). "Every organization is made up of people (the social system) using tools, techniques and knowledge (the technical system) to produce goods or services valued by customers (part of the organization's external environment)" (Liu et al., 2006, p. 521). The socio-technical system theory (STS) analyses organisations in terms of these two systems, and measures an organisation's effectiveness by the extent to which the social and technical systems combine to satisfy customers (Hong et al., 2014). The joint optimization of the technical and social systems of firms is believed to create outstanding performance.

Lean social practices (LSPs) refer to the actions of and relationships between employees within organisations. LSPs encompass the responses and feelings of workers, as well as their social interactions (Hong et al., 2014). The intent of LSPs is to enhance work procedures by adjusting people's behaviour through effective initiatives. On the other hand, technical practices are employed in improving non-human processes. (Hadid et al., 2016). Lean-technical practices (LTPs) involve the implementation of technical process improvements such as computer systems, data management systems, or service devices (Hong et al., 2014). Container shipping companies have pursued LTPs in order to improve service quality and reduce cost in a competitive market.

This study differs from earlier work in several respects. First, most studies (Agarwal et al., 2013) have evaluated lean performance by assuming that lean components work in isolation to improve performance. This ignores the potential impacts which the interaction between individual components of lean systems may have on performance (Hadid and Mansouri, 2014). Second, various studies (Fullerton et al., 2014) have examined the relationships between lean management and financial performance especially in the manufacturing context, but existing studies of the service industry have ignored the role of container shipping. These particular characteristics illustrate the difficulties service operators experience that are not encountered by manufacturers. This study attempts to address these gaps by drawing on the STS theory. Given the growing importance of the container shipping industry in the competitive market, such a study will provide useful insights to develop managerial strategies.

2. Theoretical background and hypotheses

2.1 Definition of the socio-technical system (STS) theory

The socio-technical system (STS) is a concept that considers technical factors, individuals, social relationships, and organizational factors in the design of organizational systems (Baxter and Sommerville, 2011). The technological system is concerned with tasks, processes, using tools, equipment, and the technology required to transform inputs into products or services, whereas the social system includes people and relationships among them (Hadid et al., 2016). As the social and technical systems are interdependent and intertwine, the interaction between the social and technical systems is thought to be very important. Trist (1981) indicated that the social and technical systems are separate but interdependent, and a firm excelling in these two areas can enhance further organisational aspects in order to obtain outstanding performance. Both lean technical and lean social systems were found to be positively related to operational/financial performance.

2.5 LSPs and LTPs and organizational performance

An increasing number of studies have discussed the relationship between LSPs/LTPs and organizational performance in the service industry (Bonavia and Marin-Garcia, 2011; Chavez et al., 2013). Bonavia and Marin-Garcia (2011) showed that lean management is associated with organizational performance because implementation of lean practices improves the training of workers in daily work tasks as well as improving their employment security. Chavez et al. (2013) examined the effect of internal lean practices on multiple dimensions of operational performance and the findings indicated that lean practices had a significant impact on quality, delivery, and flexibility. They recommend that managers remember that internal practices are not universally applicable and they should consider the rate of change at the time of implementing lean practices. Accordingly, this study hypothesizes that:

Hypothesis 1. LTPs are positively related to organizational performance in the container shipping industry.

Hypothesis 2. LSPs are positively related to organizational performance in the container shipping industry.

Methodology

3.1 Sampling

The sample of this study was taken from container shipping companies and container shipping agencies in Taiwan. The population of firms was drawn from the Directory of ROC National Shipping Companies and the National Association of Shipping Agencies. 16 container shipping companies and 95 container shipping agencies were invited to participate. Participants were chosen from those holding the position of manager or above because they were considered to be the most knowledgeable about container shipping. A questionnaire was sent to 460 of these people on January 2, 2018 and finally 198 useable questionnaires were received, resulting in an overall response rate of 43%.

3.2 Measures

This study used existing measurement items taken from the literature, and data was collected by means of a questionnaire survey based on the approach suggested by Iacobucci and Churchill (2015). Respondent were asked to indicate their level of agreement with 25 measurement items using a five-point Likert type scale, where 1 is equal to "strongly disagree" and 5 is equal to "strongly agree". Questionnaire items were not only adapted from the previous literature, but also from interviews with shipping experts.

LSPs are assessed in terms of the feelings and responses of employees within organizations and their social interaction. LSPs were measured using 8 items adapted from the studies of Hadid et al. (2016), Hadid and Mansouri (2014), Hong et al. (2014), Martínez-Jurado et al. (2013), Piercy and Rich (2015), and Prajogo et al. (2016).

LTPs are the extent to which technical aspects of process improvement have been implemented, including computer systems, data management systems, and service devices which can reduce cost and operational errors. 9 measurement items were adapted from Bhasin (2012), Hadid and Mansouri (2014), Hong et al. (2014), Piercy and Rich (2015), and Prajogo et al. (2016).

Organizational performance is assessed by the reduction of operating expenses and the efficient use of fixed and working capital by applying lean practices. 8 measurement items for organizational performance have similarities with the assessment of the operational and strategic benefits of lean practices by Bhasin (2012), Chavez et al. (2013), Hadid et al. (2016), Hadid and Mansouri (2014), Hong et al. (2014), and Prajogo et al. (2016).

3.3 Research methodology

First, exploratory factor analysis was employed to identify the crucial dimensions of LSPs, LTPs, and organizational performance. A measurement model was assessed with confirmatory factor analysis (CFA) using maximum likelihood estimation to test the convergent and discriminant validity of the measurement items. Structural equation modeling (SEM) was used to examine the research hypotheses of the theoretical model. All analyses were carried out using SPSS and AMOS for Windows statistical packages.

4. Results and empirical analysis

4.1 Profile of respondents

A profile of respondents in the overall study sample is provided in Table 1. As can be seen, nearly 74% of respondents were managers or above. This implies that most respondents

had abundant practical experience and held a high enough position to answer questions in container shipping. With respect to work experience in their employing company, a large majority of respondents (70.2%) had worked at their company for over 10 years. The majority of respondents therefore possessed more than sufficient knowledge to assess the survey items. As regards number of employees, 33% of respondents' employing firms employed less than 50 employees, and 27.8% employed between 101 and 500 employees. Firm ownership patterns are also presented in Table 1, which shows that more than half (53%) of respondents' employing firms were locally owned, and 26.3% were foreign-owned.

Table 1
Profile of respondents

	Number of respondents	Percentage of respondents
Job title		
Vice president or above	60	30.3
Manager	85	42.9
Director	42	21.2
Sales representative	11	5.6
Work experience (years)		
5 years or less	5	2.5
6-10	54	27.3
11-20	81	40.9
21 or above	58	29.3
Number of employees		
50 or less	67	33.8
51-100	34	17.2
101-500	55	27.8
501-1,000	12	6.0
1,001 or above	30	15.2
Ownership pattern		
Local firm	105	53.0
Foreign-owned firm	52	26.3
Foreign-local firm	41	20.7

4.2 Exploratory factor analysis

Exploratory factor analysis (EFA) seeks to use a separate data set to refine the initial measurement model by purifying the scales and examining reliability (Hair et al., 2013). Table 2 reveals that two factors underlay the eight measuring LSPs attributes. The KMO statistic was 0.89 and Bartlett's Test of Sphericity was 652.65 ($p < 0.000$), which confirmed their suitability for further factor analysis (Hair et al., 2013). The two factors accounted for approximately 64.95% of the total variance. Therefore, these two factors were subsequently identified as underlying LSPs in the view of survey respondents. They are labelled and described as below:

Table 2 Factor Analysis of LSPs Attributes

Lean social practices attributes	Factor 1	Factor 2
Employees' communication is very important in my company.	0.826	
My company believes empowerment is very important.	0.811	
Employees' involvement is very important in my company.	0.753	
My company has a lean leadership.	0.727	
My company always tries to improve team spirit.	0.724	
My company has an appropriate reward system.		0.779
My company has efficient training programs.		0.760
My company has a performance measurement system.		0.615
Eigenvalues	4.194	1.002

Percentage variance (%)	54.426	12.528
Cumulative percentage variance (%)	54.426	64.954

EFA with VARLIMAX rotation was conducted to reduce and identify the nine LTPs attributes in order to gain a better understanding of the underlying factors. The Kaiser-Meyer-Olkin statistic was 0.928 and Bartlett's Test of Sphericity was 1079.77 ($p < 0.000$), which indicated that the data were adequate for conducting factor analysis (Hair et al., 2013). eigenvalues of service attributes greater than one were considered significant in each set. As seen in Table 3, the two factors accounted for approximately 69.94% of the total variance. Thus, two factors were found to underlie the LTPs dimensions in the view of survey respondents. They are labelled and described as follows.

Table 3 Factor Analysis of LTPs Attributes

Lean-technical practices attributes	Factor 1	Factor 2
My company has a vertical information system.	0.904	
My company has a good computer-aided system.	0.875	
My company is good at using new technologies.	0.829	
My company is good at outsourcing for lower cost.	0.826	
My company has a lower level of human errors in the implementation process.	0.791	
My company is good at on-time pick-up and delivery.	0.785	
My company has a good cargo and customer database system.	0.686	
My company has the ability to simplify work procedures and content.		0.898
My company has the ability to redesign processes.		0.685
Eigenvalues	5.203	1.092
Percentage variance (%)	57.812	12.129
Cumulative percentage variance (%)	57.812	69.942

EFA with VARIMAX rotation was also used to identify the factors underlying organizational performance. The Kaiser-Meyer-Olkin value was 0.933 and Bartlett's Test of Sphericity was 857.24 ($p < 0.000$), indicating that the results were valid. One factor was obtained which underlay the organizational performance dimension as viewed by survey respondents. The single factor consisted of all items, namely, "Employees are satisfied with lean management and its performance", "Employees understand the lean-work process", "My company has higher productivity", "My company has good service quality", "My company has higher customer satisfaction", "My company has good operational efficiency", "My company can reduce human error in operations better", and "My company can reduce operational costs better". Therefore, this factor was named as an organizational performance dimension. "Employees are satisfied with lean management and its performance" had the highest factor loading on this dimension. This factor accounted for approximately 60.42% of the total variance.

4.3 Confirmatory factor analysis

CFA was used to further justify the factor structure. Acceptable overall model fit was reflected by the Chi-square (χ^2) value = 237.648 with 268 degrees of freedom and was not significant ($p = 0.909$). The GFI was 0.917, CFI was 0.999, and the adjusted goodness-of-fit index (AGFI) was 0.900. RMR was 0.026, and RMSEA was 0.000, below the recommended level of 0.05. The normed Chi-Square (χ^2/df) was 0.80 (below 3.0) showing a good fit (Hair et al., 2013). The values of the goodness-of-fit indices thus suggested that the model acceptably represented the hypothesized constructs.

4.4 Convergent validity and item reliability

Table 4 presents descriptive statistics and composite reliability for each construct reliability value and provides further assessment of international consistency. The reliability values

of LSPs, LTPs, and OP were 0.89, 0.70, and 0.91 respectively. A construct reliability reflects internal consistency. Construct reliability values in the study ranged from 0.70 to 0.91, reflecting excellent internal consistency, and there was good proof of convergent validity (Hair et al., 2013).

Average variance extracted (AVE) is an alternative test which shows the amount of variance accounted for by a latent construct (Hair et al., 2013). Table 4 shows the square root of the AVE for each construct along the diagonal, and the correlation coefficients among constructs as the off-diagonal constituents. As shown in Table 4, the LSPs had the highest AVE value of 0.8, followed by LTPs (AVE = 0.55) and OP (AVE = 0.55). Overall, the goodness-of-fit results and assessment of the final model confirmed its reliability and acceptability.

Table 4
Assessment of average variance extracted

Measure	AVE	Construct reliability	LSPs	LTPs	OP
LSPs	0.80	0.89	1		
LTPs	0.55	0.70	0.33**	1	
OP	0.55	0.91	0.43**	0.30**	1

4.5 Hypotheses testing results

Structural equation modeling (SEM) was utilized to test the research hypotheses H1-H2 and results of the model estimation are reported in Figure 1. Fit statistics show that model fit is excellent. The χ^2 (262) = 457.207 is statistically significant, and other fit statistics (CFI = 0.932; GFI = 0.882; IFI = 0.933; AGFI = 0.853; RMR = 0.08; RMSEA = 0.05) suggest that the model provides a very good fit to the data. LTPs were found to be related to organizational performance (H1) (estimate = 0.66, $p > 0.05$). LSPs were found to have a significant relationship with organizational performance (H2) (estimate = 0.43, $p < 0.05$), H2 was validated.

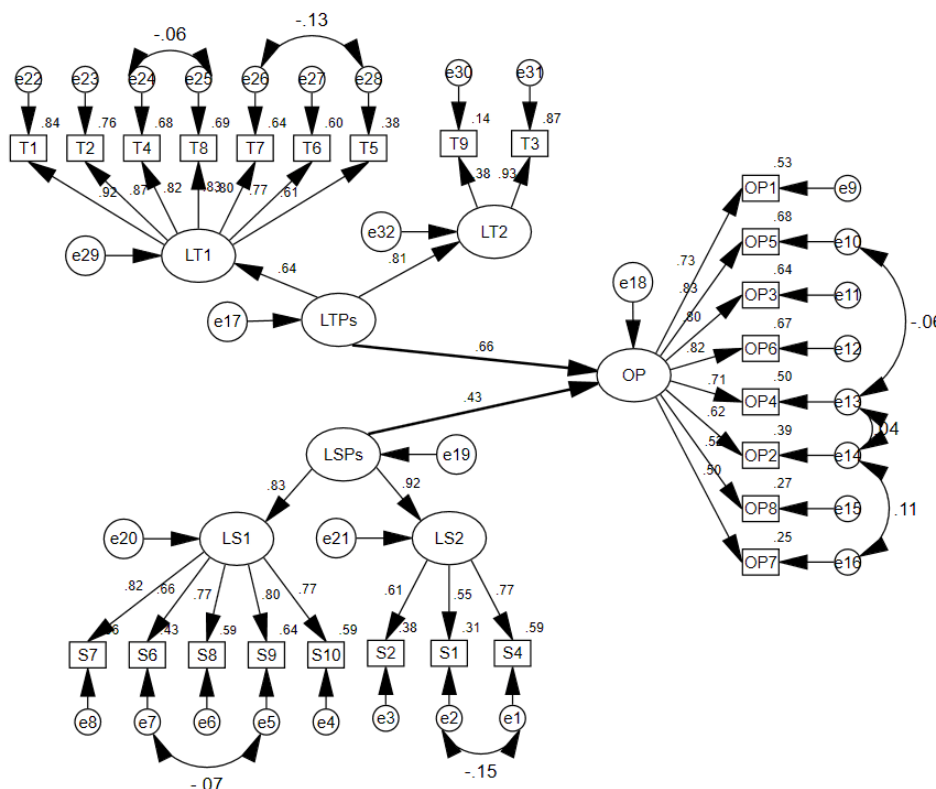


Figure 1. Results of the direct relationship model

5. Discussion and conclusions

Respondents contributed to the field's understanding of survey measurements. As regards LSPs attributes, respondents strongly agreed that their employing companies had efficient communication, followed by having good management support and empowering employees. A related issue concerns the most important of the LTPs attributes: whether respondents' companies had a good computer-aided system. The results implied that container shipping companies are focused on technological system development, believing that it assists lean management.

Second, LSPs have been found to have a positive effect on organizational performance. This study suggests that container shipping companies need to be good at: employee communication, management support, and empowering to employees. Additionally, container shipping companies will improve if they have a performance measurement system; have an effective communication platform; and set up efficient training programs.

Third, LTPs have been found to have a significant relationship with organizational performance. The findings indicate that container shipping companies have to be good at: maintaining a computer-aided system; using new technologies to prevent losing competitive advantage; and utilizing a vertical information system to arrange a complete data set. Container shipping companies should continue to focus on on-time pick-up and delivery; having the ability to redesign processes; and a lower level of human errors in the implementation process.

Despite the limitations discussed above, we drawn on several contributions in this study. an interesting insight from the result is that both LSPs and LTPs were found to have a positive relationship with organizational performance. Container shipping companies which have better LSPs than other firms can solve their issues of human management and retain committed employees. People matter a lot. Not only would firms like to attract high-quality employees, but firms also need to improve their levels of communication. LSPs will directly influence organizational performance. Another interesting aspect of LTPs is that container shipping company which have higher LTPs have employees that have developed improved ways to be productive. Further research could use this research and extend participants to other international container terminal operations in different regions.

ACKNOWLEDGMENTS

This research has been sponsored by the Ministry of Science and Technology in Taiwan under research grant number MOST107-2410-H-346-001-002.

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QUALITY PERFORMANCE OF FOOD SAFETY: INSIGHTS FROM THE THAI FOOD MANUFACTURING INDUSTRY

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ABSTRACT

The purpose of this paper is to empirically identify the main operational and business incentives for the implementation of Hazard Analysis and Critical Control Point (HACCP) and Good Manufacturing Practice (GMP), and how these two approaches can help to improve overall organisational performance. Data were collected from 53 Thai medium and large food companies which are HACCP and GMP certified. Factor analysis and multiple linear regression were used for data analysis. The analysis revealed two latent constructs regarding HACCP implementation, four latent constructs regarding GMP and three latent constructs regarding organisational performance. The multiple linear regression models results suggested that logistics and human resource development and operational improvement are influenced by determination and monitoring the critical control points, building and facilities and production and process control. Moreover, hazards analysis and verification and personnel and equipment control were primary contributed to market benefits. The results provide insights into the implementation of specifically two quality management systems (HACCP and GMP), and how they help to improve company performance.

INTRODUCTION

Consumers are increasingly concerned about food safety due to the recent food scandals. According to the European Food Safety Authority and European Centre for Disease Prevention and Control (2016), 4,362 foodborne and waterborne outbreaks have been reported in 2015 caused by bacteria, bacterial toxins and viruses respectively. Hence, safety and quality of product are vital and considered as a key concern for supply chain management (Bourlakis and Weightman, 2004; Schoenherr et al., 2015). Therefore, to assure quality and food safety, adopting quality assurance systems such as the International Organisation for Standardisation (ISO), Hazard Analysis and Critical Control Point (HACCP) and Good Manufacturing Practice (GMP) has become a common practice in most industrialised countries (Kafetzopoulos and Gotzamani, 2014; Song et al., 2017). Firms and their upstream and downstream supply chain (SC) partners have to take their responsibilities by working under the requirements regarding quality management systems standards.

This research aims to identify the main HACCP and GMP practices that food companies should focus on to improve organisational performance, as this is a universal concern to the

management of food companies (Sun, 2012; Schoenherr et al., 2015). We focus on food producers and try to gauge the contribution to quality by their suppliers. Our research questions were: (1) "What is the underlying structure of the HACCP practices (latent constructs/factors) that are implemented in food companies?", (2) "What is the underlying structure of the GMP practices (latent constructs/factors) that are implemented in food companies?", and (3) "Which aspects of HACCP and GMP impact on organisational performance in food companies?" The following sections provide a review of existing literature, a description of the methodology and data collection, and the analysis and the results. Finally, the results are discussed and final conclusions are presented.

LITERATURE REVIEW

Thailand is one of the world's top producers of food products such as fish, meat and fruit (Thailand Board of Investment, 2016). The food industry has grown rapidly and provided the highest food export rate in 2015 (increased by 7% over 2014) compared with other industries such as the electronics and automotive industries (Thailand Board of Investment, 2016). Quality management systems in the food industry are vital due to the requirements of public quality standards and regulations (Trienekens and Zuurbier, 2008; Ringsberg, 2014; Rahman, 2007). This is especially true for food companies from developing countries as they are often challenged with serious problems when trying to comply with the continuously increasing number of standards (Sun, 2012). Quality assurance systems such as ISO, GMP and HACCP are mandatory for certain products (Thailand Board of Investment, 2016). Food safety is defined as the assurance that food will not harm the consumer when it is prepared and/or eaten in the correct manner of consumption (Schoenherr et al., 2015). Hence, food safety control is necessary to realise food assurance and provide confidence in meeting safety requirements. Additionally, there is a need for community-wide food safety regulation, food safety control and consumer information (Bourlakis and Weightman, 2004). The purpose of food safety certification is to reach a defined performance regarding the production process and product quality, which illustrates an acceptable level of food production to the consumer (Kafetzopoulos and Gotzamani, 2014), which also needs to be effectively communicated to stakeholders (Ringsberg, 2014; Song et al., 2017).

There is also evidence that effective implementation of quality management systems can lead to an overall improvement of organisational performance (Dias et al., 2012; Jraisat and Sawalha, 2013; Kafetzopoulos and Gotzamani, 2014; Song et al., 2017). For instance, Cao et al. (2004) indicated that implementation of food quality and safety management systems, together with the ability to inform the consumer, can lead to marketing advantages and financial advantages to an organisation. Song et al. (2017) pointed out that quality system standards can improve working efficiency and food safety leading to consumer trust regarding food quality. The documentation regarding the quality system standards also make the production process more organised and transparent in nature. Quality management records can provide opportunities for transaction costs reduction (such as negotiation costs) to improve firm performance. Organisational performance has been identified as a multidimensional construct that is related to the quality of the organisation's results (Pradabwong et al., 2017). Prior research identified sub-dimensions of firm performance, such as financial performance (e.g., profitability, net profit margin, sales growth), and non-financial

performance (e.g., productivity, process effectiveness, delivery ability, operational cost) (Kafetzopoulos and Gotzamani, 2014; Pradabwong et al., 2017).

HACCP practices

To ensure food safety, the food industry aims at the implementation of HACCP for their production processes (Rahman, 2007). It is a well-known system within the food industry as food production is extremely sensitive to health and hygiene issues and with safety concerns at all stages. It is considered a prerequisite for the food manufacturers that aim to export their products internationally (Fotopoulos et al., 2009). It has been the *gold standard* of food safety since the 1960s (Sun, 2012). HACCP practices cover the identification, assessment and control of all the stages of the production process, especially the critical production stages (Fotopoulos et al., 2009) to guarantee the production of healthy, good quality and safe food products (Rahman, 2007; Taylor, 2008). Prior research identified the benefits of HACCP in reducing levels of foodborne pathogens in food production (Trienekens and Zuurvier, 2008), benefiting humans and animal health, and increasing consumer confidence, which should lead to better financial performance (Jraisat and Sawalha, 2013). For instance, effective internal implementation of the quality management systems such as HACCP had a significant impact on organisational performance in the Greek food industry (Kafetzopoulos and Gotzamani, 2014). Therefore, HACCP should also have an impact on competitiveness through the effects on production efficiency and cost level.

GMP practices

GMP can be defined as a series of manufacturing and administrative practices adopted by food industries that intend to certify that products are consistently produced to satisfy customer requirements and expectations (Rahman, 2007; Dias et al., 2012). It is a continuous process based on the concepts of the PDCA cycle (Plan, Do, Check, Action). GMP is concerned with product quality by applying the logic of quality thinking into all stages on the operation and activities, including: hygiene in primary production, hygienic design of equipment and facilities, control of operations, maintenance and sanitation practices, personal hygiene, transportation, product information, and consumer awareness and training (Rahman, 2007). It is based on two main components: effective manufacturing operations and effective food control operations (Silva, 2007). Effective food control operations mean that an efficient food control management plan has been developed, and the relevant procedures cover all processes from receiving raw materials to the delivery of goods to the customer. The implementation of GMP leads to significant changes in the daily routine of the food production process because of behavioural changes due to training or infrastructure changes (Ringsberg, 2014), offers greater assurance of food quality and safety (Silva, 2007), improves profits, and increases awareness in product safety (Dias et al., 2012). Hence, GMP is broad, tends to be generic in scope and mainly qualitative in terms of the data analysed (Sun, 2012). However, it can be used in combination with other quality management systems such as HACCP (Rahman, 2007; Sun, 2012). The implementation of GMP ensures that HACCP implementation focuses on critical control points for product safety; if GMP is not implemented effectively then the HACCP implementation will also be ineffective (Rahman, 2007).

Summary and research gap

According to past research, pharmaceutical and drug manufacturers are the main types of companies that have implemented GMP practices (e.g., Shanley, 2016; Challener, 2017). In term of food manufacturing, Dias et al. (2012) reported on the implementation of GMPs, indicating that GMP implementation improves overall organisation, especially in terms of managers' and food handlers' behaviour and the safety and production of high quality cheese. Cunha et al. (2014) evaluated the implementation of GMP; their results indicated a high conformity of GMP practices in terms of hygiene and environmental sanitation. However, there is a limited number of previous empirically tested studies focusing on whether GMP can improve firm quality performance. A number of researchers have suggested that future studies may consider exploring the relationships between quality system standards such as HACCP, GMP effectiveness and food companies' overall performance (Fotopoulos, et al., 2009; Kafetzopoulos and Gotzamani, 2014; Jraisat and Sawalha, 2013; Schoenherr et al., 2015). Therefore, the main contribution of our study was to evaluate the HACCP and GMP system effectiveness in Thai food companies, and to examine the degree to which the effective implementation of GMP and HACCP influences the overall performance of the certified food companies.

METHODOLOGY

The questionnaire was developed to cover the main constructs of GMP, HACCP and the respective results. A pilot study was run with 10 food companies (from July to mid-August 2017) to check for item refinement and content validation. A five point Likert scale was used as the main response format. The data was collected from food and beverage companies, located in the Thai provinces of Rayong and Chonburi, which have been certified to GMP and HACCP standards. A total number of 128 medium and large food companies were the target population for the data collection. A self-administrative questionnaire was distributed by post and company visits from mid-August to October 2017, resulting in 53 useable replies – a response rate of 49.34%. 42.6% of the participants were from food processing companies and the rest were from supplemental food, frozen food, seasoning and beverages companies. The participating companies had on average 8 and 9 years of experience in implementing HACCP and GMP respectively. The products were mostly sold domestically (57.4%), exported (11.1%), or were sold both locally and internationally (31.5%). The respondents were in relevant positions: quality assurance managers (33.3%), production managers (24.1%), owners/general managers (20.4%), and engineering managers and others who had sufficient knowledge in terms of quality management in the companies (22.2%). Non-response bias was checked via a Chi-square test, revealing that the data was free from non-response bias.

ANALYSIS

The measured variables of HACCP, GMP and organisational performance were primarily used for the factor analysis with the Verimax method. Then, the relationships between the latent constructs/factors of HACCP and GMP practices and the results were analysed by using multiple linear regression analysis with SPSS 17 being used for the data analysis. Regarding factor analysis, item loading lower than 0.5 was removed from the data analysis to guarantee the convergent and discriminant validity (Fotopoulos et al., 2009; Psomas and Fotopoulos, 2010). Table 1 shows the results of factor analysis provided 2 latent constructs for HACCP practices, 3 latent constructs of GMP, and 3 latent constructs of organisational performance.

Table 1 Factor analysis results

Construct and items	Item loadings
HACCP: KMO = 0.668, Barlett's test of Sphericity = 131.828 (p-value = 0.00), Eigen-value = 1.516, total variance explained = 83.691%	
Hazards analysis and verification (H1): Cronbach's alpha = 0.877	
HACCP1: Hazard analysis provides detailed examination of the raw materials, process, product and end use.	0.931
HACCP2: Identification of the critical control points (e.g., temperature, time).	0.908
HACCP3: Establishing corrective action procedures that involve methods, procedure, tests, and monitoring to determine compliance with the HACCP plan.	0.832
Determination and monitoring the critical control points (H2): Cronbach's alpha = 0.852	
HACCP4: Establishing measurable limits (specification) for each critical control point (e.g., temperature, pH, and moisture content).	0.922
HACCP5: Establishing procedures for monitoring the critical control points.	0.930
GMP: KMO = 0.706, Barlett's test of Sphericity = 1409.696 (p-value = 0.00), Eigen-value = 3.365, total variance explained = 68.937%	
Building and facilities (G1): Cronbach's alpha = 0.924	
GMP1: Food containers and all equipment in food production are in good condition and do not cause food contamination during the production process.	0.910
GMP2: Ceiling made out of materials that prevent mould growth or build-up of dust.	0.854
GMP3: Water used in the production process is validated by the Ministry of Public Health. Consumption of water and used in hygienic conditions.	0.812
GMP4: Tools, machinery and equipment in the production process are maintained in a good condition, both before and after production.	0.802
GMP5: Building is maintained in a clean and tidy condition.	0.766
GMP6: Floors, wall and ceiling are in a good condition (e.g., smooth and clean).	0.745
GMP7: Staff who have direct contact with food wear gloves that are clean and in a good condition.	0.743
GMP8: The production areas are cleaned and maintained in hygienic manner.	0.680
Production and process control (G2): Cronbach's alpha = 0.923	
GMP9: Tools and equipment are sufficient for the production process.	0.915
GMP10: There is a proper disposal system.	0.884
GMP11: Raw materials are good quality and in a clean condition.	0.834
GMP12: There is no dirty water around the building.	0.821
GMP13: Staff wear clean and appropriate clothes for the operation.	0.757
GMP14: All staff follow the rules to ensure that production process are in a clean condition.	0.711
GMP15: There are effective drainage and sewerage which do not cause contamination to food production.	0.708
GMP16: Table used in the food production process do not cause adverse reactions to the health of food consumers.	0.663
GMP17: Staff who have direct contact with food wash their hands both before and after the operation.	0.611
Personnel and equipment control (G3): Cronbach's alpha = 0.926	
GMP18: All surfaces that come into contact with food are clean.	0.869
GMP19: Ice and steam used in the production process that are in contact with food are of the quality regulated by The Ministry of Public Health.	0.864
GMP20: Drains are provided and connected to the drainage and sewerage systems.	0.859
GMP21: Location of the building is away from any contaminated or dirty areas.	0.823
GMP22: Training regarding general hygiene and knowledge of food production are provided.	0.742
GMP23: Production process, storage, and transportation of food products and containers are free from contamination and deterioration.	0.722

Table 1 Factor analysis results (Cont.)

Construct and items	Item loadings
GMP24: Staff who have direct contact with food wear hat, veil or mesh.	0.690
GMP25: There is a separation of production areas to prevent possible contamination that would occurred.	0.640
GMP26: Tables used in the production process are made from anti-corrosive material and are easy to clean.	0.608
Organisational performance: KMO = 0.705, Barlett's test of Sphericity = 228.361 (p-value = 0.00), Eigen-value = 1.584, total variance explained = 77.673%	
Logistics and human resource development (O1): Cronbach's alpha = 0.864	
OP1: Inventory turn over	0.887
OP2: On time delivery	0.816
OP3: Training and skills	0.896
Operational improvement (O2): Cronbach's alpha = 0.839	
OP4: Productivity	0.867
OP5: Defective rate	0.826
OP6: Innovation	0.893
Market benefits (O3): Cronbach's alpha = 0.795	
OP7: Profits	0.875
OP8: Customer satisfaction	0.858
OP9: Customer responsiveness	0.750

The Kaiser-Meyer-Olkin Measure (KMO) values exceed the recommended value of 0.6 and the Barlett's test of Sphericity revealed p-values of 0.000 (less than 0.05), providing statistical significance, supporting the factor ability of the correlation matrix (Pallant, 2010). All latent constructs provided the values of Cronbach's alpha over 0.6, indicating acceptable construct reliability (Hair et al., 2014). Consequently, multiple linear regression analyses were performed to assess the effect of those latent constructs of HACCP and GMP that significantly influence organisational performance. Regarding the relationship between HACCP and organisational performance, 3 multiple linear regression analyses were undertaken. The same method was applied to identify the relationship between the 3 latent constructs of GMP and organisational performance. Hence, each regression model was run separately. The results showed that logistics and human resource development (O1) was affected by determination and monitoring of the critical control points (H2) (p-value = 0.000, beta standardized coeff. = 0.591, $R^2 = 0.326$) and it was not affected by hazards analysis and verification (H1) (p-value = 0.692, beta standardised coeff. = 0.045). Operational improvement (O2) was affected by determination and monitoring of the critical control points (H2) (p-value = 0.006, beta standardised coeff. = -0.366, $R^2 = 0.128$). The regression model also revealed that hazards analysis and verification (H1) (p-value = 0.000, beta standardized coeff. = 0.616, $R^2 = 0.387$) was the significant factor affecting the dependent variable market benefits (O3). Regarding the multiple linear regression models of GMP, 3 models were analysed. Logistics and human resource development (O1) was affected by building and facilities (G1) (p-value = 0.000, beta standardised coeff. = 0.469) and production and process control (G2) (p-value = 0.001, beta standardised coeff. = -0.388, $R^2 = 0.335$) respectively. Operational improvement (O2) was also affected significantly by building and facilities (G1) (p-value = 0.001, beta standardised coeff. = -0.417) and production and process control (G2) (p-value = 0.003, beta standardised coeff. = 0.366, $R^2 = 0.274$). Personnel and equipment control (G3) (p-value = 0.003, beta standardised coeff. = 0.597, $R^2 = 0.331$) was the only independent variable that had a significant impact on market benefits (O3).

CONCLUSIONS

This study empirically evaluated the HACCP and GMP practices and their relationships to organisational performance in Thai food companies. The results enhance our understanding of the implementation of these two systems, and how they contribute to improved company performance. The results reveal a significant impact between the latent constructs of HACCP and GMP on organisational performance. More specifically, determination and monitoring of the critical control points (H2), building and facilities (G1) and production and process control (G2) were found to primarily contribute to logistics and human resource development (O1) and operational improvement (O2). The results also showed market benefits (O3) are equally influenced by hazards analysis and verification (H1), as well as personnel and equipment control (G3). The findings are in line with prior research, such as Rahman (2007), Silva, (2007), Dias et al. (2012), and Ringsberg (2014) who identified the benefits achieved in implementing HACCP or GMP. However, there was a lack of prior research that empirically tested these two quality management systems and the relevant benefits that companies can achieve. Our study provides empirical results regarding the combination of the two quality management systems and their benefits in terms of organisational performance.

The findings provide initial guidelines to food companies with regards to their certified quality systems of HACCP and GMP. They not only have to be implemented due to government regulations, but these standards can result in improved organisational performance. The scale developed can be used as a self-evaluating checklist regarding the implementation of HACCP and GMP to gain organisational performance improvement. Also, apart from implementing food quality standard systems, firms should develop relationships with their suppliers who are familiar with such systems to effectively meet the requirements for HACCP and GMP. Hence, firms and their SC partners should work collaboratively to clarify their responsibilities in every stage in their production process (e.g., implementation, validation, and monitoring) regarding HACCP and GMP approaches. This will ensure that the raw materials and ingredients used in the production process are of acceptable quality. There are some limitations in our study; first, the data collection was conducted using a small sample. Future research could consider a larger sample and analyse whether there are any statistically significant differences in different types of food companies (e.g., frozen food, processing, and seasoning food).

ACKNOWLEDGEMENT

We would like to acknowledge the contribution by Miss Natthaya Saengsan and Miss Laddawan Seema in the questionnaire development and data collection phases.

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Session 5: Big Data & Supply Chain Analytics

SUPPLIER SELECTION USING DATA ANALYTICS: A COLLABORATIVE FILTERING-BASED APPROACH

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ABSTRACT The usage of innovative digitized enterprise models and advancements in the field of big data analytics have created a competitive edge in business practices with the potential for significantly improving the function of supply chain management. This paper utilizes a Collaborative Filtering-Based (CFB) approach with the K Nearest Neighbors (KNN) algorithm to recommend suppliers for manufacturers/buyers based on how similar manufacturers have rated the suppliers. The Cosine and Euclidean similarity metrics were used as input to the KNN algorithm. In our supervised machine learning approach, a portion of a large open-source dataset was used for training the algorithm. The remaining data was used to statistically test for accuracy and validation. The application of a KNN data analytics model within the CFB framework was successfully applied and its accuracy was calculated by the Root Mean Square Error (RMSE) metric for four different techniques, where the cosine similarity method showed to be statistically superior. The link for all our codes in Python 3 is provided and future related research is recommended.

INTRODUCTION Supply chain management (SCM) is a strategic aspect of manufacturing enterprises. Companies seeking business partnerships with global suppliers are constantly seeking effective and novel methods to select their suppliers based on quality, delivery velocity, cost, flexibility and related competitive business factors. The existing literature on traditional methods for supplier selection is quite extensive and beyond the focus of this paper. However, the reader is referred to an excellent summary of various criteria as well as methods of supplier selection process in a paper by Thiruchelvam and Tookey (2011), in which the authors discuss a variety of methods ranging from subjective evaluation and Analytical Hierarchy Process (AHP), to Monte Carlo simulation and genetic algorithms. The paper, however, emphasizes that the selected criteria and methods for supplier selection should be compatible to the type of business and hence recommends that an artificial neural network may be a more suitable method for supplier selection for their case study of the electrical supply sector in the Malaysian industry. As a related corollary, one can propose that the other global electrical supply sectors may have similar decision-making criteria in their supplier selection process. The point is that in most of the existing research the supplier selection decision makers do not directly, and systematically, utilize the experience and knowledge of other similar business groups. Hence, we conclude that there is a need for novel approaches in collaborative methods for supplier selection among companies with similar needs.

The concept of collaborative filtering-based (CFB) approach to match suppliers to buyers in prefabricated construction industry has been recently presented in a paper by J. Du and H. Jing (2018). In this novel approach, Du and Jing utilize the K-means clustering algorithm to match and recommend suppliers for similar manufacturers to facilitate e-Commerce decision making for B2B business models. They simulated their model by using the green Newell Platform and the historical buying information for 1,000 buyers, including cost, quality and physical attributes of the purchased products. For their K-means algorithm, they used the Cosine Similarity to measure similarity between manufacturers (buyers). The work by Du

and Jing provides motivation to conduct further research for the application of CFB method to facilitate the process of supplier selection.

Meanwhile, in the past few years the concept of Big Data Analytics (BDA) is noted as having a vital strategic importance across various global business communities. Many CEOs of manufacturing companies have criticized that currently only a small percentage of their internally created data are utilized for predictive business analysis and hence there is an urgent need for research and development on big data sets and relevant BDA methods. However, the research in this field is rather new and the relevant contents in the current literature either remain at a conceptual level or the clarity and transparency of the BDA models and methods are not presented in such away to be easily replicated by other researchers (R. Pouraghabagher, T. Arikati, 2017). We, therefore, have attempted to experiment with and utilize the CFB model of supplier selection in a different format than the work by Du and Jing with the objective of creating a higher motivation for further research in this field. Specifically, we have used the KNN (K-Nearest Neighbors) algorithm as opposed to their K-means clustering model. Secondly, we have utilized two different data input approaches to KNN model, namely Cosine Similarity and Euclidean Distance methods. Additionally, our research measured our model's performance by extensively testing it using RMSE (Root Mean square error) computations. Most importantly, our research utilized a subset of a massively large, open source enterprise data bank to test and train the model. Finally, this paper has attempted to clarify the relatively complex process of a specific machine learning approach (KNN algorithm) for business predictive analysis through transparent and easy-to-replicate computations.

METHOD The objective of this research project is to create a BDA model to facilitate the supplier selection process by utilizing the experience of other similar manufacturing organizations that have already conducted business with certain global suppliers that one needs to select from. This digital collaboration would take place via a semi-intelligent recommendation that contains the ratings of many suppliers by many manufacturing organizations. The semi-intelligent advisory method is created through the utilization of a collaborative filtering-based approach using the KNN algorithm to generate similarity measures among manufacturers to match their suppliers' selections. Matching a supplier to a manufacturer in need of specialized services is handled through a similarity analysis either by the cosine similarity or Euclidean distance metrics as input to our KNN algorithm. Both methods are well established in machine learning applications and will be briefly reviewed later. Meanwhile, to clarify the functionality of our algorithm, we simply resort to the example of the Netflix business model as we have indeed used their open source data (to be discussed later). This on-line movie entertainment company has millions of users/customers around the world. The algorithm for Netflix operations is constantly searching to find similarities between the choices of customers and offers recommendations of new movies to customers based on the preferences of other customers who have similar patterns and choices for search and selection of movies. Some of the recommendations Netflix makes may be a miss, as opposed to a hit. But as the number of customers increases, the algorithm learns how to make better predictions to more effectively match the customers with products (movies) that other customers with similar movie preferences have selected. The semi-intelligent aspect of our algorithm is attributed to the fact that there is no way to guarantee that the ranking of similar manufacturing organizations have no mismatch or bias, similar to the Netflix business model.

APPROACH This paper has two major parts. First, it defines the relevant parameters of our CBF model and manually demonstrates sample computations for the benefit of readers who have similar research interests. Second, it utilizes a realistic, big data set to implement the model for large-scale computations. Data tables, formulas and examples are provided to facilitate the understanding of the model. In terms of notations, we are using the term

"manufacturer" for a "user," and "supplier" for an "item" as user and item are common terms in Collaborative Filtering. All coding for this model is done using the language Python 3. The coding environment is a set of Jupyter Notebooks. There were four Python libraries used when conducting research: Pandas, NumPy, Scikit Learn, and Matplotlib. Pandas is used to create tables and manipulate data in a tabular format. NumPy is used for linear algebra and mathematical operations. Scikit Learn is used for finding similarity metrics and nearest neighbors in an efficient and optimized manner. Matplotlib is used to create graphs to visualize our results. The reader is welcome and encouraged to refer to our notebook link. <https://github.com/oats-meal/ISL2018-CF-Demo>

SAMPLE COMPUTATIONS Table 1 includes the simulated data for ratings of 10 suppliers (S-A through S-J) by 10 manufacturers (M-A through M-J), where "1" is the lowest and "5" is the highest rating. The objective of the model is to utilize Table 1 to compute similarity measures for all manufacturers and use that information to predict the empty cells where some of the manufacturers have not previously rated certain suppliers. First, one must standardize the data in Table 1 to dampen the effects of outliers and extreme values. In data analytics, there are several techniques to handle missing data. Examples include filling the missing data by a zero value, using the mean, median, or mode of the row/column, or by the Pearson's correlation method. We chose the latter by subtracting the mean of each row from the values of each cell in that row, while the missing values were replaced by zero. Table 2 shows the results where each row is a vector and our objective is to find similarities between them.

Table 2 is utilized to compute the similarity measures among all pairs of manufacturers. This required computation can be handled by several different methods where Cosine Similarity and Euclidean Distance methods are most popular for KNN algorithm. Equations 1 and 2 give the formulas for these two methods.

$$\text{Cosine Similarity (A, B)} = \text{Cos}(\theta) = \frac{\text{dot(A,B)}}{(\|A\|*\|B\|)} \quad (\text{Equation 1})$$

$$\text{Euclidean Distance Similarity (A, B)} = \text{SQRT} \sum_i^n (X_i - Y_i)^2 \quad (\text{Equation 2})$$

Using Table 2 and Eq.1, a cosine similarity sample computation for the manufacturers B and C, or Cos (B, C), would be:

$$\frac{(-1.333*0.667+1.667*-2.333)}{\{[(-1.333)^2+ (1.667)^2+ (-0.333)^2]^{1/2} * [(0.667)^2+ (-2.333)^2+ (1.667)^2]^{1/2}\}} = -0.751$$

However, in our implementation we add 1 to all computed cosine similarities to ensure there are no negative similarities and therefore Cos (B, C) similarity = - 0.751+1.000 = 0.249. The sample computation for the Euclidean Distance similarity between manufacturers B and C would be:

$$\text{Euclidean Distance (B, C)} = [(-1.333-0.667)^2+ (1.667-(-2.333))^2+ (-0.333)^2+ (1.667)^2]^{1/2} = 4.784$$

Writing a computer code in Python and applying Equations 1 and 2 to Table 2 data, similarity values for cosine and Euclidean methods were generated and are shown in Tables 3 and 4, respectively. They include, and verify, the above sample computations. These two tables can be used to predict the ratings of suppliers by manufacturers and therefore filling all empty ratings in Table 1. We will, however, cover this analysis more pertinently with our big data set in the next section.

Table 1- Simulated ratings of 10 items (Suppliers A-J) by 10 users (Manufacturers A-J)

	S-A	S-B	S-C	S-D	S-E	S-F	S-G	S-H	S-I	S-J
M-A	5			3			1		4	
M-B		2	5					3		
M-C		4	1			5				
M-D					4					5
M-E	3		3							
M-F				3	5		2		1	3
M-G						4				
M-H	3	5	2				1		2	5
M-I	1	2								
M-J										4

Table 2- Standardized ratings of Table 1 data

	S-A	S-B	S-C	S-D	S-E	S-F	S-G	S-H	S-I	S-J
M-A	1.750	0.000	0.000	-0.250	0.000	0.000	-2.250	0.000	0.750	0.000
M-B	0.000	-1.333	1.667	0.000	0.000	0.000	0.00	-0.333	0.000	0.000
M-C	0.000	0.670	-2.333	0.000	0.000	1.667	0.00	0.000	0.000	0.000
M-D	0.000	0.000	0.000	0.000	-0.500	0.000	0.00	0.000	0.000	5.000
M-E	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.000	0.000	0.000
M-F	0.000	0.000	0.00	0.200	2.200	0.000	-0.800	0.000	-1.800	0.200
M-G	0.000	0.000	0.00	0.000	0.000	0.000	0.00	0.000	0.000	0.00
M-H	0.000	2.000	-1.000	0.000	0.000	0.000	-2.000	0.000	-1.00	2.000
M-I	-0.500	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
M-J	0.000	0.000	0.000	0.000	0.500	0.000	0.000	0.000	0.000	-0.500

Table 3- Similarity measures using the Cosine Similarity method

	M-A	M-B	M-C	M-D	M-E	M-F	M-G	M-H	M-I	M-J
M-A	2.000	1.000	1.000	1.000	0.000	1.046	0.000	1.339	0.582	1.000
M-B	1.000	2.000	0.249	1.000	0.000	1.000	0.000	0.464	0.564	1.000
M-C	1.000	0.249	2.000	1.000	0.000	1.000	0.000	1.333	1.160	1.000
M-D	1.000	1.000	1.000	2.000	0.000	0.523	0.000	1.378	1.000	0.000
M-E	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
M-F	1.046	1.000	1.000	0.523	0.000	2.000	0.000	1.342	1.000	1.477
M-G	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
M-H	1.339	0.464	1.333	1.378	0.000	1.342	0.000	2.000	1.378	0.622
M-I	0.582	0.564	1.160	1.000	0.000	1.000	0.000	1.378	2.000	1.000
M-J	1.000	1.000	1.000	0.000	0.000	1.477	0.000	0.622	1.000	2.000

Table 4- Similarity measures using the Euclidean Distance method

	M-A	M-B	M-C	M-D	M-E	M-F	M-G	M-H	M-I	M-J
M-A	0.000	3.663	4.173	3.041	2.958	4.093	2.958	3.905	3.317	3.041
M-B	3.663	0.000	4.784	2.273	2.160	3.670	2.160	5.228	2.550	2.273
M-C	4.173	4.784	0.000	3.028	2.944	4.179	2.944	3.916	2.915	3.028
M-D	3.041	2.273	3.028	0.000	0.707	3.362	0.707	3.536	1.000	1.414
M-E	2.958	2.160	2.944	0.707	0.000	2.966	0.000	3.742	0.707	0.707
M-F	4.093	3.670	4.179	3.362	2.966	0.000	2.966	3.899	3.050	2.702
M-G	2.958	2.160	2.944	0.707	0.000	2.966	0.000	3.742	0.707	0.707
M-H	3.905	5.228	3.916	3.536	3.742	3.899	3.742	0.000	3.536	4.062
M-I	3.317	2.550	2.915	1.000	0.707	3.050	0.707	3.536	0.000	1.000
M-J	3.3041	2.273	3.028	1.414	0.707	2.702	0.707	4.062	1.000	0.000

BIG DATA ANALYTICS MODEL In 2006, Netflix announced a \$1 Million prize for anyone who could create a recommendation system that would result in a lower RMSE than their proprietary recommendation system, known as Cinematch. Netflix provided a large, open source dataset for public to use and create their models (<https://www.kaggle.com/netflix-inc/netflix-prize-data>). While the above dataset contains over 100 million rows of data, approximately 685,000 rows were used in our research project to maintain processing efficiency on our computer while developing a proof of concept for our model. The original data were row-formatted where per each movie (Item) ID, a data row included the subscriber (User) ID, the rating of the movie (1-5) and the date of rating. We cleaned our data to reformat it into a matrix format where rows correspond to the Users (in our case the manufacturers), columns correspond to the Items (in our case the suppliers). Additionally, only the records from the users that had given the most ratings and the items that had been rated the most were used. This stage of data cleaning resulted in keeping Users that had given more than 1,400 ratings, and Items that each had been rated more than 97,200 times, all based on the 99th percentile of the original Netflix data set. The initial data cleaning provided 685,000 rows of data which yielded approximately 4,700 Users and 177 Items.

The clean, new formatted data set was divided into two parts: a training set, and a testing set, as a verified methodology in machine learning. This process is necessary so that the analyst does not over-fit the model and ensures that the algorithm can effectively handle the analysis of the test data. An additional benefit the withholding of data has is to simulate a "sparse" scenario in which there is a significant amount of missing data and hence providing a sense of realism for the analysis. The splitting of data was randomly assigned as 70% for the training set and the remaining 30% for the testing set (about 480,000 and 205,000 rows respectively).

Table 5 shows an extremely small snapshot of the input table for the training data where the rows are manufacturers (users), columns are suppliers (items), and the numerical values are the ratings those manufacturers have given to those suppliers. Note that "NA" means no rating is available for that manufacturer/supplier combination in our training dataset. Table 6 shows the standardized ratings computed according to the procedure shown earlier in our sample computations. The ID numbers included in these tables are the original Netflix codes and they may vary in length due to being randomly selected data among more than 100 million rows of raw data contained in their database.

Table 5- Original ratings data format

	S-10042	S-10168	S-10358	S-10359	S-10550
M-1979083	5	1	NA	NA	2
M-2293835	NA	1	NA	1	NA
M-25049	NA	NA	NA	1	3
M-2584676	3	5	4	NA	NA
M-94326	3	2	2	NA	NA

Table 6- Standardized Rating of Table 5 data

	S-10042	S-10168	S-10358	S-10359	S-10550
M-1979083	1.375	-2.625	0.000	0.000	-1.625
M-2293835	0.000	-1.918	0.000	-1.918	0.000
M-25049	0.000	0.000	0.000	-1.056	0.944
M-2584676	-0.949	1.051	0.051	0.000	0.000
M-94326	-0.035	-1.035	-1.035	0.000	0.000

At this stage of our analysis, the SciKit-Learn Nearest Neighbors model (SKNN) was utilized to handle the KNN algorithm more efficiently than we had coded and utilized initially in the sample computations part of this paper. SciKit-Learn is an open source library of machine learning algorithms used to conduct a variety of data analytics and machine learning procedures. One can input to SKNN which similarity method to use (e.g., Cosine or Euclidean) to determine how close/similar two manufacturers (or users) are to one another. The SKNN algorithm then creates the similarity table for all manufacturers; in this case for the cosine method as shown in Table 7.

Table 7-Cosine Similarity table (generated by SKNN)

	M-1979083	M-2293835	M-25049	M-2584676	M-94326
M-1979083	2.000	1.142	1.017	0.975	1.250
M-2293835	1.141	2.000	1.113	0.788	1.108
M-25049	1.017	1.113	2.000	1.075	1.062
M-2584676	0.975	0.788	1.075	2.000	1.096
M-94326	1.250	1.108	1.062	1.096	2.000

Upon training the SKNN algorithm, one can conduct the final phase of the CFB analysis by using the testing data set and directing a query to SKNN to receive the K nearest neighbors of any user (K is the choice of the analyst), where the "nearest neighbors" in our case is a list of the most similar manufacturers (users) based on their ratings of the suppliers. Now, we need to compute a predicted rating value for each of the "NA" cells. To conduct this analysis, the data in Tables 5 and 7 are utilized by a weighted average method. The predicted overall rating for a specific supplier of interest (say, S-10042) by a manufacturer (say, M-2293835) that is originally "NA" can be achieved by using the SKNN output and Equations 3 or 4 (choice between cosine and Euclidean methods), where P_r = Predicted supplier rating by a given manufacturer, R_i = Rating of the same supplier by the i th similar/neighbor manufacturer, S_i = Computed similarity between the given manufacturer and the rating i th manufacturer.

Cosine Similarity Method: $P_r = \sum (S_i + 1) R_i / \sum (S_i + 1)$, $i = 1, K$ (Equation 3) , per supplier

Euclidean Distance Method: $P_r = \sum (1/S_i) R_i / \sum (1/S_i)$, $i = 1, K$ (Equation 4), per supplier

Table 8 contains these results for five manufacturers who had not rated one or more of five given suppliers, as previously reflected in Table 5. Due to page limitations, we have included the predicted supplier ratings only based on cosine similarity method.

Table 8- Predicted Ratings Using Cosine Similarity Method

	S-10042	S-10168	S-10358	S-10359	S-10550
M-1979083	5.000	1.000	3.401	3.299	2.000
M-2293835	3.994	1.000	2.799	1.000	3.991
M-25049	3.999	3.793	3.190	1.000	3.000
M-2584676	3.000	5.000	4.000	4.902	4.005
M-94326	3.000	2.000	2.000	4.301	3.602

TEST OF ACCURACY Root mean square error (RMSE) is a common metric used to evaluate the performance of classification and regression machine learning models. We used RMSE to measure the average error of our method for predicted ratings of n suppliers as compared to the true ratings in our testing data. RMSE is described by the equation 5, where R_i is the actual rating given to a supplier, and $R_{i, \text{predicted}}$ is our predicted rating. **RMSE= SQRT [$\sum(R_i - R_{i, \text{predicted}})^2/n$]** (Equation 5)

To validate our CFB model for supplier selection, 100 samples each with 100 observations were randomly selected from our testing data set, where an observation was the rating given by a manufacturer to a supplier. For each sample, RMSE was computed based on the results obtained by four different methods: 1) KNN and Euclidean Distance; 2) KNN and Cosine Similarity; 3) Average rating for the supplier (baseline); 4) Average rating by the manufacturer. A one-factor ANOVA was conducted on the above four vectors to see if the average RMSE was the same across the four predictive methodologies. The ANOVA test showed a significant result at $P = 0.000$. Table 9 shows the average RMSE values for 100 random samples iterations.

Table 9- Average RMSE results

Euclidean Method	Cosine Method	Supplier Mean Rating	Manufacturer Mean Rating
1.081	0.941	1.013	0.986

Follow-up statistical tests (six pair-wise comparisons) revealed the cosine method to have the least average RMSE, at $P= 0.000$, and it was significantly more accurate than the baseline method 3.

From a data analytics/machine learning point of view, our CFB model is functional. However, from a practical perspective the challenge is to design and create a digitized platform to connect different global manufacturers and suppliers through a rating system similar to the one described in this research. We enthusiastically invite the supply chain professionals and relevant research organizations for future collaboration with us for an initial dialogue on the design and operation of this platform. The issues that need to be addressed are the functionality of such an open-source database/website platform, administration and ownership, design, security, future operational costs, security, and scalability, to list a few critical factors.

There are two other challenges that may indeed have adverse effects on the utilization of the platform. One is the problem of the “cold start” for those suppliers who have never been rated before and those manufacturers who have never rated any supplier before. This problem has also been pointed out by Du and Jing (2018) in their K-means algorithm for CFB method realizing that there is a need to explore the relations between manufacturers and suppliers from alternative sources of data. Another researcher has shown that demographical and social network information can be useful for determination of similarities of online purchasing in the absence of historical purchasing data (Sedhain et al., 2014). A third paper discusses the use of proximity, impact and popularity (PIP) factors of ratings and proposes a heuristic model to improve the cold-start problem when making recommendations based on the collaborative filtering method (Ahn, 2008).

The second challenge is the idea of sharing data among manufacturers and buyers, many of whom may indeed be on the list of business competitors. However, in a recent article (Hummel, 2018) an empirical analysis has found that 98% of Google’s top 1,000 mobile App advertisers always benefit from sharing advertisement related data. With the rapid migration of industry to a more digitized business world, we anticipate new business models will correct the above challenges for our envisioned platform to become a feasible reality. Gainfully, we hope, such a platform would act as a global resource for data analytics researchers in the field of supply chain management.

CONCLUSION This research has shown that the KNN algorithm of machine learning can be successfully utilized as a tool for collaborative filtering-based selection of suppliers. Furthermore, we have effectively tested the accuracy of the model by RMSE computations. Within the constraint of page limitations, we have attempted to provide clarity for our research approach along with detailed required computations as how to utilize predictive analytics and recommend solution for an important supply chain problem, that of suppliers selection. However, other machine learning algorithms and approaches, such as Bayesian networks, random forests and neural networks certainly are potential future research tools in this area.

The applications of big data analytics are at the beginning stages of exploration and experimentation in the fields of supply chain management and logistics business analysis. The requirements, however, are extensive computer coding, data cleaning/management and complex algorithmic analysis, especially within the broad domain of machine learning. Therefore, we strongly recommend future incorporation of data analytics research, both theoretical and applied, into the above fields with the goal of achieving a more productive and value-added link between research and related business.

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BIG DATA ANALYTICS AS A SOLUTION TOOL FOR NP HARD OPTIMIZATION PROBLEMS IN INVENTORY MANAGEMENT

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Abstract: Inventory control need to be able to analyze data trends for SKU in real time to gain a significant amount of value for the execution of the daily inventory operations. Big data comes from a very wide variety of sources, devices, software and products and being used in the daily operations in supply chains. Traditionally, the models of inventory management are developing the tools that secure to come up with accurate forecasts and predict future demand as accurately as possible and try to find "ideal connections" within all the data and decisions. The forecasts serve as the input in an optimization scenario that analyzes constraints to make decisions on managing inventory. In big data analytics "ideal connections" between data are much more than using traditional historical data on previous sales. It's possible to link data that are generated by product interactions, warehouse operations and transactions (generated by industry competitors). Inventory control problem belongs to the class of the NP (Non-deterministic Polynomial) hard problems and occurs in many areas, especially in inventory control. Almost, only way to solve these problems, is to use searching methods - heuristics and metaheuristics. Heuristics and metaheuristics methods are used for space searching (possible solutions), do not use classically formalized mathematical procedures based on theory and finding optimal solution is not guaranteed. These methods generate extremely large volumes of both structured and unstructured data, which are difficult to process by using traditional database methods as a result of their size. In an inventory control situations, the volume of data is too large, moves too fast and is beyond the processing ability of current technology. Regardless of these limitations, big data has a lot of potential to help companies enhance their inventory operations and become more profitable solving these NP hard inventory problems. The objective of this paper is to show complexity of heuristics search in terms of generated large number of potential solutions for a NP hard multiproduct inventory management problem with storage space constraints, as a combinatorial optimization problem and big data analytics problem.

Keywords: *Big data, Big Data Analytics, Multiproduct EOQ inventory problem, discrete time system control, special heuristics*

1. INTRODUCTION

Data Analytics involves applying an algorithmic process to derive insights. For example, running through a number of data sets to look for meaningful correlations between each other. It is used in a number of industries to allow the organizations and companies to make better decisions, as well as verify and disprove existing theories or models.

Analyzing big data allows analysts to make better and faster decisions using data that was previously inaccessible or unusable. Using advanced analytics techniques such as prescriptive analytics, predictive analytics, data mining, heuristics algorithms, error detections algorithms, we can analyze previously untapped data sources independent or together with their existing enterprise data to gain new insights resulting in better and faster decisions. To solve the NP hard inventory problems, in a process of big data analytics have been developed

the mathematical algorithms of special heuristics based on the local search technique. Special heuristics was developed in order to facilitate relations between “good and bad” solutions, in a huge volume data of solutions 365^m (where, 365 - number of days of forecast period, m - number of products - over 30000 SKU). As the result of this big data analytics study, we were able to present special heuristics algorithm that generates a feasible set of ordering scenarios, also algorithms of error detection approach for dynamic discrete inventory control models in order to solve this NP hard optimization problem.

The basics conclusion of paper is to show there is strong relationship between big data concept and NP hard problems which have a large number of potential feasible and unfeasible solutions, in other words, NP hard problems generates big data. The majority of inventory operations are continue to be driven by statistics and quantifiable performance indicators, for example: inventory purchasing of large number of SKU are driven by just sales performance indicators (such as number of days of selling goods), but in reality this indicator is very poor and inadequate, and don't have a large number of real time data. However, in order to keep up with changing inventory environment, it is imperative for operations management to adopt real time analytics.

The explosion in the availability and accessibility of machine-readable data is creating new opportunities for better decision making in applications of operations management. The swell of data and advances in machine learning have enabled applications that predict, for example, consumer demand for video games based on online web-search queries (Choi and Varian 2012) or box-office ticket demand based on Twitter chatter (Asur and Huberman 2010). In the context of inventory management, demand is the key uncertainty affecting decisions and such works suggest a potential opportunity to leverage large-scale web data to improve inventory decisions, for example, for stocking video game titles or allocating cinemas of varying capacities. There are also many other applications of machine learning, including Da et al. (2011), Goel et al. (2010), Gruhl et al. (2005), Kallus (2014), that use large-scale and web-based data to generate predictions of quantities that may in fact be of interest in operations management applications. By and large, however, these applications and the machine learning techniques employed do not address optimal decision-making under uncertainty that is appropriate for operations management problems and, in particular, for inventory management.

2. BIG DATA ANALYTICS

Stored data does not generate business value, and this is true of traditional databases and data warehouses. Once the data is appropriately stored, however, it can be analyzed, which can create tremendous value. A variety of analysis technologies, approaches, and products have emerged that are especially applicable to big data, such as in-memory analytics, in-database analytics, and appliances

The term analytics is not used consistently; it is used in at least three different yet related ways [Watson, 2013]. A starting point for understanding analytics is to explore its roots. Decision support systems in the 1970s were the first systems to support decision making [Power, 2007]. Decision support systems came to be used as a description for an application and an academic discipline. Over time, additional decision support applications such as executive information systems, online analytical processing (OLAP), and dashboards/scorecards became popular. Then in the 1990s, Howard Dresner, an analyst at Gartner, popularized the term business intelligence. A typical definition is that “BI is a broad category of applications, technologies, and processes for gathering, storing, accessing, and analyzing data to help business users make better decisions” [Watson, 2009]. With this definition, BI can be viewed as an umbrella term for all applications that support decision making, and this is how it is interpreted in industry and, increasingly, in academia. BI evolved from Decision support systems, and one could argue that analytics evolved from BI (at least in terms of terminology). Thus, analytics is an umbrella term for data analysis applications. BI can also be viewed as “getting data in” (to a data mart or warehouse) and “getting data out” (analyzing the data that is stored). A second interpretation of analytics is that it is the “getting data out” part of BI. The third interpretation is that analytics is the use of “rocket science” algorithms (e.g., machine learning, neural networks) to analyze data.

Due to the diversity and size of datasets in Big Data, effective representation, access as well as analyses of unstructured as well as semi-structured data are still problematic. It is

required to determine the way of searching space of all potential variable sub-sets as well as the assessment of prediction performance of learning machines for guiding searches and also which predictor to utilize. Extensive searches may be carried out if the quantity of parameters is not too much. However the issue is NP-Hard and search rapidly turns operationally intractable. Vast set of search schemes may be utilized, which include best-first, branch-and-bound, simulated annealing, genetic algorithm.

Research shows the benefits of using data and analytics in decision making. One study of 179 large publicly traded firms found that companies that have adopted data-driven decision making have output and productivity that is 5% to 6% higher than that of other firms. The relationship extends to other performance measures such as asset utilization, return on equity, and market value [Brynjolfsson, 2011]. In 2010, the MIT Sloan Management Review, in collaboration with the IBM Institute for Business Value, surveyed a global sample of nearly 3,000 executives [LaValle, 2010]. Among the findings were that topperforming organizations use analytics five times more than do lower performers, and that 37% of the respondents believe that analytics creates a competitive advantage. A follow-up study in 2011 found that the percentage of respondents who reported that the use of analytics was creating a competitive advantage rose to 58%, which is a 57% increase. Although these studies do not focus exclusively on big data, they do show the positive relationships between data-driven decision making, organizational performance, and competitive position.

3. MATHEMATICAL MODELLING

The Economic order quantity (EOQ) model belongs to a class of classical inventory models with a known total deterministic product demand, where the order product quantity should be determined to minimize the total costs of the production, ordering and inventory holding.

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 (Bertsekas 1987). Numerous special heuristics and metaheuristic-based algorithms are used to solve such problems (see Zoller 1988, Jans and Degraeve 2007 for an overview).

Static time-continuous multiproduct EOQ-based inventory problem with storage space constraints. In order to solve it approximately the problem is modeled 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). To solve this model we have developed a special heuristics based on the local search principle in Section 4 and metaheuristic technique based on VNS in order to compare results.

We consider a time-continuous multiproduct EOQ-based inventory problem which has most of the characteristics of a well-known classical economic lot-size model (Djordjovic, 2016).

A number of products m are given and for each product i , $i = 1, \dots, m$, the total deterministic demand D_i which should be satisfied within a finite time horizon T .

For each product i the only cost to be considered is the cost related to ordering – the setup cost S_i and the purchase cost of C_i per product unit, and the inventory holding cost of H_i per product unit in time unit. The total inventory holding cost in period t_i is calculated with respect to the average inventory level $Q_i/2$.

Ordered amounts of different products share the same storage with the total available space G which is known in advance, and consequently, for each product i the storage space P_i , occupied by its unit, is given. Therefore, inventory levels during the observed time period $[0, T]$ should satisfy the following *storage space constraints*: at any moment in this period the total space occupied by the stored amount of all products should not exceed the space limit G .

Then, the following inventory problem is considered: find amounts $Q_i, i=1, \dots, m$, which satisfy storage space constraints and minimize the total cost (2).

In order to solve it approximately, the problem is modelled as a combinatorial optimization problem of the corresponding discrete time system control process in the following way.

Instead of $Q_i, i=1, \dots, m$, we consider $u_i \in \{1, 2, \dots, n\}, i=1, 2, \dots, m$, as decision variables, while $Q_i = D_i / u_i$.

Now, for each product i a change of its inventory level during the whole time period can be formally represented as a discrete time system control process with the following elements:

$X_t^i, t=1, 2, \dots, n$ - the total amount of product i remaining on the stock at the end of period t .

$Y_t^i, t=1, 2, \dots, n$ - the amount of product i ordered at the beginning of period t .

If we consider X_t^i as the *state* of a process at period t then the *state equations* which describe the behaviour of the process can be defined as

$$X_0^i = 0 \quad (1)$$

$$X_t^i = X_{t-1}^i + Y_t^i - D_i / n, \quad t=1, 2, \dots, n. \quad (2)$$

Obviously, ordering of amount $Q_i = D_i / u_i$ is realised at the beginning of a period t only in the case when the stored amount of a product i remaining at the end of the previous period $t-1$ is not enough to satisfy demand D_i / n within period t . Therefore, the value of Y_t^i depends on u_i and can be formally expressed as

$$Y_t^i = \begin{cases} D_i / u_i, & X_{t-1}^i < D_i / n \\ 0, & \text{otherwise} \end{cases} \quad t=1, 2, \dots, n. \quad (3)$$

Also, as $X_0^i = 0$ then, consequently, $X_n^i = 0$.

Storage space constraints are considered only at the beginning of periods t and consequently can be formally defined as

$$\sum_{i=1}^m (X_{t-1}^i + Y_t^i) P_i \leq G \quad t=1, 2, \dots, n. \quad (4)$$

Let us determine the total cost $J(u_1, u_2, \dots, u_m)$ for the inventory system described by (3)-(5). A more simplified expression for total cost J is

$$J(u_1, u_2, \dots, u_m) = \sum_{i=1}^m S_i u_i + \sum_{i=1}^m \frac{H_i T}{n} \sum_{t=0}^{n-1} X_t^i + \sum_{i=1}^m (C_i D_i + H_i D_i \frac{T}{2n}) \quad (5)$$

where we include the fact that $\sum_{t=1}^n Y_t^i = D_i$.

Now the following combinatorial problem on the dynamic discrete time system control process can be formulated: for control variables u_1, u_2, \dots, u_m of the process (1)-(3) find such values from $\{1, 2, \dots, n\}$ which satisfy all storage space constraints (4) and minimize the total cost (5).

4. SPECIAL HEURISTICS

In this section we develop a special heuristics for solving problem approximately as defined in Section 3. The main elements of the algorithm are defined in the following way:

The Search space U : Space U contains all m -triples $u = (u_1, u_2, \dots, u_m)$ such that $u_i \in \{1, 2, \dots, n\}, i = 1, 2, \dots, m$. It means that during a search process through space U the heuristic can generate not only feasible solutions u (where coordinates u_1, u_2, \dots, u_m satisfy storage space constraints (4)), but also unfeasible ones which do not fulfill these constraints.

Objective functions: The "quality" of a generated solution u is measured in two ways:

if u is feasible then its quality is measured by the corresponding value of the total cost $J(u)$ defined by (5). Namely, a feasible solution u_1 is better than a feasible solution u_2 if $J(u_1) < J(u_2)$.

The heuristics is based on the local search technique. Starting from an initial solution, the best (feasible or unfeasible) point from the "neighborhood" of current solution is obtained in each iteration. The obtained solution represents next searching point. If the current solution is feasible and there is no better solution in the neighborhood, the structure of this neighborhood is changing. Now, the best solution is searched again in the modified neighborhood.

δ -neighborhood $N(\delta, u^k)$ of current point $u^k = (u_1^k, u_2^k, \dots, u_m^k)$ from space U is defined as a set of all points $u = (u_1, u_2, \dots, u_m)$ from U such that u^k and u are different in just one coordinate, for example coordinate u_i^k and $|u_i^k - u_i| = \delta$ is satisfied. Theoretically speaking, neighborhood $N(\delta, u^k)$ could be empty in the case when there is no a coordinate i such that $u_i^n + \delta$ or $u_i^n - \delta$ belong to $\{1, 2, \dots, n\}$. Neighborhood structures are defined in accordance with a predefined set of natural numbers $\delta_0, \delta_1, \dots, \delta_s$ where $s > 1$ and $\delta_1 < \delta_2 < \dots < \delta_s < \delta_0$. When current point u^k is unfeasible, structure δ_0 is joined, i.e. heuristic searching δ_0 neighborhood $N(\delta_0, u^k)$. When it is feasible, one of the δ_j structures is joining $j \in \{1, 2, \dots, s\}$ i.e. δ_j -neighborhood $N(\delta_j, u^k)$ is searched. If the current point cannot be improved, we continue searching the $N(\delta_{j+1}, u^k)$ neighborhood. Note that in real-life problems n is much larger than δ_0 (usually $n = 365$ days) and therefore defined neighborhood structures provide non-empty neighborhoods.

The initial solution: The initial solution $u^1 \in U$ can be generated in the following way: for each product i we consider independently the problem of minimizing the total cost for this product (5) and it refers to storage space constraints $(X_{t-1}^i + Y_t^i)P_i \leq G, t = 1, 2, \dots, n$. We find the optimal solution u_i^* to this problem using a total enumeration procedure. Now, the heuristics starts from $u^1 = (u_1^*, u_2^*, \dots, u_m^*)$ as an initial solution. Although u^1 represents an "ideal" point that minimizes the total cost for each product, it is usually unfeasible according to storage space constraints (4). Starting from this point, the heuristics strives to generate feasible points where total costs (5) are as close as possible to the values of the costs for an ideal point.

Heuristics can be described more specifically with the following steps:

Initialization step: generate ideal point $u^1 = (u_1^*, u_2^*, \dots, u_m^*)$. If u^1 is a feasible point, join δ_1 structure. If u^1 is unfeasible point, join δ_0 structure;

Iteration step: For $k = 1, 2, \dots$

- If point u^k is infeasible, find the best feasible point u_{best}^f in the neighborhood $N(\delta_0, u^k)$ (according to criteria function $J(u)$), join the neighborhood structure δ_1 and set $u^{k+1} = u_{best}^f$. If there are no feasible points in the neighborhood $N(\delta_0, u^k)$, find the best unfeasible point u_{best}^f (according to criterion function $L(u)$). If u_{best}^f is better than u^k , join the neighborhood structure δ_0 and set $u^{k+1} = u_{best}^f$.
- If the point u^k is feasible with joined structure δ_j for $j \in \{1, 2, \dots, s\}$, find the best feasible point u_{best}^f in the neighborhood $N(\delta_j, u^k)$. If u_{best}^f is better than u^k , join the neighborhood structure δ_1 and set $u^{k+1} = u_{best}^f$. If u_{best}^f is not better than u^k or there are no feasible points in the neighborhood $N(\delta_j, u^k)$ remain in the point u^k , i.e. $u^{k+1} = u^k$, and join the new neighborhood structure δ_{j+1} .

The stopping criterion:

- If the current point u^k is infeasible and there are no feasible points in the neighborhood $N(\delta_0, u^k)$, stop if the best unfeasible point u_{best}^f from the neighborhood is worse than the point u^k .
- If the point u^k is feasible with joined structure δ_s stop if the best unfeasible point u_{best}^f from the neighborhood $N(\delta_s, u^k)$ is worse than the point u^k or there are no feasible points in this neighborhood.

4. NUMERICAL RESULTS

The implementation of special heuristics, described in Section 3. was realized in *Visual Basic for Application*, and it uses intermediate results obtained from the model developed in *Excel spreadsheets*. All experiments were performed on *Windows 7 Ultimate* operating system on a *Pentium (R) Dual-Core CPU T4200* processor with 4.00 GB of RAM and 2.00 GHz.

In order to investigate the behavior of the special heuristics, we developed also VNS algorithm (Mladenovic, 1995), and compare their efficiency. They were preliminarily tested on problem with $m=102$ products, where the inventory management process is considered during period $T= 1$ year which is divided into $n=365$ days. The total available storage space is equal to $G= 3500$ m². Ranges of other input data for all products are given in Table 1. The optimal solution to this problem is not known in advance.

Special heuristics define output results matrix with dimensions 365x102, where the columns of the matrix presents total cost and the maximum occupied space per period for each product for the number of orders from 1 to 365. The number of order combinations can be calculated as 365^i , where i is the number of ordering products $i=1, \dots, m$. For the three products the number of combinations is $365^{102} = \text{Big data number}$

Table 1: Ranges of input data

	D_i [unit]	P_i [m ² /unit]	S_i [\$/order]	C_i [\$/unit]	H_i [\$/unit/day]
range	[1000; 10000]	[0.10; 2.00]	[1;15]	[0; 100]	[3; 7]

We performed four groups of numerical experiments with $k_{max} = 5, 10, 15, 20$. For each of these values the VNS algorithm (Mladenovic, 1995) was applied 10 times generating an initial solution by the deterministic procedure. Special heuristics was applied once for each value, because the results were the same for the same value of parameter k_{max} , generating an initial solution by the same deterministic procedure as by the VNS algorithm. The stopping criterion for the VNS algorithm is more than 1000 iterations between two improvements of objective function (5). The stopping criterion for special heuristics is described in Section 3. The corresponding best values of the objective function (5) as well as the average execution CPU time for both solving techniques are presented in Table 2.

The numerical experiments show that in all cases the results obtained using the special heuristics, as well as the duration of execution time, are better than those obtained with the VNS based algorithm. Taking into account only the results of special heuristics we could not notice that either the quality of obtained objective function values or the duration of execution time are dependent on values of k_{\max} .

Table 2: Numerical results

k	Solving technique	Initial solutions	Best value of the objective cost function	Average value of the objective cost function	Time of search for column 3 (sec)	Average time of search for column 4 (sec)
	1	2	3	4	5	6
5	Special heuristics	Deterministic	119.145,02	119.145,02	0:01:57	0:01:57
	VNS algorithm	Deterministic	120.960,53	122.857,79	0:05:05	0:06:42
10	Special heuristics	Deterministic	119.565,54	119.565,54	0:01:02	0:01:02
	VNS algorithm	Deterministic	121.619,03	124.585,00	0:02:11	0:03:06
15	Special heuristics	Deterministic	118.734,27	118.734,27	0:00:43	0:00:43
	VNS algorithm	Deterministic	123.669,93	127.404,19	0:01:41	0:02:02
20	Special heuristics	Deterministic	116.979,20	116.979,20	0:00:34	0:00:34
	VNS algorithm	Deterministic	124.150,54	129.120,54	0:01:09	0:01:36

5. CONCLUSION

Today, big data is having a huge influence on inventory management methods and also positive influence on how companies handle inventory management in order to increased and improved: profits and sales, operational efficiency, customer satisfaction and cost reduction. This paper presents an overview of heuristics methods and space searching algorithms for inventory control problems. The practical contribution of this paper by should be prove that the heuristics algorithms can be used as reliable and easy way for control and ordering of inventories and also as the "tool" for creating Big Data Analytics..

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BIG-DATA DEPLOYMENT IN SHAPING INDONESIA'S E-COMMERCE BASED REGIONAL CONNECTIVITY

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ABSTRACT

As e-commerce is characterized by borderless trading between and among regions, it also encouraged inter-connectivity among regions. Drawing from the idea of utilizing big data for addressing whether or not e-commerce spurs inter-city connectivity, this research investigates sellers' preference to measure customers' willingness to purchase using price uniformity as proxy. This research conducted the availability of big-data and develop a descriptive statistic model to indicate a set of policy in order to improve the competitiveness regarding the cities' inter-connectivity in e-commerce. Employed statistical methods to measure standard deviation of the second-hand products, the study found that price uniformity could be utilized to indicate whether inter-connectivity exists in classified ads. The finding implies that price uniformity is useful in contributing to the decision-making processes of policy concerning e-commerce and could be applied to other commodities as well.

Keywords: e-commerce, classifieds, big-data, inter-connectivity.

INTRODUCTION

The rapid growth of online trading in the last ten years or more lead providers or business owner to innovate their platform to cope with the market and create big-data that could be used in many different sectors (Schwab, 2016). The trend of buying and selling used goods online is still growing and in demand by the people of Indonesia. This is marked by a recent report from OLX – the biggest classifieds ads web - that describes the growth in the number and value of transactions in the first quarter of 2016 which increased significantly from the previous quarter. Number of transactions recorded as 1.6 million per month and keep growing to create big-data repository accordingly (Goenawan, 2016).

Nevertheless, the uniformity price of important to calculate. It is related to seek the inter-city connectivity by overcoming the relative weight or average of price, distance, regional GDP and their variances (Goldberg & Verboven, 2005). Seeking the inter-city connectivity by overcoming the relative weight or average of price, distance, regional GDP and their variance is a big challenge for this research to shape the understanding in how the city correlate to other cities (Crucini, Shintani, & Tsuruga, 2009). By accommodating a statistical approach to find the standard deviation of tested products. The standard deviation from regression analysis of specific product also could be used as a proxy for determining the inter-city connectivity. This can be achieved by accommodating a statistical approach to find the standard deviation of tested products (Stiglitz & Salop, 1982).

Drawing from this argument, we posit that the uniformity price of goods is associated with the inter-city connectivity by overcoming the relative weight or average of price, distance, regional GDP and their variances. This paper aimed to answer the following research question: Is there any difference between region X and region Y regarding the sellers' reference in order to allow their businesses to gauge the willingness of consumers' awareness to make the purchase?

LITERATURE REVIEW

Rapid deployment of e-commerce which started since previous two decades led to the emergence of a number of factors which attributed to buying decision and market orientation from both customer and seller's perspectives (Meffert, Morawiak, & Schumacher, 2015). In addition, the price of high-quality attention has skyrocketed, increasing as much as nine-fold in the last two decades (Teixeira, 2014). The emerging situation has lead providers or business owner to innovate their platform to cope the market and create big-data that could be used in many different sectors (Akter & Wamba, 2016). Particularly in initial markets, online advertising enjoyed double-digit annual revenue growth rates, while in more mature markets, annual revenue growth rates are not far behind, as the rate was estimated at almost 10 percent (Jones & Fox, 2009).

A dramatic leap from print to digital version was inevitable and has proven itself to be quite beneficial for digital players (Burton, 2009; Meffert et al., 2015). A classified advertisement is designed to capture the local market by reducing transportation cost and risk of un-matching supply-demand needs (Jones & Fox, 2009). On the other side, the uniformity price of goods is correlated to the expectation of getting similar goods at the same or similar price. Uniformity implies consistency in lack of variation between the items being compared, over a long period and across a wide range (Eckert & West, 2004). Seeking the inter-city connectivity by overcoming the relative weight or average of price, distance, regional GDP and their variance is a big challenge for this research to shape the understanding in how the city correlate to other cities (Mann, 2002).

Relevant studies explain connectivity as interaction between two or more nodes (in this case, interaction between two or more cities/regions) that indicates by flows of goods and/or services that reflects economic, social, and human mobility linkages (Eckert & West, 2004; Evans, 2002; Goldberg & Verboven, 2005). Using the above argument on connectivity, we consider it is necessary to employ transaction data which is including origin and destination from node-i to node-j, vis-versa. Since e-commerce data in this study did not record such criteria, we utilize the theory of Law of One Price (LOOP) as our method in this study. Price uniformity idea comes as a proxy of high connectivity among nodes on certain regions (Crucini et al., 2009). We use the approach of `Staggering Price model` (Stiglitz & Salop, 1982). Following, log relative price of goods in city i and city j is written as:

$$q_{ij} = \ln \frac{P_{i,t}}{P_{j,t}}, \text{ where:}$$

$$q_{ij,t} = \lambda q_{ij,t-1} + \frac{(1-\lambda)(1-\lambda\beta)}{(1-\lambda\beta\rho_z)} (2s_{ij} - 1)z_{ij,t}$$

$s_{ij} = 1/(1 + (1 + \tau)^{1-\theta})$ is home bias,

and $Z_{ij,t} = \ln \frac{Z_{i,t}}{Z_{j,t}}$ is good price index, λ is random-shock.

When $\lambda = 0$, the relative price of two nodes is decreasing in τ (market friction). Here, market friction is depicted as terrain, bad infrastructure and physical factors that exogenously creates price difference. If consumers are homogenous, firms perfectly compete, transportation cost is not a vital factor, and there is no market friction then the relative price is one, or there is no price dispersion. Price uniformity implies consistency in lack of variation between the items being compared, over a long period and across a wide range. Price uniformity might be equilibrium but it above competitive equilibrium. In reality, price dispersion should exist regardless of connectivity because firms add transportation cost and consumers spend search cost. Even though price uniformity is a utopian-concept, it is still applicable for the purpose of measuring inter-city (inter-region) connectivity.

RESEARCH DESIGN AND METHODOLOGY

In this section, we employ big data set from OLX Indonesia regarding the monthly goods traded for property, car, and motorcycles. To match the concept of price uniformity (Dickey & Fuller, 1979), the selected goods should satisfy the criteria of LOOP, which are: (1) liquid and exchangeable; (2) consumer`s preference is only price, independent over features; (3) firms produce the single-identical good and consumers have easy access to the goods; and (4) no asymmetric information.

Based on the criteria, we selected Toyota Avanza and Yamaha Mio as the unit of analysis. Toyota Avanza and Yamaha Mio are two most searched items and traded items in OLX website, as measured by the volume of sales advertised. The data is investigated at the city and district level. The procedure is plotting the price of selected goods into a map to grasp the spatial pattern of price distribution. Further, we also calculated price variance on the provincial level as the proxy of interconnectivity in each province. The last part is an experiment to interconnectivity by several variable i.e. GDRP, infrastructure, and population.

FINDINGS

Figure 1 shows the distribution of Toyota Avanza (manufactured at 2014) price. In this figure, we normalized the price of Avanza by taking the average price of Avanza in central Jakarta as indices. Red coloured dots are Avanza that was sold cheaper than Jakarta's price and blue is the expensive one. The similarity of colour on certain provinces represents the price uniformity.



Figure 1

Price Distribution of Toyota Avanza



Figure 2

Price Distribution of Yamaha Mio

It is also can be inferred that Java, Bali and Southern Sulawesi have a low variation of price, which means that those regions are more connected than other regions, who have higher variance in terms of price. Similar findings can also be found when Yamaha Mio is used as the unit of analysis (figure 2).

The following table showed the calculation summary of calculated price variance on provincial level derived from regression analysis of Toyota Avanza and Yamaha Mio proxy to determine the inter-city connectivity in each province, the lower standard deviation is shown the higher interconnectivity.

Table 1: calculated price variance on provincial level

<i>Province</i>	<i>Toyota Avanza</i>		<i>Yamaha Mio</i>	
	<i>Log Price</i>	<i>Log Price</i>	<i>Log Price</i>	<i>Log Price</i>
	<i>Mean</i>	<i>Std. Dev</i>	<i>Mean</i>	<i>Std. Dev</i>
Aceh	0.03576	0.23750	0.21824	0.326697
Bangka Belitung	-0.03683	0.26484	0.02714	0.313144
Bengkulu	-0.11445	0.25045	0.2576	0.28395
Jambi	-0.04239	0.238836	0.00281	0.51427
Kep. Riau	-0.11119	0.241804	0.03182	0.35275
Lampung	-0.01996	0.224622	0.08747	0.437552
Riau	-0.04711	0.238805	-0.11888	0.226659
Sumatra Barat	-0.14951	0.348268	0.03878	0.282948
Sumatra Selatan	-0.04494	0.243011	0.11977	0.362717
Sumatra Utara	0.01356	0.261699	0.08273	0.358521
Banten	-0.03649	0.250455	-0.04011	0.61558
Jakarta	0	0.195975	0	0.367891
Jawa Barat	-0.04701	0.245985	0.03131	0.379916
Jawa Tengah	-0.03368	0.173141	0.14922	0.338347
Jawa Timur	0.01816	0.174183	0.15234	0.363599
Yogyakarta	-0.04472	0.173807	0.16486	0.415303
Kalimantan Barat	0.04384	0.15721	0.00621	0.221485
Kalimantan Selatan	-0.05036	0.311832	0.15751	0.494052
Kalimantan Tengah	-0.05348	0.23248	-	-
Kalimantan Timur	-0.02630	0.252619	0.06413	0.492134
Kalimantan Utara	-0.16614	0.256592	-	-

Gorontalo	-0.52247	0.391028	-	-
Sulawesi Barat	0.05743	0.100268	0.03878	0.282948
Sulawesi Selatan	0.01566	0.259313	0.34197	0.353929
Sulawesi Tengah	-0.10096	0.326928	0.28636	0.196182
Sulawesi Tenggara	-0.10096	0.344518	-	-
Sulawesi Utara	-0.18343	0.13070	0.32889	0.447721
Bali	0.06321	0.13070	0.18042	0.410917
NTB	0.0844	0.20081	0.26227	0.139412
NTT	0.0774	0.192524	-	-
Maluku	-0.11632	0.301706	-	-
Maluku Utara	-0.17254	0.46848	-	-
Papua	-0.08522	0.258583	-	-
Papua Barat	-0.15367	0.305788	-	-

The well-connected regions were still small compared to the total number of regions in Indonesia. Therefore, we argue that this was one of several reasons why Indonesia has a low competitiveness level, especially in terms of logistics cost.

DISCUSSION

These findings are supported the OLX tagline's "hyper-local ads" in which the price of second-hand goods tends to be uniform in some stages derived from region's area, street length, and local GDP. Several factors need to be added as different considerations and proxies to calculate price uniformity, as an example from customer view: the digital literacy level and customer (economics) maturity level as predictors for customer's awareness align with a business view: corporate awareness and e-commerce size and platform. Those two factors suggested has a major impact in shaping the price uniformity and regional connectivity. But like any other market, commodity prices are determined by supply and demand. At the same time relative to one area to another, the demand for the product is not necessarily affected. This indicates many influencing factors that consider formatting the commodity price. Moreover, the result can be refined if we are able to use the brand new product rather than second-hand product and obtain the origin-destination (O-D) data of e-commerce product sales. We recommend that these improvements should be tailored to our method and implemented as future research.

CONCLUSION

From this research, we can conclude that price uniformity can be used as a proxy to indicate the inter-city (inter-region) connectivity. By looking at the data of Toyota Avanza and Yamaha Mio ads, most areas in Indonesia still have low connectivity inside and outside the city. The government can use the connectivity map in this research to develop the issue of inter-city (inter-region) connectivity in Indonesia.

The globalization of production and trade in second-hand goods is associated with increased use of information technologies (number of listed ads and economic transaction on OLX) and transformation of economic activities. Price uniformity for second-hand goods could be used as a proxy for policymakers to assess the scope and expand the projected policies on online to which the trade of their economy is concentrated in the second-hand goods that are the heaviest users of technology (OLX).

Acknowledgements

We'd like to acknowledge Pulse Lab Jakarta and OLX Indonesia who initiate Research Dive 4 Program and made this research collaboration done.

ESTIMATING EXHAUST EMISSION OF OIL TANKER VESSELS USING BIG DATA IN THE PORT OF SINGAPORE

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Abstract

Purpose of this paper:

As one of the busiest ports in the world, the Port of Singapore handles a considerable number of vessels every month. The consequential emissions from visiting vessels lead to increasing concerns about the impact on the environment and human health. In recent years, application of big data is changing the traditional ways of emission accounting, especially by using the data extracted from Automatic Identification System (AIS). This paper aims to utilise the AIS data and establish an emission accounting model to estimate the amount of exhaust emissions from oil tanker vessels in the Port of Singapore in 2016.

Methodology:

The bottom-up methodology is adopted to develop the model, with the aid of coastal Automatic Identification System (AIS) with fine data resolution. Pollutant emissions and various Greenhouse Gases (GHGs) are estimated which include carbon monoxide (CO), carbon dioxide (CO₂), sulphur dioxide (SO₂), nitrogen oxides (NO_x), nitrous oxide (N₂O), methane (CH₄), non-methane volatile organic compounds (NMVOC) and particulate matters (PM).

Findings:

Findings show that oil tankers that have visited the Port of Singapore have produced 2,990,940.33 tonnes of exhaust gases in 2016. In terms of ship engines, boilers generate the most emissions while the main engines produce the least. The most emissions are generated while tankers are at berth. The rule of Economies of Scale (EOS) is found to be applicable for the relationship between emission and tanker capacity, implying that the emission per DWT decreases as the size of the tanker increases. The newer vessels are also suggested to emit less exhaust gases.

Value:

This study is the first in literature that utilises AIS data to estimate tanker vessel emission in the Port of Singapore. It reveals the enormous potential of how big data (AIS) could help in environmental policy making in port cities such as Singapore. Potential beneficiaries of this study include port authority, local environment agency, ministry of health etc.

Key Words: Exhaust emissions, Greenhouse gases, Big Data, Emission Accounting, Port, Oil Tanker

1. Introduction

Among all human activities, shipping generates a significant amount of exhaust emission (Beirle et al., 2004; Tzannatos, 2010), with about 2.1% of global anthropogenic greenhouse gases (GHG) emissions or about 10% of the global CO₂ emissions nowadays (Psaraftis and Kontovas, 2009). Being an island nation, Singapore has its major port sitting adjacently to densely-populated city centre. Emissions from the Port of Singapore could spread easily into residential areas via sea breeze (Yau et al., 2012). Hot weather in Singapore also accelerates the dissemination of exhaust gases. In addition, as one of the busiest ports in the world (World Shipping Council, 2017), the accumulated amount of emission in the Port of Singapore could not be neglected. Tankers, as compared with container vessels and dry bulk carriers have the most vessel arrivals in Singapore for the

past few years (MPA, 2018). However, the exhaust emission generated by tankers in Singapore waters and its implications have not been thoroughly researched on.

In recent years, application of big data is changing the traditional ways of emission accounting. The increasing number of data sources have offered a more accurate and efficient way of emission accounting. For example, data extracted from Automatic Identification System (AIS) have improved the resolution of ship movement records. There are also more complete and better structured vessel specifications database available. These databases allow better estimation of load factors and emission factors.

This paper aims to establish an emission accounting model to estimate the amount of exhaust emissions from oil tanker vessels in the Port of Singapore. The findings are expected to facilitate future policy making, assessment and re-evaluation of the emission conditions, as well as business decisions, in the sector of shipping and port operations. Pollutants investigated include carbon monoxide (CO), carbon dioxide (CO₂), sulphur dioxide (SO₂), nitrogen oxides (NO_x), nitrous oxide (N₂O), methane (CH₄), non-methane volatile organic compounds (NMVOC) and particulate matters (PM).

This paper is organised as follows. The second part of the paper discusses approaches in emission accounting. Methodology is described in the third part of the paper followed by the results and discussion in Part 4. Conclusion and implication are lastly presented in Part 5.

2. Literature Review

There are two popular methods in calculation of emission in ports: top-down approach and bottom-up approach. Top-down approach is usually adopted when there is not much information for individual ships. Assumptions in ship characteristics are usually needed and thus top-down approach is considered to be more uncertain and less accurate (Jalkanen et al., 2012; Ng et al., 2013). On the contrary, calculations in bottom-up approach are made based on individual ship performances. Detailed vessel characteristics are involved such as speed, engine power, location of the vessel to calculate the displacement of the vessel (e.g. Jalkanen et al., 2009; Olesen et al., 2009; Yau et al., 2012; Li et al., 2016). Despite the high accuracy, full bottom-up approach is usually not feasible even with the help of AIS data. This is mainly because of missing data. For one, it is unlikely to fully capture all vessel movements as not all vessels turn on AIS transmission at all time. Secondly, there are still cases that the data of engine power especially for auxiliary engines and boilers are not available.

To solve the problem, a hybrid approach exists that utilises both bottom-up and top-down methods. An example is given by Wang et al. (2008) where ship traffic model was established based on AIS data, but ship activities were anticipated and assigned to different shipping routes. A subsequent research by Vinken et al. (2013) has also proven the predictions using the hybrid method with less than 15% difference.

One of the main gaps of the existing studies is that most studies focus on only the emission of GHG, while exhaust gases emitted by ships also include toxic gases such as CO and PM. Also, average speed of vessels or AIS time intervals over several hours were usually employed in the previous studies, and this may create significant inaccuracy, as speed of a vessel is constantly changing due to volatile wave and weather conditions. Moreover, most emission studies use Propeller Law to estimate the actual power of main engines with the relationship between speed and engine power as a cubic of three. However, more accurate cubic relationship should depend upon the type of a ship. For large high-speed ships like container vessels, the relationship is a power of 4, while for low speed ships like tankers and bulk carriers, the relationship is a power of 3.2 (MAN Diesel & Turbo, 2011). In this paper, AIS time intervals are set as 15 minutes, and tanker-specific cubic relationship is employed to improve the accuracy of the calculation.

3. Methodology

3.1 Sampling frame and data

A hybrid method is adopted in this study. For efficient demonstration, tankers are categorised by cargo type into oil tankers, chemical tankers, liquefied gas tankers and others. Only oil tankers are examined in this paper. Based on the speed and load factor

of tankers, four operating modes are identified, namely at anchorage, at berth, manoeuvring and cruising.

The movement of vessels is obtained using the AIS. The AIS system is a broadcasting system using Very High Frequency (VHF) video carried on board ships to automatically provide navigation information to other ships and coastal port authorities (Goldsworthy and Goldsworthy, 2015). AIS could identify each ship by its Maritime Mobile Service Identify (MMSI) or IMO number and provide information such as vessels' name, type, size, speed, location, and operational mode (IMO, 2001). Actual main engine power, fuel consumption and consequently the emission of the ships could be estimated using the actual speed of the vessel.

In this study, a total of 1,409,517 AIS observations inside Singapore port waters are recorded over January to December 2016. Majority of the observations have a time interval of 15 minutes. Data with more than 48 hours of time gaps are assumed as new arrivals or port of calls. After deleting missing data and invalid data, the final sample consists of 1,311,825 AIS observations, 1,432 vessels and 6,752 arrivals. Data with the speed at each end node is recorded and assumed as the average speed of the past time interval. Emission for each time interval of each vessel is calculated, summed, and divided by a total number of arrivals to generate an average emission per visit. Overall emission for the entire year is estimated using the actual crude oil tanker calls multiplied by the estimated average emission per visit.

3.2 Operating modes

Most modern ships have three types of engines, the main engine that provides propulsion power, the auxiliary engine that provides ships with electricity regardless of operating modes, and the boiler that is used for heating bunker fuel oil, steam pumps, and cargoes (Goldsworthy and Goldsworthy, 2015). Ships at different operating modes require different power supply depending on the activity of the ships. Some common operational modes of vessels include manoeuvring, cruising, at berth and at anchorage (IMO, 2014). This paper adopts the modes assignment method from the Third IMO GHG Study (Table 1).

Table 1 Conditions for operating modes assignment

Operating mode	Condition
At berth	Speed \leq 1knot
At anchorage	1knot \leq speed \leq 3knots
Manoeuvring	Speed \geq 3knots, load factor $<$ 65%
Normal cruising	Speed \geq 3knots, load factor \geq 65%

Source: (IMO, 2014)

3.3 Calculation of fuel consumption and emission

Emission from ships could be quantified through two factors: i) fuel consumption of engines, and ii) emission factors of bunker fuel. The former is dependent on the actual engine power and the actual speed of the ships while the latter indicates the ability of the bunker fuel in emitting exhaust gases during combustion.

i. Main engine

The actual power of a vessel is calculated according to Propeller Law (MAN Diesel & Turbo, 2011) using the speed given by AIS data:

$$L_i = \left(\frac{V_i}{V_d}\right)^{3.2}$$

$$P_i = P_{max} * L_i,$$

where L_i denotes the load factor; V_i (unit: knot) is the actual speed of the vessel of during time interval t_i (unit: minute); V_d is the vessel designed speed; P_{max} (unit: kW) is the maximum power of the main engine and P_i (unit: kW) is the estimated actual engine power during t_i .

$$C_{j,m} = \sum_{i=1}^{i=n} P_i * SFOC * t_i$$

where $C_{j,m}$ (unit: g) is the fuel consumption of the main engine using fuel type j during time period t_i ; SFOC measures the consumption of fuel for each unit of energy output (unit: g/kWh). This paper takes reference of the SFOC values from IMO (Table 2).

Table 2 SFOC for each engine with different fuel types

Engine type	Fuel type	SFOC (gram/kWh)
Main engine	HFO	215
	MGO/MDO	205
Auxiliary engine	HFO	227
	MGO/MDO	217
Boiler	HFO	305
	MGO/MDO	300

Source: (IMO, 2014)

ii. Auxiliary engine and boiler

This paper takes reference from the third IMO GHG Study (IMO, 2014) for assumptions of auxiliary engine load and boiler load. The default values are shown in Table 3.

The fuel consumption of the auxiliary engine is calculated as follows:

$$C_{j,a} = \sum_{i=1}^{i=n} P_a * SFOC * t_i$$

Where P_a (kW) is the default engine load of the auxiliary engine; $C_{j,a}$ (unit: g) is the fuel consumption of the auxiliary engine using fuel type j during period t_i .

The total consumption of the boiler is calculated as follows:

$$C_{j,b} = \sum_{i=1}^{i=n} P_b * SFOC * t_i$$

Where P_b (kW) is the default engine load of the boilers; $C_{j,b}$ (unit: g) is the fuel consumption of the boiler using fuel type j during period t_i .

Table 3 Auxiliary engine (A) and boiler (B) load (kW) of oil tankers based on deadweight tonnage (DWT)

Capacity Type	At berth		At anchorage		Maneuvering		Cruising	
	A	B	A	B	A	B	A	B
0-4,999	250	500	250	100	375	100	250	0
5,000-9,999	375	750	375	150	563	150	375	0
10,000-19,999	625	1,250	625	250	938	250	625	0
20,000-59,999	750	1,500	750	300	1,125	300	750	150
60,000-79,999	750	1,500	750	300	1,125	300	750	150
80,000-119,999	1,000	2,000	1,000	400	1,500	400	1,000	200
120,000-199,999	1,250	2,500	1,250	500	1,875	500	1,250	250
200,000-+	1,500	3,000	1,500	600	2,250	600	1,500	300

Source: (IMO, 2014)

iii. Estimating total emission

$$E_{j,k} = C_{j,m} * EF_{j,k} + C_{j,a} * EF_{j,k} + C_{j,b} * EF_{j,k}$$

where $E_{j,k}$ is the emission of exhaust gas type k for the vessel using bunker type j ; $EF_{j,k}$ is the emission factor of exhaust gas type k using bunker fuel type j (Table 4).

Table 4 Emission factors of HFO and MDO for exhaust gases

Gas emission	HFO emission factor (ton/ton fuel)	MDO emission factor (ton/ton fuel)
CO₂	3.11400	3.20600
CH₄	0.00006	0.00006
N₂O	0.00015	0.00016
NO_x	0.09030	0.00961
CO	0.00277	0.00277
NM VOC	0.00308	0.00308
PM	0.00728	0.00097
SO₂	0.025	0.010

Source: (IMO, 2014)

Vessels usually burn two types of bunker oil, Heavy Fuel Oil (HFO), and Marine Diesel Oil (MDO) or Marine Gas Oil (MGO) (Ng et al., 2012). Yet, the proportion of each fuel type being utilised is not equal. With reference from IMO (2014) based on the global fuel sales statistics from International Energy Agency (IEA), the ratio of consumption is estimated as 87% of HFO and 13% MGO/MDO. Hence, the total emission of gas type k could be obtained as follows:

$$E_k = 87\% * E_{HFO,k} + 13\% * E_{MGO\backslash MDO,k}$$

Where E_k is the total emission of gas type k ; $E_{HFO,k}$ is the total emission of gas type k from all types of engines burning HFO and $E_{MGO\backslash MDO,k}$ is the total emission of gas type g from all types of engines burning MGO or MDO.

$$E_{k,total} = \frac{E_k}{S} * P$$

Where $E_{k,total}$ denotes the total emission of gas k in the population i.e. among all oil tankers; S is the sample size, i.e. sample number of arrivals; P is the actual number of oil tanker arrivals in 2016 (Table 5).

Table 5 Actual tanker arrivals at the Port of Singapore in 2016

	Number	Gross Tonnage ('000)
Oil Tankers	15,805	620,756
Total Tankers	23,695	780,849

Source: (MPA, 2018)

4. Results and Discussion

4.1 Emission estimation

It is estimated that in 2016 (Table 6), oil tankers that have visited the Port of Singapore have produced 2,990,940.33 tonnes of exhaust gases. Specifically, the total emission consists of 2,884,163 tonnes of CO_2 , 55.36 tonnes of CH_4 , 139.58 tonnes of N_2O , 73,889.74 tonnes of NO_x , 21,314.80 tonnes of SO_2 , 5,979.83 tonnes of PM, and 2,555.99 tonnes of CO. In terms of percentage of the total exhaust gases, CO_2 contributes the largest amount of 96.430% followed by NO_x of 2.470% and SO_2 of 0.713%. In terms of average emission per arrival, an oil tanker emits an average of 442.97 tonnes of exhaust gases each time it visits Singapore port.

Table 6 Estimated oil tanker emission for each exhaust gas in 2016

Exhaust type	Estimated emission using number of tankers (tonnes)	% of total exhaust gas	Average Emission per arrival (tonnes)	Average Emission per vessel (tonnes)
CO₂	2,884,163.00	96.430%	427.16	2,014.08
CH₄	55.36	0.002%	0.01	0.04
N₂O	139.58	0.005%	0.02	0.10
NO_x	73,889.74	2.470%	10.94	51.60
CO	2,555.99	0.085%	0.38	1.78
NM VOC	2,842.03	0.095%	0.42	1.98
PM	5,979.83	0.200%	0.89	4.18
SO₂	21,314.80	0.713%	3.16	14.88
TOTAL	2,990,940.33	100.000%	442.97	2,088.65

4.2 Emission and oil tanker capacity

In order to examine the relationship between emission and oil tanker capacity, two scatter diagrams (Figure 1 and Figure 2) are plotted. To eliminate the influence of erratic port call durations, the emission per minute value is used for discussion. It is suggested that the fitting function between emission per minute and gross tonnage (GT) is monotonically increasing with a reasonable r-square value of 0.466. This means that a larger vessel capacity is likely associated with a higher exhaust emission. On the contrary, the fitting function between emission per minute per GT and GT is monotonically decreasing with a higher r-square value of 0.5681. This implies when tonnage increases, the average emission per minute per GT decreases. In other words, a ship of a larger capacity is associated with less emission per GT. This is in accordance

with the findings of Lindstad et al. (2012) that the theory of economy of scale applies in exhaust emissions of oil tankers. In addition, the fitting function in Figure 2 also provides evidence of a diminishing return of vessel emission with reference to a larger vessel size. In other words, the decrease in emission per minute per GT is likely going down when the vessel increases in size.

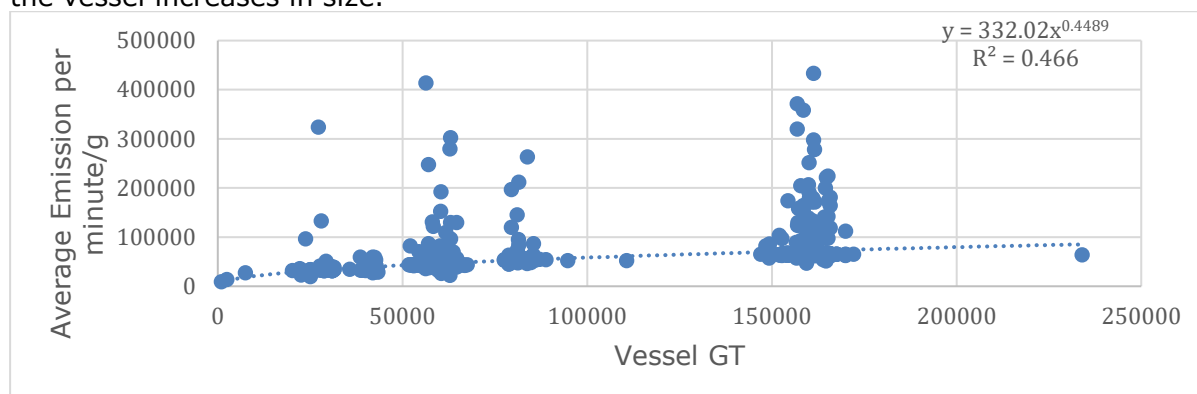


Figure 1 Average emission per minute and oil tanker's GT

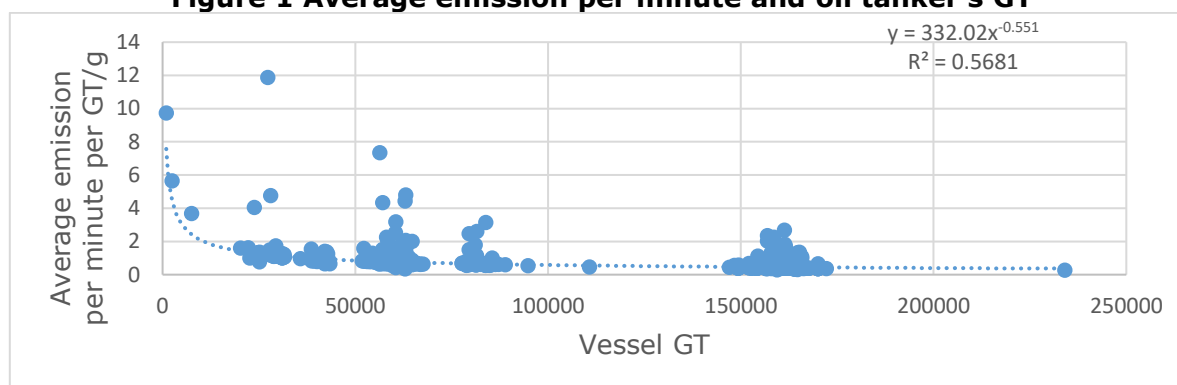


Figure 2 Average emission per minute per GT and oil tanker's GT

4.3 Emission and oil tanker's building year

To examine the factor of oil tankers' age on their exhaust emission, a regression of oil tanker's average emission per minute per GT in 2016 on oil tanker's building year is conducted (Table 7). The significant F test and the negative coefficient in X Variable suggests that newer oil tankers likely emit less exhaust gases in terms of average emission per minute per GT. The yearly decrease in oil tanker's emission is estimated to be 0.011 gram per minute per GT.

Table 7 Results of regression between oil tanker's average emission per minute per GT in 2016 and oil tanker's building year

<i>Regression Statistics</i>								
Multiple R							0.100	
R Square							0.010	
Adjusted R Square							0.009	
Standard Error							0.615	
Observations							1427.000	
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>			
Regression	1.00	5.39	5.39	14.25	0.00			
Residual	1425.00	539.03	0.38					
Total	1426.00	544.42						
	<i>Coefficients</i>	<i>Standard Error</i>	<i>t</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
Intercept	23.33	5.99	3.89	0.00	11.58	35.08	11.58	35.08
X Variable	-0.011	0.003	-3.78	0.00	-0.017	-0.005	-0.017	-0.005

4.4 Emission and engine type

Overall, boilers produce the largest quantity of emissions among the three engines, followed by the auxiliary engines, and the main engines produce the least emissions (Figure 3). One reason for the dominance of emission from boiler is that oil-carrying tankers may require constant steam and heating for their cargoes. Furthermore, the large capacity of oil tankers may also require more heating.

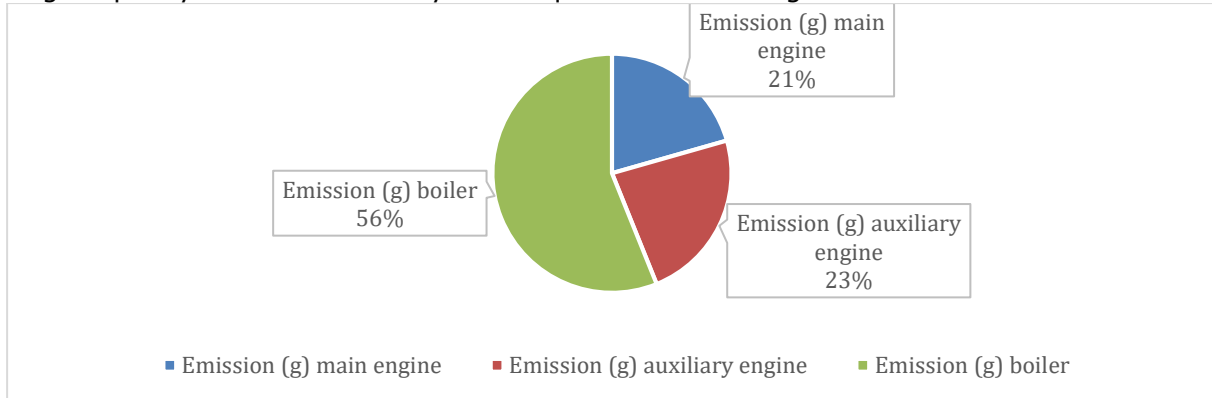


Figure 3 Emission percentage by engine type for oil tankers

4.5 Emission and operating mode

The emission behaviours of oil tankers at each operating mode differ significantly (Table 8). Tankers at berth generate the most emission of 2,254,181.66 tonnes, 75% of the total emission (Figure 4), due to the prolonged stay time. Tankers at anchorage produce the least emission with only 18,832.75 tonnes of exhaust gases, only about 1% of the total emission. It is also interesting to note that the emission at the anchorage mode is only 3.6% of that at cruising mode although the total stay time is 12 times higher. As a result, average emission per minute in normal cruising mode is about 300 times higher than that in anchorage mode. In fact, when comparing with other operating mode, average emission per minute in normal cruising mode is also significantly higher. This is likely due to a higher load factor of the main engines with the use of both auxiliary engine and boiler at normal cruising (Feng et al., 2015).

In terms of port visiting time, oil tankers spend the most time at berth, at an average of 2,869.1 minutes, and the least time spent at normal cruising, for about 4.6 minutes on average. Anchorage time is comparatively short as well, for 57.1 minutes.

Table 8 Total visiting time and average visiting time per arrival, total emission, and average emission per minute

	Total time (min)	Average time per arrival (min)	Total emission (tonne)	Average emission per minute (tonne)	Average emission per arrival (tonne)
Anchorage	385,498	57.1	18,832.75	0.049	2.79
Berth	19,372,260	2,869.1	2,254,181.66	0.116	333.85
Manoeuvring	1,742,008	258.0	191,262.36	0.110	78.00
Normal cruising	31,365	4.6	526,663.56	16.792	28.33

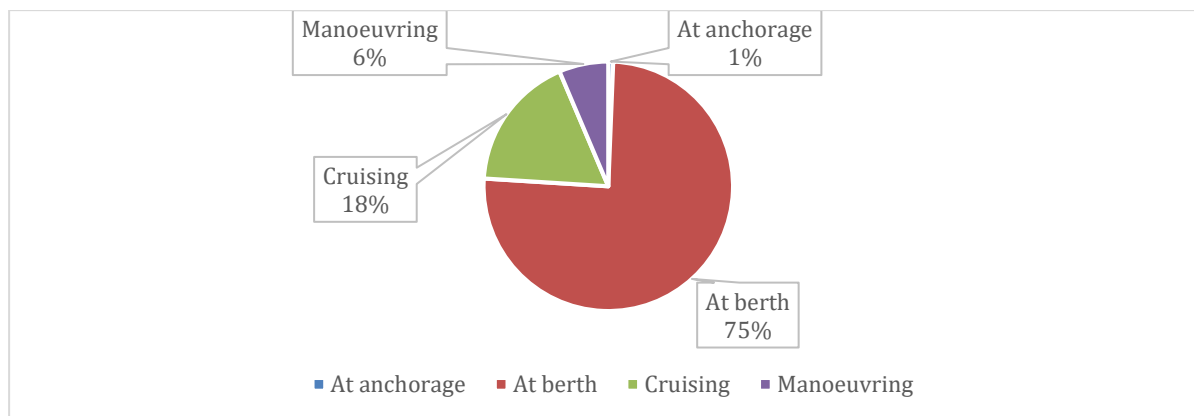


Figure 4 Emission percentage by operating mode for oil tankers

5. Implications and Conclusion

This study has established the first emission inventory for oil tankers visiting the port of Singapore using the latest big data emission statistics, AIS data. Among other results, oil tankers spend 3189 minutes on average in the port of Singapore, among which 2869 minutes are spent at berth and 4.6 minutes are spent during normal cruising mode. The most emission is also generated during at berth.

By estimating the emission from ships visiting the port, this study provides a humble insight of the environmental implication of visiting ships to Singapore. As no emission inventory has been done using the same methodology in the port of Singapore, this research could provide policy makers such as the port authority, local environment agency, ministry of health, etc., with a notion of the considerable amount of emissions generated by visiting ships. This paper could also raise the concern of shipping companies to reduce emission in collaboration with the MPA and act as a reminder to the possibly more stringent regulations to come due to the considerable amount of exhaust emission from ships. In addition, the observation that oil tankers produce the most emission at berth mode could be utilized by policy makers to craft regulations with specific targets.

As this is the first emission inventory for the region, there exist limitations that bring uncertainties in the estimation. Firstly, as this paper adopts the default auxiliary engine and boiler load assumptions from IMO (2014), the accuracy of these assumptions on the engines working in the local hydrology requires further examination. Secondly, the proportion of HFO and MDO being used is based on the global bunker sales data, which may differ from the actual proportion of fuel consumption in the port. In addition, data with more than 48 hours of time gaps are assumed as new arrivals while the actual arrivals and departures of oil tankers are unknown.

Future research could deploy satellite AIS data which has broader spatial coverage. In combination with high-resolution coastal AIS data, the accuracy of emission accounting could be significantly improved. More comprehensive information on auxiliary engines and boilers should be collected and analysed, in conjunction with considerations for Singapore's meteorological and hydrological characteristics. Actual fuel consumption within the area could be gathered to improve accuracy.

Acknowledgement

This research is supported by the Singapore Maritime Institute under Maritime Energy and Sustainable Development Centre of Excellence.

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Session 6: Technology and ICT in Supply Chains

DIGITALIZATION IN INDUSTRIAL LOGISTICS AND SUPPLY CHAINS – THE CONTEMPORARY SITUATION IN SWEDEN AND FINLAND

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ABSTRACT

Digitalization of industries, Internet of Things (IoT) and Industrial Internet of Things (IIoT) are frequently discussed among scholars and practitioners. Digitalization has a potential to provide remarkably increased visibility of logistics and supply chain processes, over the whole lifecycle of the products. As a result, cost efficiencies as well as value improvements are expected outcomes of increased digitalization efforts. Despite many new technologies and applications available on the market, observations from practice however indicate that the pace of implementation of digitalization in industrial logistics and supply chain management is slow. The purpose of the paper is to discuss the contemporary digitalization of logistics and supply chain management in Sweden and Finland. More specifically, the paper address (1) new and changed roles of supply chain members, and (2) barriers to digitalization.

KEYWORDS: Digitalization, Industrial logistics, Internet of Things, Sweden, Finland

INTRODUCTION

Digitalization has been recognized to be the main trend shaping the modern industrial economy. A global game of digital disruption is under way in many industries. Leaders around the world recognize that the prevailing business models in their industry could drastically and fundamentally change. Widely, the discussion about digitalization means evolvement of Internet of things (IoT), which is in an industrial setting often called "Industrial Internet of Things" (IIoT). IoT is typically defined as "*a dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols where physical and virtual 'Things' have identities, physical attributes, and virtual personalities and use intelligent interfaces, and are seamlessly integrated into the information network*" (van Kranenburg, 2008, in Xu et al., 2014, p. 2233). Digitalization, in its very essence, means the capturing of an analogue signal and converting it into a digital form that can be stored and processed (Kayikci, 2018). In practice, this means that a range of different sensory, communication, networking and information processing technologies are combined (Xu et al., 2014).

Based on this "digitization", a number of digitalized applications has emerged that are today frequently discussed, in a logistics context ranging from e.g. RFID tags, sensors, 3D Printing, robots, drones, blockchain, etc. Advantages of digitalization could for instance render improved information and control (Tu, 2018; Xu et al., 2014), customer services and expectations (Tu, 2018) and traceability (Xu et al., 2014). Digitalization also allows

and reinforce the emergence of “supply chain visibility”, and “big data” analytics. This development can in essence unify and facilitate overview, prediction and management of logistics beyond individual company borders. Thus, digitalization has become an important tool for the realization of the SCM philosophy.

The rapid development of digitalization is expected to have a great impact on the development of logistics and supply chain management (SCM) over the next coming years (Tu, 2018; Kayikci, 2018; Xu et al., 2014; Hemilä, 2017). Indeed, the development gives ground for disruptive businesses and behavior also in the field of logistics and SCM. Disruptive change means that new entrants are offering lowering prices, meeting customer needs in novel ways and making better use of unutilized resources. For instance, autonomous trucks without drivers could dramatically change transportation operations, as the cost for the driver often represent 50-70% of the total cost for the truck.

So far, however, the implementation of digitalization in a logistics context has been very modest (Tu, 2018; Xu et al., 2014). In practice, there are many software and hardware providers for complete IoT solutions, but still industries are facing barriers to be bigger than opportunities. This dilemma of great opportunities but slow implementation is the main motivator for this study. To better understand current situation, the purpose of this paper is to discuss the contemporary digitalization of logistics and supply chain management in Sweden and Finland, two countries with high IT maturity and significant digitalization knowledge thanks to companies like Ericsson and Nokia. More specifically, the paper address (1) new and changed roles of supply chain members, and (2) barriers to digitalization.

DESIGN/METHODOLOGY/APPROACH

Academic research in the area of digitalization in logistics and supply chains is so far very limited (Tu, 2018). Grounded in the situation in Sweden and Finland, the paper brings new insights to state of the art in the digitalization hype, especially in the logistics and supply chain context. This paper makes an attempt to structure the research by focusing on new and changing roles of supply chain members, as well as the barriers included.

So far, research on technology adoptions have been dominated by quantitative studies (Tu, 2018). For this study, a combination of different qualitative data collection methods have been applied, mainly interviews, workshops and observations. Interviews have been conducted mainly for their opportunity to obtain personal cognitions and feelings of the interviewee. The researchers have had the opportunity to pose follow-up questions as a means to create in-depth understanding. Workshops have enabled the researchers to follow the dialogue regarding barriers to digitalization among different types of stakeholders, and get insights into different actors' view. Finally, observations have enabled triangulation and in-depth understanding and possibilities to ask follow-up questions.

Data collection topics have been wider than the topics focused in this particular paper. Overall, the researchers have during the different types of data collection activities aimed for an overall understanding of the situation regarding digitalization in logistics and SCM in Sweden and Finland. In particular, the practitioners' perspective has been captured.

The table 1 shows the major data collection activities that constitute the results of this particular paper.

Table 1: Major data collection sources in the study

Sweden	Activity	Focus/topic cover
	3 interviews with supply chain consultants	Overall development of digitalization across industries in Sweden
	1 presentation of a retailer	Digitalization and implementation of RFID in warehouse
	2 workshops with primary and secondary supply chain members, and IoT providers	Current situation and challenges related to digitalization
	1 workshop with logistics managers	Current situation regarding implementation of digitalization and IoT.
Finland	Several development workshops with logistics manager	Continuing development of industrial supply chain digitalization
	1 presentation of IoT in service supply chain	Digital twin on service supply chain
	1 workshop with IT provider	Connectivity with 5G in industrial context

NEW AND CHANGING SUPPLY CHAIN ROLES

The findings of this study revolve around the many different stakeholders involved in digitalization of logistics. Traditional primary supply chain members (i.e. manufacturing and retail companies) and secondary supply chain members such as Logistics Service Providers (LSPs), are nowadays accompanied with different kinds of IoT and platform providers. An explanation for the existence of new and changed supply chain roles is the increased transparency that follows with digitalization. The traditional view of supply chains consists of a series of discreet, separate steps involving marketing, product development, manufacturing, distribution, and finally customers. In contrast, the ongoing digitalization break down walls and creates a completely integrated ecosystem that is fully transparent to all the players involved. This transparency relies on several key digital technologies including logistics platforms, analytics, warehouse robots, and even 3D printing, of which some might be provided by new members of the logistics ecosystems. Overall, independent from if it is an old or new supply chain member, those who move quickly to digitalize their supply chain will gain efficiencies, develop new business models and revenue streams, and create competitive advantage (Harvard Business Review, 2017). As part of the Material Handling Institute survey (MHI, 2018), over 1,100 manufacturing and supply chain professionals were asked to identify the top technologies that either disrupt or create a competitive advantage for their business. The number one response was robotics and automation (65 percent), followed closely by predictive analytics (62 percent), the Internet of Things (59 percent), artificial intelligence (53 percent), and driverless vehicles and drones (52 percent). As the respondents were partly manufacturing personnel, the importance of technologies was more related to manufacturing processes than logistics. However, the study indicates the common trends of automation, digitalization and exploitation of totally new technologies within the manufacturing industry supply chains, which are important drivers for new and changing supply chain roles.

As a result of the increased transparency, a new category of supply chain members very active today in their development can be labelled connectivity and network providers. Simply put, the transparency of a digitalized supply chain needs some kind of platform for its functionality and here a range of Swedish, Finnish as well as multinational companies (operating on the Swedish and Finnish markets) can be seen:

- Nokia for example announced in May 2018 acquiring the IoT startup SpaceTime Insight, which is developing machine learning based simulation and analytics for logistics and energy sectors. FedEx is already customer of SpaceTime Insight.
- General Electric (GE) is a multinational technology provider, who have developed own IoT platform for industrial asset management. GE's Predix is a software platform for the collection and analysis of data from industrial machines, but also for supply chain visibility.
- Software company Microsoft have already long history in industrial supply chain visibility, as their BizTalk integration server was widely used in changing EDI messages to XML format in before year 2010. Today, Microsoft offers Azure platform, which is an open, flexible, enterprise-grade cloud computing platform.
- SAP is most known about large scale ERP systems, but they have moved to industrial wide digitalization with their SAP Leonardo platform. Leonardo delivers software and microservices that enable customers to leverage future-facing technologies like the Internet of Things, machine learning, blockchain, analytics, and Big Data.
- Software giant IBM have developed their Watson platform, which is a cognitive system that learns from, and infuses intelligence into the physical world. IBM's Watson is then slightly different solution than other platforms presented, as the approach is trying to replace human decisions with cognitive intelligence. For example, technology provider ABB is bringing its industry-leading digital offering together with Watson IoT cognitive capabilities to unlock new value for customers in utilities, industry, transport and infrastructure.

Except for platform providers, another key group of supply chain members are IoT providers. These companies could be new ones, but also existing companies that have changed their role in the supply chain. In the digital era, logistics and supply chains will be fully integrated to other business processes and manufacturing industries are now aiming towards full visibility over the operations. New active ecosystem members are coming to offer technologies that enhance transparency and visibility with IoT devices at different places and levels in the supply chain: item, pallet, container, vehicle and system levels. For instance, smart tracking with paperless documentation and artificial intelligence (AI) based automated supply chain coordination can be reality already today. Collected data from different parts of the supply chains can be utilized to predict future process bottlenecks. Huge amount of collected process data combined with external data (weather, traffic, etc.) and with the advanced analytics, professionals can get totally new view to actual logistic process. Indeed, the very rapid development of cloud and mobile connectivity removes previous technology barriers and could be seen as an enabler for creation of new, disruptive services and relationships in the supply chain (World economic forum, 2016a). According the GT Nexus (2016) study, 94% of responders said Supply Chain Visibility Platforms/Tools be the key technology enablers have been identified, but are not widely used yet. An example of an IoT provider at the Swedish market is Toyota Materials Handling that has dramatically changed their role in the supply chain in recent years. By equipping their products, forklifts, with advanced sensors and computers, the

company is now able to provide the customers with a long range of relevant information about their logistics operations. Advanced knowledge about the use of forklifts could for instance be used for future predictions on volumes and need of manpower, layout and planning of new warehouses, etc. Overall, Toyota Materials Handling has strengthened their role in the supply chain and has become an important speaking partner for their customers, i.e. the primary and secondary supply chain members.

IDENTIFIED BARRIERS TO SUPPLY CHAIN DIGITALIZATION

Despite intense discussion and interest among practitioners, the implementation of digitalization in supply chains and famous success stories are today rare. In the study of GT Nexus (2016), 75% of respondents say that digital transformation of the supply chain is "important or very important", but 33% of the respondents said they are "dissatisfied" with progress so far.

Although the new technologies render many advantages as pointed out by practitioners in Sweden as well in Finland, the full potential of the technologies is difficult to grasp and judge. Limitations with existing technologies are also discussed among the members of the supply chain, for instance stability and use in certain conditions and environments. In line with other research (e.g. Kayikci, 2018), there is also a strong focus on cost-reducing benefits, neglecting for instance environmental impact of digitalization. Although costs related to technology such as RFID tags has been significantly reduced in recent years (World Economic Forum, 2016a), high costs are still considered a barrier for digitalization, in particular among primary supply chain members. Although it is clear that for instance IoT providers offers a wide range of devices at different price levels, the primary supply chain members still have difficulties with motivating "the use" of the technology. Still, in terms of e.g. pay-off times in investment calculations, digitalization devices seem too expensive. Overall, it is striking that among primary supply chain members the hard core, quantitative "investment calculations" are crucial. "Money talks" and goes before more "soft" considerations such as potential customer service improvements, flexibility and environmental impact that could motivate and improve the calculations. Two parallel, major reasons for the cost-related barrier seem to exist among practitioners in Sweden and Finland. First, the costs in relation to the use of the devices may still be too high, i.e. the "value for money" is not enough. Second, the calculations of the primary supply chain members lack full understanding of potential cost savings related to the implementation of the digital devices. To capture and include these potential benefits total cost analysis in a wider system is required, which is difficult to manage.

Somewhat related to the vagueness of expected benefits, the entire digitalization area lacks standardization. In fact, there are *too many* standards, often competing each other. This means that the use of IoT devices and their connections rapidly becomes complex matters. As a result, judgement and implementation matters regarding digitalization often requires competencies far outside the logistics domain in a company. The lack of standardization also means that judgement regarding trustworthiness and functionality of new IoT devices may be difficult. As an example, a Swedish retailer that was about to implement RFID tags in their warehouse was unsure about the physical range of the signal from the tag. Another standardization example is the forthcoming 5G network, when IoT device manufacturers are already marketing 5G ready products. However, entire 5G network standard is still under development, which will be the basis for future applications.

A reason for lack of standardization could also be a result of competition among providers of technologies and IoT applications. Standardization in the area of digitalization would facilitate improved, more cost-efficient and rapid development of new applications, but also lower entry barriers for new providers, thus increasing competition among existing players (e.g. Xu et al., 2014). Overall, when forming the future standards of digitalization, large interests are at stake.

Another important barrier is related to security, e.g. unauthorized access and the disclosure of privacy data. Partly security issues are related to standardization as well. Actually, security is one of the major barriers discussed in literature (e.g. Xu et al., 2014) and is also clearly mirrored among practitioners in Sweden and Finland. Indeed, during next coming years, technology, law and other regulations must be synchronized and harmonized.

Overall, given the barriers presented above, in particular the cost barrier, lack of standards, and vague benefits, there is in general a “wait-and-see” attitude among primary supply chain members in Sweden and Finland. A common argument is that the existing older technology still fulfills the needs of the company. For instance, extra benefits of RFID tags in relation to bar codes that is used today may not be seen. Also, as a result of the rapid pace of development, it is tempting to wait for next version before making the investment. Wait-and-see might also be result of lacking digitalization competencies, as the development of the technologies is so fast and there are not enough experts yet around the technologies and processes. Technology Industries Finland have estimated that over 53000 new talents is needed in Finnish industry until year 2021. Only to digitalization, artificial intelligence and data-analytics experts are needed around 11400 persons by that year. In Sweden there is a similar situation with lack of IT competence in a variety of different business industries and sectors. In fact, lack of IT competence is pointed out as one of the main reasoning for the reduced growth rate in the Stockholm area 2017-2018.

CONCLUSIONS

The results from this study suggests that the ongoing digitalization in many supply chains in Sweden and Finland (as well as the rest of the world) means that existing roles and supply chain structures may change in the future. However, although digitalization seems to render many advantages the implementation is still relatively slow. Practitioners are still taking a “wait-and-see” approach to the digitalization.

In conjunction with other research (e.g. Tu, 2018), this study suggests that powerful, often large companies may play a channel captain role and force the supply chain towards a higher degree of digitalization. Like the adoption of RFID in WalMarts supply chain, other IoT devices and standards might be implemented. Another key player for reinforcing the implementation rate, behind the scenes and behind the channel captains, are different kinds of platform providers, in Sweden and Finland typically Ericsson and Nokia. These companies may play a crucial role for the roll-out of more digitalized supply chains in the future. The cross-functional characteristics of digitalization, the implementation of IoT, typically has an impact that goes beyond company borders. Sometimes unexpected benefits could emerge (e.g. the use of RFID tags, Boeck & Wamba, 2008) as a result of this. To exploit the potential benefits at a supply chain level there is however a need for an understanding of how the IoT devices can be used at different actors in the supply chain

(Hemilä, 2017). Otherwise there is a risk that the benefits cannot be realized. Thus, implementation of digitalized devices should as much as possible be made at a supply chain level (in contrast to single company level).

The slow adoption rate might also originate from different, sometimes contradictory incentives among the different stakeholders involved. Ownership and control of data, and at the end of the day a channel captaincy role, is here at stake. Actually, the ownership of the data is an important part of the new digital business. Some scholars are arguing that data is a new oil. The concept is usually credited to Clive Humby, the British mathematician who established Tesco's Clubcard loyalty program. General rule is that, who owns the device that collect data, also owns the data. As IoT adoption grows in the future, schemas and policies governing data ownership rights and conveyance may become standardized.

Digitalization development is also rendering organizational changes that this study has come across. It could be argued that because of the growing volume, complexity, and strategic importance of data, it is no longer desirable or even feasible for each function to manage data by itself, build its own data analytics capability, or handle its own data security (Hemilä, 2016). A general pattern observed in larger companies, but also in the public sector such as administrative authorities and municipalities, is the emergence of specific organizational units typically headed by a "Chief Digitalization Officer" (CDO) or similar. Their task is to consolidate data collection, aggregation, and analytics, and being responsible for making data and insights available across functions and business units. Porter and Heppelmann (2015) suggested in a similar manner a new organizational unit called Unified Data Organization, responsible for company wide data management. The future of such specific organizational units could however be questioned. It could be argued that digitalization is covering all functions of business and as a result no specific function should "own" the digital processes. There is an obvious risk that projects being conducted in parallel to the usual business operations, not being anchored in existing operations and business logics. A comparison could be made to the role of sustainability managers that until recently often operated "in parallel" with existing operation. As argued in a report from World Economic Forum (2016a), CDOs plays a major role for leading digital transformation in the company, but its role is likely to be obsolete and disappear when company is fully digitalized.

This explorative paper has summarized the current situation regarding digitalization, with specific focus on new and changing supply chain roles and implementation barriers experienced by practitioners. It draws on practical evidences from Sweden and Finland, but to enhance more rigid outcomes the results need to be considered in other geographical contexts. More in-depth studies are also needed in the future, for instance in the form of multiple case studies. In particular, as the existing level of digitalization implementation is relatively low, in-depth studies regarding adoption of IoT devices should be made. Here interdisciplinary research may be needed in order to capture the multifaceted challenges with digitalization.

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THE IMPACT OF 3D PRINTING ON SUPPLY CHAINS: HYPE VS REALITY

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ABSTRACT

This paper examines the literature on 3D printing and supply chains, focusing on the impact that increased use of 3D printing in a manufacturing, as well as product development environment, will have on supply chain operations. By focusing on applications in the food industry, in particular the baking sector, specific insights were possible. The popular Gartner Hype reports provided a practical backdrop to compare the hype with the actual situation. The research provides input to the foundations of a framework, which has the potential to inform of the likelihood impact 3D Printing will have on global supply chains and how affected sectors should respond to these changes to secure long-term business success.

BACKGROUND

According to Gartner (Gartner 2014), by 2030, every kitchen is set to have a 3D food printer. One driver for this situation is to assist with feeding the increasing world population. The idea is that waste will be reduced, as people print customised meals, printed layer by layer, from cartridges filled with liquid/powdered ingredients, being delivered in the amounts required in the comfort of their home. Instead of cookbooks, digital recipes will provide input for nutritionally appropriate meals for those who deem this method convenient, those unable to cook in the traditional manner and those being catered for by healthcare professionals (e.g. the elderly and physically or mentally impaired).

Printing of food, using 3D technology, has been an evolving method of food production over recent years, and its acceptance is set to continue to grow. Additive Manufacturing within the food industry has allowed designers to combine their 3D design knowledge with food technologists to produce shapes, textures, tastes and forms that were previously found too challenging to create by hand, all whilst still being edible. This method of manufacture could additionally prove to be a healthy alternative, which is good for the environment. Proteins from beet leaves, insects and algae can be converted into edible products (TNO Netherlands 2016; Holland et al, 2018). It is also a step forward for food customisation, and even NASA is using this technology to look at ways to 3D print food in space (NASA 2013). The Global market for 3D printed food is set to be driven by the increasing demand for mass customization and individualisation, as 3D printing saves both time and waste. The actual nutrients themselves can even be customised, so consumers can benefit from tailor made food for their dietary requirements.

The market for this method of food manufacture can be broken down to the application of the food product, ingredients used and the country or area in which the food is used. One particular application could be the creation of foods with specific nutritional values whilst being easier to eat. For example, 3D printed carrots can be produced so that they have a softer consistency than regular carrots, meaning they are easy to chew and swallow. Potential markets for this would be hospitals and elderly care centres. Other applications include domestic cooking, catering and personalised chocolates (Mellor 2014). 3D printing

is already being used for bakery products, coffee, ice cream and confectionary – Hershey has collaborated with culinary schools and 3D systems to print personalised chocolate (3D Systems 2014). Confectionary (such as chocolates, sweets and biscuits) in particular is believed to be one industry where 3D printing could considerably grow in popularity, without any major advancements in the technology being required. The broad appeal and low level of expertise required to produce the products are additional factors that make entry into this market attractive.

Geographically, the global 3D food printing market can be divided into major regions which include North America, Latin America, Western and Eastern Europe, Asia-Pacific region, Japan, Middle East and Africa. Europe is regarded as the current market leader in 3D food printing (Reuters 2017), although many countries are making leaps and bounds outside of Europe.

However, this method of food creation also has its constraints. Many food ingredients used for 3D printing need to be turned into paste or melted, which is in itself rather limiting as there many foods that cannot easily be processed in this way while retaining their appeal (for example crunchy fruit and vegetables). The process can also be rather slow, typically taking several minutes to produce each piece (depending on size and texture) and needs to be cooled before the food can be consumed. A further problem is the relatively high per unit manufacturing costs compared to traditional food processing techniques. Although 3D printed food provides many opportunities (e.g. reduction in food waste and personalised nutrition and well-being) barriers remain.

A key question that needs to be addressed is whether consumers are ready for 3D printed food or if the idea remains a distant vision. Furthermore, will we have 3D printers in our kitchen alongside microwaves in the near to mid-term future? Questions such as these were used as the motivation and starting point of this research and later as a trigger to create the basic conceptual framework (described later).

To provide a theoretical backdrop, we investigated the issue of 3D printed food through the lens of the Gartner Hype Cycle. This states that almost every technology goes through five main phases on their way to peak productivity (Gartner 2017), as shown in Figure 1.

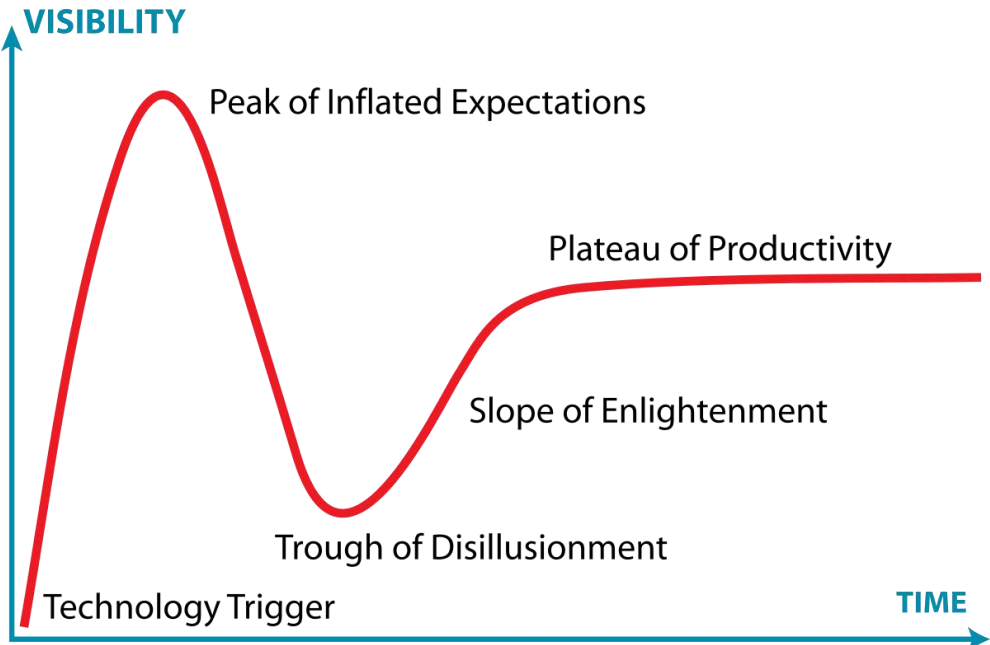


Figure 1: Gartner Hype Curve (Source: Gartner 2017)

Technology Trigger – The first stage, at which the public becomes aware of a new product on the market, technological breakthrough or similar, causing excitement and hence people talk about the innovation.

Peak of inflated expectations – With the help of media channels like social media, a lot of over-enthusiasm about the new technology is created. This is the stage where the technology/innovation experience their peak.

Trough of disillusionment – Consumers look beyond the initial excitement and hype. The curve of the Hype Cycle begins to descend and the media lose interest in the technology. This happens when the technology fails to fulfill the hype

Slope of enlightenment – The benefits of the technology are fully understood and the innovation can be used effectively as it is seen to be useful.

Plateau of productivity – Benefits and practical application of the technology are taking place and the technology is stable. A second or third generation may emerge as a result.

RESEARCH OBJECTIVES

This paper forms part of a larger research project, which investigates the opportunities and risks 3DP technologies on global supply chains. This exploratory paper aims to shed light on the supply chain management challenges that companies face when adopting 3DP technologies in the emerging customised food sector. The main research objective is to identify the degree of application of 3D printing technologies. The broader scale of the paper evaluates the impact of these technologies on supply chain configurations, in key sectors, while investigating the gap between hype and reality and evaluating future prospects.

RESEARCH METHODOLOGY

The project focuses on 3DP applications in the customised food industry – assessing the readiness of both businesses and consumers in the sector. As both academic and popular press sources were limited and scarce, it was necessary to carry out a deeper investigation. As part of the pilot study, the first stages involved surveying a specific target group (ages 18-30) to analyse the willingness of consumers, concerning acceptance of 3DP technologies being used in food manufacturing. This particular age group was chosen, as younger people are generally more 'tech savvy' and open to technological advancements such as these.

On the business side, local bakeries were interviewed, allowing us to gain some initial insights into one market (Germany). As the majority of data collected was limited to a local area, it was necessary to research the feasibility 3DP technology of the food industry at a bigger scale, hence looking at the industry at a national level. An elaborated survey was designed and a trade fair visit to the Cake and Bakell fair in Dortmund in May 2016 provided an opportunity to acquire such inside knowledge. The data collection was carried out between March 2016 and June 2016, resulting in 138 responses being collected. Examples of the question are provided below in Table 1.

The data collection provided a solid basis for better understanding how the bakery industry is being transformed by the use of 3DP technology and how future projections are set to disrupt supply chains and business models. A follow up study is currently under way, with results expected in mid-2018.

Sample Questions	
1)	What methods do you currently use to decorate cakes/cupcakes?
2)	Do you know someone who uses 3DP technology for baking/decorating?
3)	Is 3DP technology something you would consider using?
4)	Are you aware of the possibilities 3DP offers?
5)	What are the most important customer segments?
6)	Where are you located?

Table 1: Sample Questions to Businesses at the Cake and Bake Fair

ANALYSIS/DISCUSSION

3D printing has generated considerable hype and excitement, with business models being considered across a wide range of industries. The interest and investment in the technology is substantial and it clearly has the potential to revolutionise production and supply chain management in many industries, including customisable food. However, many people believe that the hype around 3D printing especially concerning the food industry has been largely unjustified. Despite widespread enthusiasm for the technology, adoption of 3D printing has been slower than many originally predicted. These circumstances raise the interesting question of whether 3D printing technology represents the future of food manufacturing or is merely a passing hype.

Although we observe emerging technologies being subject to a high degree of overly optimistic enthusiasm, the hype surrounding 3D printing has been, in many cases, extreme. In 2013, Harvard Business Review published an article, which predicted the widespread adoption of additive manufacturing technology and how these would overturn, decades of macroeconomic trends and end China's global manufacturing dominance (Economist 2015). Maybe, this is because 3D printing falls into the predictable pattern also known as the Gartner Hype Cycle (Deloitte 2015). Despite various criticisms, 3D printing has followed the Gartner pattern to some extent for the past 10 years (DHL 2016).

The results of this research, covering readiness and willingness of the public to try 3D printed food, however were rather surprising and did not correspond to the Hype Cycle predictions. Many industry experts (e.g. Cake Factory and the Renshaw Cake Academy) were not aware of 3DP technology being applicable to the food industry - some did not know about 3DP technology at all, explaining its lack of use so far. Other industry experts (e.g. Confectioner at TortenBoutique) were aware of the technology being used in food manufacturing however, they expressed their concerns about the question marks regarding food safety. For example, they were unsure if mixing different ingredients with a range of shelf lives, would allow safe consumption of 3DP food. Another concern that posed a barrier to 3DP being used was that the technology is regarded as unreliable and too slow,

as many complex designs cannot be implemented yet – making 3DP technology being more costly than traditional food manufacturing processes. Some confectioners (including TortenBoutique) saw 3DP as a threat, rather than an opportunity. They felt that 3DP will result in the industry losing its competitiveness. They further stated that the technology would mean less demand for professionally designed cakes by bakers, as consumers may decide to acquire a 3D printer and go through the process themselves, cutting the experts out of the process altogether.

However, interest and enthusiasm was expressed, indicating that many companies would consider adopting the technology provided that 'grey areas' were addressed. For example if hygiene standards were accurately defined and shelf life durations agreed upon. Another criteria for adoption was that use of the technology would result in cost-savings.

The findings of this initial research agree with those of Earls and Baya (2014), whereby it was stated that 3DP technology has not been sufficiently capable nor cost-effective to warrant application in most end products or in high-volume commercial manufacturing. Today's 3D printer industry is concentrated at two ends: high cost-high capability and low cost-low capability. As further stated by the report, the 3D printing technology advances through weakly coordinated development in three key areas, namely printers and printing methods, software to design and print, and materials used in printing.

Despite an encouraging trend in the 3D printing industry, the application of this technology in customisable food industry is relatively new. Although, the expectations for food applications of 3D printing are high, the idea of having a machine in the kitchen ready to create meals by loading capsules of ingredients, as well as the thought of quickly prepared healthy food is currently far from becoming a reality for most consumers.

The research suggests that analysing consumers' expectations rather than following predictions such as the Gartner Hype Curve is the way forward to successful implementation of 3DP technology in food manufacturing (see Figure 2).

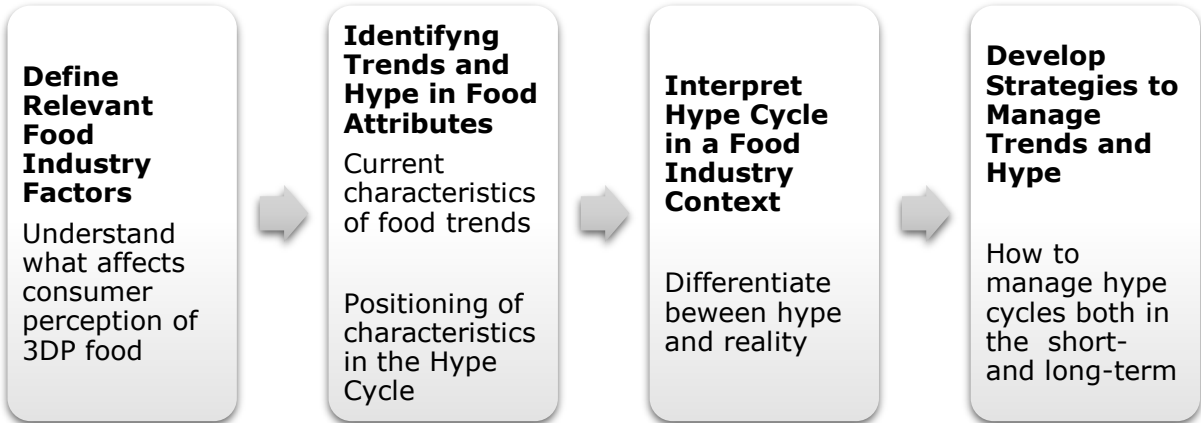


Figure 2: Customisable Model of 3DP Usage in the Food Industry

CONCLUSIONS

In the process of investigating the impact of 3DP technology on supply chains, this paper aimed to provide insights into the feasibility of its application within the customisable food industry and address relevant limitations and risks.

As indicated from the results of our survey amongst baking industry experts, 3DP technologies have the potential to disrupt a variety of industries, with acceptance slowly being achieved in the food industry. The fundamental concept behind usage of 3DP technology in the food industry is the possibility to print meals without the need for extensive prior knowledge. Although 3DP is still at the early stages within the food manufacturing process, Gartner predicts that the technology is set to change the food industry on a global scale.

Despite the limited information available regarding the specific application of 3D technology in food preparation, the potential for the market is present and ready to embrace the products offered using this technology. Although interesting insights were gained, it remains difficult to make accurate predictions in the direction of future development. As the study is based on a pilot study, further and more extended studies are needed in order to fully investigate further development in the field, by focusing on factors such as moderating effects of personality traits and academic/managerial implications.

As 3D printing moves further, many challenges are yet to be addressed, including assessment of hygiene standards, as well as copyright and intellectual property rights. Both of these issues are being actively discussed in the industry. Research into this field revealed that there are no exact guidelines as to how to approach legal issues concerning 3DP technology and its further development. Instead it was found that there are many discussions surrounding the potential hazards in terms of hygiene standards and copyright establishment. As 3DP technology will have a significant impact on business models, supply chain configurations and the traditional structure of productions, copyright issues will need to be specified, enabling companies to streamline their production, making them more sustainable and energy efficient.

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NETWORKED USE OF ADDITIVE MANUFACTURING CASE STUDY

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Abstract

Purpose of this paper: To empirically ground the networked use of additive manufacturing. Research directs attention to the impact of additive manufacturing on network structure and the degree to which additive manufacturing can be considered as a disruptive innovation.

Design/methodology/approach: This is a work in progress case study of different Norwegian firms and their use of additive manufacturing, either advanced or at a trail stage. The study encompasses interviews of 15 companies including observations of some of these companies. The research seeks through a series of qualitative interviews to detect company history of using 3-D printing tools, its current use and future prospects as perceived by various informants. The research is founded in supply chain management literature providing focus on how companies integrate to collaborate and coordinate production processes in an industrial network. Proximity to customers is a key analytical factor in the studied networks to facilitate co-creation. This implies considering new business models focusing on proximity in business relationships as a key factor associated with organizing supply.

Findings: One detailed company example from the case study is provided. This example shows that additive manufacturing is still in its infancy technologically and use is limited. It can at this point in time not be considered as a disruptive innovation due to its current limited use in the supply chain of the studied firm.

Value: The study develops a research approach considering use of additive manufacturing in the supply chain thus laying empirically founded grounds for further research on this is type of technological innovation in industry.

Keywords: Additive manufacturing, Disruptive innovation, 3-D printing, Integration, Supply chain structure.

Introduction

This paper addresses the topic of the impact of additive manufacturing on supply chain structure. Additive manufacturing, also known as 3D printing or desktop fabrication, has revolutionized the manufacturing industry. The American Society for Testing and Materials (ASTM) International, defines additive manufacturing as: "A process of joining materials to make objects from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing methodologies." Unlike traditional manufacturing where one start with a block of raw material and molds it in the desired form, additive manufacturing uses computer-aided-design (CAD) software or 3D (three dimensional) scanning of the desired object and develop it using the layer-on-layer approach. It was first developed in 1980 and since then it has been gaining attention in all areas of product manufacturing including food industry, clothing industry, fashion industry, aircraft and car manufacturing industry, medical industry and culture and heritage industry. This technology has been used to process vast range of materials like

polymers, metals, and ceramics with the potential to use a combination of materials. It also promises immense design freedom and the capability to create incredible geometrics, surpassing the effectiveness of CAD. Some of the main advantages of AM are; (1) It can provide flexibility to the product designer. Using a computer program, a designer can make different complex designs, (2) reduce the manufacturing time significantly. Since the design process is done digitally, it is possible to make the alterations digital, (3) reduce manufacturing cost and material waste and (4) with the use of additive manufacturing, the weight of the parts is significantly reduced, which makes the handling process much easier. In addition to that the strength of the material is also increased with the use of organic material.

Due to these advantages, most of the manufacturing industries have opted for additive manufacturing. Although there are numerous benefits of this technology, there is still some resistance in accepting the possibilities that this technology can bring into the industrial segment. The process of design increases the amount of virtual prototyping with products subjected to rigorous testing for optimization. There is also a need to consider the legal ramifications for patenting of designs, changes in certificate standards (CE) and product proving. With the rapid advancement in technology, companies must rethink their business models with the ever so changing demands from the customers. Additive manufacturing being one of these technologies has affected the organizations specially their supply chain network structure.

The supply chain is a network structure composed of the company, its suppliers, and its customers. This supply chain structure enables the distribution of both raw materials and finished goods, which can finally be distributed to the end customer through various channels. The main objective of the supply chain is to meet the demands of the customers as soon as they are placed. The increase in demand of customized products and faster delivery of goods and services has not only affected the cost of logistics but also modified the relationships with the suppliers. Therefore, to fulfil the needs of the customers as quickly as possible, there might be a need for customer-proximate production which will also help in reducing the costs related to storage, handling and transportation of finished products to the end user. The global supply chain has become volatile with the advent of sophisticated technology, the phenomenon of globalization, market competition and lean processes. Additive manufacturing may prove helpful in producing on demand customized products and in close proximity of the customers, thus rendering some stability and flexibility to the existing supply chains.

This paper is at this stage a working paper, a report from an ongoing empirical investigation. It provides a synopsis of one of the performed interviews of an advanced technology maritime parts and component supplier. This presentation is briefly analysed in conclusion. We consider the following research issues: (1) The impact of additive manufacturing on network structure and (2) the degree to which additive manufacturing can be considered as a disruptive innovation. In conclusion lines of further research as well as how this paper may be developed into a full paper are briefly considered.

Frame of reference

Production takes place in a supply chain structure. This structure may be characterised by the number and features of the more or less integrated firms that take part in this form of network. The local versus the global supply chain structure is rendered an increasingly important issue of investigation (Laplume et al. 2016, Li et al. 2017, Rogers et al. 2016, Wagner and Walton 2016). Literature discusses the proximity to customers as facilitating co-creation (Rayna and Striukova 2015, Rayna et al. 2015). This implies also considering new business models focusing on proximity in business

relationships as a key factor associated with organizing supply (Pisano et al. 2015). A supply chain is considered as a system, meaning it has for analytical purposes a common purpose and a defined borderline. The aim of supply chain management (SCM) in this picture is to integrate to facilitate effective collaboration. In supply chain studies, the 'network' is used as a metaphor to capture the complexities of interlocked exchange relationships, and to relate to the connection between social change and stability. Anderson et al. (1998) regard firms as actors that own different resources, perform exchange activities, and have relationships. Therefore, networks can be described as structures composed of exchange relationships between actors who own and use different resources. But these networks are not stable, in fact they are continuously changing due to changes in the existing relationships. It has been argued that the dynamics in networks can be understood based on the interplay between the positions and roles of the actors i.e., the firms. The increasing use of additive implies change in network structure through moving the site of some of the production from large-scale factories to small devices often found at the location of the industrial producer of mainly components of finished products.

Positions depict the situation of the actors in a given network structure, embrace the expected activities known as 'taken-on-activities'. While role describes what the actors intend to do, how they construct meaning in a situation and how they bring changes to it. The existence of these two dimensions, stated as position and role, can be found in any business network. The dynamics in any network are unique to that of the other networks. Changes in business networks can be explained by the activities an actor performs, given its position within a network structure. The primary determinant of the actors' activities and thereby of the network dynamics is attributed to the ability of the actors to interpret changes and create meaning of their own and other actors' network positions and roles (Anderson et al., 1998).

The role and position of actors and their interaction in a network structure may lead to innovations through creation and transfer of shared knowledge. This aspect has been studied by Guercini and Runfola (2015) who has interpreted that the innovation role of actors can be defined in terms of their learning and teaching processes as well as the internal and external relationship that they maintain. The basic assumption in this study is that the actors carry out and leverage a complex set of roles which define their unique profiles. The innovation push of the actor is determined by the set of roles which in turn depend on the nature of interactions with other actors both external and internal to the system. Additive manufacturing represents currently an emerging example of measurable impact of technology change on the supply chain network.

In the case of additive manufacturing, innovation is clearly technology-driven. Öberg et al. (2017) state that most studies on additive manufacturing concern technology. Hoover & Lee (2015) state that additive manufacturing be considered as disruptive; it changes industry settings, but Sandstrom (2016) disagrees with this. In a detailed case study in the hearing aid industry, 3-D printing of hearing aid shells were considered. Sandstrøm (2016) points out that the change to increased use of 3-D printing in the hearing aid producing industry he studied was economically driven. As the technology became cheaper to implement and efficient in use, a previously artisan type of profession became eliminated. The reasoning for the industry to take into use 3-D printing was mainly that it was a competitive necessity. The industry structure remained however mainly the same with the making of hearing aid shells, products designed to an individual user's ear, digitalized. Sandstrøm (2016) therefore interestingly concludes that the implementation of additive manufacturing mainly involved a competence destroying process innovation rather than a disruptive innovation. This indicates that additive

manufacturing may have the same consequences as modernistic mass production, the reduction or even elimination of handicraft skills in goods production. This also implies a spurious impact on the institutional layer of production. This raises another question regarding to what degree innovation is a threat to how goods are currently distributed. Is this moving of production into small scale production facilities closer to the customer a disruptive innovation?

“Disruptive innovation” was conceptualised in an article by Bower and Christensen (1995) meaning innovation when it creates a new market and organizational network radically changing how the needs of a customer, displacing thereby established market leading firms, products, and alliances. If an innovation is disruptive, this means that the networked market agents will need to re-think how the produce and exchange in the networks of industrial relationships facilitating production and transaction exchanges. Old agents may die, new ones may become important. Previously weak agents may become more powerful or vice-versa. Old processes of exchange and production may also change. Therefore, it is of importance to analyse to what degree this form of unceasingly common production and exchange can be characterised as a disruptive innovation.

Method

This paper provides summaries of 15 qualitative interviews with companies using additive manufacturing. Out of thirty (30) companies that were contacted only fifteen (15) companies are interviewed as some of the companies are currently not using 3D printing technology and few of them didn’t respond at all. These were carried out as personal or telephone interviews. Table 1 provides the interview guide:

Interview guide	
1	Describe the current supply chain structure (suppliers and customers)?
2	Describe the current use of 3-D printing in your production. Benefits & challenges?
3	How has the use of 3-D printing changed the structure of the supply chain?
4	Why did the firm choose to implement 3-D printing?
5	What are the realized benefits from the use of 3-D printing?
6	How do you envision the future use of 3-D printing?

Table 1. Interview guide

Several company manufacturing facilities were visited in Møre og Romsdal region in Norway. We observed 3D Printing facilities in order to study the additive manufacturing process technology in further detail. Together these interviews, applying a uniform interview guide, are considered a case study of the use of additive manufacturing in the Norwegian industry. Limitations include that only seven companies were interviewed and research therefore provided examples of additive manufacturing technology use. Still, this research provides insights forming a basis for further studies on this topic. At this stage of research we were only finished transcribing seven of these interviews and provide due to the short format of this paper only one rather detailed case example from a producer of high-tech maritime products, mainly parts and components.

Maritime parts and component producer

The studied company is an international group that supplies high-technology systems and solutions to companies in the industries of the oil and gas, the maritime and the defence and aerospace. The manufacturing plants are located both in Norway and abroad including US, Canada, UK, Germany, and China. The main business activity consists of systems for dynamic positioning and navigation, marine automation, handling systems, safety management, cargo handling, subsea survey and construction, marine training, satellite positioning, and autonomous solutions. The key markets are countries with large offshore, shipyard and energy exploration.

Synopsis of the interview

We have a in house production of sonars and we have sub-contractors delivering parts to us and then we mostly finish the product here in-house. We have countless suppliers. We are very large company. We have great variation in what suppliers do. So, anything from single part to ready-made industry come to us. We sell to end customers and end customers are always professional. Not private people. We have recently started 3D printing and I am personally doing 3D printing for 10 years or so. Only in prototyping and we have recently about a year ago introduced 3D printing also to do tooling, in-house tooling. We don't print products to be sold. This is maybe incorrect because we have just launched a product where we actually 3D-print parts that we sell. So, it's a little bit not mature yet that we have introduced 3D printing, we are in the introductory stages of 3D printing for sales and for tooling. But we have used it for several years for prototyping. 3D printing has given us new technique, new ways of thinking, new ways of producing and the parts that we 3D print today, we have never made before. And partly, because we knew that this part will be 3D printed then the design was made differently. Taking advantage of the 3D printing techniques and the tools that we use for in-house use they have also been specially designed will 3D printing in mind. Knowing that if we 3D print them in this way then we will save a lot of time and money rather than making them in a different way.

The tools and projects where we are changing existing parts with 3D printing parts but that's in-house tooling. Benefits are cost and time and high turnaround speed where our designer are able to have an idea for the tools to improve the process and then they are able to create that tooling overnight for example, it can be utilized next day. The challenges are the new materials we have to re-learn to design for 3D printing. Its new considerations compared to designing for machining. Time and cost are absolutely a benefit, we have three ultimate gear printers and they are running almost continuously over 3D printing tools and they are cheap to buy and cheap filament and just great benefit. As a designer, my biggest benefit is that we can create parts in 3D printing that we simply cannot make using traditional machining or molding or it would be incredibly expensive. So, there are lots of benefits, but 3D printing is yet a little bit immature so both printers and materials are little bit new and not matured yet. The components that we print they are usually printed from a supplier and with a SLS-nylon printing. So that's why we can have fantastic complex products. For production, it is accuracy and tolerances. We have chosen a cheap printer and you can't rely on it always delivering high quality that we need sometimes. It's not really a challenge but it's a learning curve to find when it is a good time to use 3D printer and when you should machine the part. If you are not Coca cola, would you like to 3D print the can and then of course time will be a horrible thing? You can't 3D print a Coca Cola Can because it takes about one and a

half second to stamp a Coca cola can but then again Coca cola makes 1 million cans every hour. We don't make 1 million things every hour. We make ten parts a month. We produce relatively low volume, high complexity parts. And if we can create a tool overnight or during few days, its much faster than having it ordered it from a machine shop which usually takes three weeks for example. They are standard products but low volume. We have much production of high cost and high complexity. Mostly the products are standardized and then maybe will customize the package to the customer. But when we build physical items they are mostly standardized yet.

The supply chain structure hasn't really changed because we have in-house machining machine, so 3D printing hasn't change the supply network structure. We don't have such a large impact because the tools are very low volume compared what we do. We still need the other suppliers, so I don't think our suppliers have noticed any difference. We are currently building a production unit with five automaker printers which are controlled by robot which will make single use molds 24/7. And we also hope to have access to metal printer not far in future and R2. I guess we will have several and different printers both for production and also for prototyping. And in printers just like any other tool there is no such thing as this is the world's best printer and they all do their different things in different ways with different materials, so we'll just see in future where we have more different printers doing different materials in different ways. Maybe we will have more 3D printers in-house than we will have other big production machine. We see that possibility for example for weight saving. It's in products and metal printed parts the great opportunity to make better and more expensive products

Conclusion

The division started 3D printing with the intention to explore new possibilities and new technologies. Currently they have been using the technology for prototyping for several years now, but they have very recently launched a new 3D printed product for the purpose of selling. It is in the introductory stages for tooling and it's not yet matured technology. The company especially points to new technology enabling 3-D metal printing as more advantageous for them than the current plastic printing devices.

The parts they are producing from 3D printing are new to them as they have never been made by traditional manufacturing. The products are made in-house with the help of tools specially designed for 3D printing. The benefits include cost, time, and freedom of design where they can have any tool within a day and improve their processes. But they are facing challenges because of new technology and the quality of the materials as they must re-learn the systems, it's basically a learning curve for them.

The use of additive manufacturing has not changed their supply chain structure because the tools they use are of low volume and they need suppliers for that. So, this has not impacted their suppliers yet. Most of the products are standardized but the packaging is customizable, and the products produced are in low volume but highly complex, so they do more manufacturing in-house with 3-D printers. This reduces time as the products can be manufactured overnight rather than to wait for the suppliers to deliver them. Due to the realized benefits of manufacturing highly complex parts quickly, the division envisions that the additive manufacturing will have a lot to offer in the future. With the advances in technology, there will be better printers available in the market that can use different materials and produce high quality products.

This provided single case example reveals that the impact on supply chain structure is limited as of now. This is mainly because the use of additive manufacturing is limited. As volume of use this indicates that there is a future potential of redesigning the supply chain visualised as a network structure. Therefore, it is fair to say that additive manufacturing, based on this one example, is more a potential for a disruptive innovation, an innovation still in its feeble and highly emergent starting phase. The next step in this research is to fully analyse all the interviewed companies and systemize these findings. This will provide a broader picture and scrutinize the preliminary findings provided in this paper. This full paper should also provide a research agenda on additive manufacturing from a SCM prospective.

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THE IMPACT OF E-COMMERCE INSTITUTIONAL MECHANISM ON THE FIRM COLLABORATION PERFORMANCE: THE ROLE OF TRUST IN THE INTER-ORGANIZATION SYSTEM

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Abstract. Firms have made extensive use of inter-organizational systems (IOSs) to share Information and pursue firm collaboration performance. Contemporary firms are using IOSs to collaborate widely across the value chain and in an ever-expanding geographic market. Thus, institutional mechanism, which is the difference between the firms' respective institutional fields, has become a prominent challenge. In this study, investigate the extent to which institutional theory and organization trust conceptualize as (E-commerce institutional mechanism (EIM) and IOS-trust) and their impact on firm collaboration performance. We propose that E-commerce institutional mechanism (EIM) and IOS-trust the finding show that, not only increasing IOS-enabled information sharing but also increasing the positive impact on firm collaboration performance. Furthermore, extending boundary object theory to organization trust (IOS-trust), IOS-trust has negative relationship with IOS-Enable information sharing but strengthens the impact of EIM in turn to IOS-Enable information sharing. Our hypotheses tested *based on a survey 246 participant's* (manager and staff) online industries. We discuss the implications of these findings for theory development and professional practice.

Study purpose: In this study, investigate the extent to which institutional and organization trust theory conceptualize as (E-commerce institutional mechanism (EIM) and IOS-trust) and their impact on firm collaboration performance.

Design/methodology/approach: Our hypotheses tested *based on a survey 246 participant's* (manager and staff) online industries. We used partial least squares (PLS) to validate the measurement model and to test the structural model.

Findings: Drawing on institutional mechanism and organization trust and conceptualize as (E-commerce institutional mechanism and IOS-trust), the result shows that, not only increasing IOS-enabled information sharing but also increasing the positive impact on firm collaboration performance. IOS-trust negatively relationship with IOS-enabled information sharing and indirect strengthen firm collaboration performance

Value: By extending boundary object theory of the institutional context and organization trust, we propose that e-commerce institutional and IOS-trust that could provide comprehensive finding which advance from the existing literature. For intend direct impact of EIM on IOS-enabled information sharing and IOS-trust strengthens the impact of EIM in relation to IOS- Enable information sharing. These findings make an important contribution to E-commerce institutional and IOS literature by advancing our scholarly understanding on

OIS- trust, IOS-enabled information sharing and its impact on the firm collaboration performance which difference from existing literatures. Prior IOSs literature has been addressed Information Sharing in general through several theoretical angles, such as the relational view of the firm and improve information sharing, organizational learning. These theoretical perspectives argue that partner misinterpretation is the main barrier to general information sharing. However, information shared through IOSs, is explicit and not subject to misinterpretation; hence, a commonly held assumption that institutional mechanism does not matter to sharing via IOSs. On these view this study extended institutional theory and organization trust as (E-commerce institutional mechanism and IOS-trust) to providing more advance finding from the existing studied.

I. INTRODUCTION

With the emergence of a global market, firms increasingly rely on outsources information resources to gain a competitive advantage by tightly collaborating with other firms along different tiers of the value chain and across a geographic market(Kumar and Van Dissel, 1996, Lee, 2002). The information needed to meet market demands is no longer easily acquirable by a single firm (Richardson, 1972). To sustain business growth, many firms develop global distribution networks by collaborating and sharing information with downstream distributors to reach remote locations (Humphreys et al., 2001). In this context, inter-organizational systems (IOSs), defined as information and Communication Technology (ICT) applications deployed to exchange information between firms(Saeed et al., 2005, Lancastre and Lages, 2006, Choudhury, 1997)are known to play a key role in spanning geographical boundaries and in enabling information sharing between firms. ICT, usually regarded as one type of General Purpose Technology, can help improve productivity and resource allocation efficiency(Hollenstein, 2004). Countries with higher ICT development level can provide easier access ICT to firms. Industries, on the other hand, differ in their demand for ICT in the production process. Consequently, industries using ICT intensively and located in ICT developed countries are able to improve their productivity and output, thus generating the ICT-induced comparative advantage in the international market. In the context of supply chains, e-commerce refers to the assimilation and adaptation of Internet-based e-commerce operations, which enables to exchange information, share resources, and undertake continuous and collaborative activities(Kong et al., 2004). It's uncommon develops an inter-organization system to reduce costs, access complementary resources, and cope with market competitive (Osarenkhoe, 2010). As a dominant aspect of IOS-trust in e-commerce market not only reflects the state of interconnecting operational processes but also materializes synergistic advantages of IOS-Enable Information share (Shi and Liao, 2015).

Research, to date, clearly shows that IOSs improve the performance of inter-firm relationships by enabling digital access and information sharing between partners(Malhotra, 2005, Liang et al., 2007).Along with collaboration between differences firms across varied geographical markets, there are increasingly function in differences between the institutional environments in collaborates within firms. Hereby termed as institutional e-commerce mechanism(Pavlou and Gefen, 2004).The concept of institutional e-commerce mechanism originated to facilitate supplier and ensure conditions that safeguard transaction success(Pavlou and Gefen, 2004).However, unlike general information sharing, here information shared concept via IOS is enabling information sharing more effectively collaborate relationship and influence by IOS-trust (inter-firm trust relationship within the organization). As such, conventional wisdom suggests that an IOS is unproblematic in facilitating information sharing in relation inter-organizational across differences institutional environments(Zhou and Benton Jr, 2007). This study aims to challenge this conventional

wisdom by our first research question: To what extent does institutional e-commerce mechanism enable information sharing within the IOS? And does IOS-trust relationship impact on the collaboration performance?

To answers to this question both practical and theoretically; practically, important for firms to understand how the institutional profile of each partner may affect the use of IOS for sharing information and ultimately building a successful collaboration. To bring successfully inter-business partnership relevant to inter-organizational trust-building relationships for operating in the geographical spread of e-commerce chain, distribution networks, and outsourcing relationship. Theoretically, most prior IOS research has only examine only via general and specific on knowledge sharing(Liang et al., 2007, Dong et al., 2017, Im and Rai, 2008)in fact that little effort has been made to date to examine IOS via other factors (information sharing) Moreover, while IOS research has drawn on institutional theory or institutional distance, little accounts from others perspective institutional (Institutional e-commerce mechanisms) in related to inter-firm collaboration and the impact of IOS-trust, IOS-Enable information sharing in relation to firm performance. The limited IOS research that draws on institutional theory challenge about how the institutional environment forces a firm to adopt(Liang et al., 2007, Kankanhalli et al., 2003)assimilate IOS technology(Bala and Venkatesh, 2007, Sodero et al., 2013, Pavlou, 2002).

This scant literature has seldom considered institutional effects on the outcomes on inter-firm digital collaboration, for example, Information sharing via IOS in relation inter-firm performance which draws from on e-commerce institutional perspective.

This study addressing this research opportunity that, institutional e-commerce does matter, how IOSs can be designed to better support IOS-enabled information sharing in view to challenge e-commerce institutional and IOS-trust to achieve firm collaboration performance. Up to that, our study makes major theoretical and professional practice contributions to the literature. First, we extent institutional theory as (EIM) and organization trust as (IOS-trust) to examine the intermediate outcome of using IOSs (i.e., information sharing, trust) and ultimate performance outcomes, by accounting for institutional e-commerce, and IOS-trust relationship management. This study adds to a new IOS literature by introducing the concept of institutional e-commerce mechanism and IOS-trust which differences from existing study (Dong et al., 2017, Pavlou and Gefen, 2004, Scott, 2013). Second, the study extends our understanding of how to improve IOS-enabled information sharing and trust relationship from institutional e-commerce and IOS-trust perspective to achieve successful collaboration performance in e-commerce chain. Last, to adopt the boundary object literature to the institutional context, this study offer insights into how IOS-trust relationship can overcome a deeper IOS enabled information sharing relationship and their impact on firm collaboration performance.

II. RESEARCH BACKGROUND

2.1 IOS-enabled information sharing

IOS-enabled information sharing refers to the extent to which an IOS is configured to exchange and process, in a timely manner, useful information between collaborating firms. Information Sharing (IS) means the distribution of critical and proprietary information to supply chain partners (Min et al., 2005). *Information sharing* may include material information, supplier information, manufacturer information, buyer information, agent information, and privacy and market information like the number of sales of different materials, buying patterns, buyers' comments on materials and others services(Zhao et al., 2002). Inter-organizational systems are networks of organization systems that allow organizations communicating and sharing information electronically across organizational boundaries (Barrett and Konsynski, 1982). These systems enable partners to be

incorporated in the redesign of their key business processes and thereby they enhance their productivity, quality, speed and flexibility (Kong et al., 2004). The Internet provides a nearly ubiquitous platform for information sharing between different organizational systems. Unfortunately, a great number of them still find difficult to share information, even though they have actively invested in ICT that support information gathering, manipulation and sharing (Lotfi et al., 2013). The main barriers that organizations encounter in upgrading information sharing in relation to trust include information privacy, incentive issues, reliability, cost and complexity of technology, timelessness, accuracy and effective utilization of information (Shi and Liao, 2015, Abdullah and Musa, 2014). It is not surprising that these barriers correspond to the main information sharing in the trust relationship between firms. Indeed, prior research generally agrees that information sharing between collaborating firms, with the support of IOS, can improve firm performance (Saraf et al., 2007, Sodero et al., 2013, Saeed et al., 2005), organizational learning (Alegre and Chiva, 2008), Knowledge sharing (Dong et al., 2017) and boundary spanning (Malhotra et al., 2007). These theories use the relational, organizational, or technical aspects of knowledge sharing played out within an inter-organizational relationship with a purpose of focusing on achieving a common understanding. Our study definition of IOS-enabled information sharing is different from the existing literature and in several important ways. Prior IOS research has considered being a broad concept involving both tacit and explicit from knowledge sharing perspective (Dong et al., 2017, Malhotra et al., 2007). In this study, IOS-enabled information sharing which more focuses on *sharing information Via IOS-trust* inter-firm relationship and based on e-commerce institutional. This difference, albeit subtle, important from difference existing study (Dong et al., 2017, Saeed et al., 2005). This distinction requires us to explain IOS-enabled information sharing, not in terms *collectively appropriated* by collaborating firms to make as much explicit information sharing, but in terms of how an IOS is a performance effecting by *inter-firm trust relationship in the term* to transmits collective information's sharing within the organization. The extended IOSs and organization trust (IOS-enabled information sharing and *IOS-trust*) enables IOS to make the maximum amount of explicit information exchange within the firms.

Institutional Theory in the IOS and organization trust Literature

The origin of the institution has been used to characterize the social context in which firms operate (Shapiro, 1987). It refers to multifaceted, social structures consisting of symbolic elements, social activities, and material resources (Scott, 2001, Scott, 2003). The institutional theory posits that structural and behavioral patterns in organizations are driven by the need for organizational legitimacy, that is, the need to comply with the surrounding institutional context (Scott, 2013). According to institutional theory, the institutional context of a given region can be characterized according to the three pillars of society, namely, the regulative, cognitive, and normative aspects (Scott, 2001). These three institutional pillars reflect different aspects of the same institutional environment; they each have distinct mechanisms for forming social patterns (Scott, 2001). Institutional theory has been previously used to explain IOS adoption (Scott, 2013, Scott, 2001) and assimilation (Bala and Venkatesh, 2007, Sodero et al., 2013). This studies described institutional environment refers to an institutional structure within IOS relationship and assimilate trust relationship (IOS-trust) subsequently assimilate IOSs trust relationship to enable the use of technology within an inter-firm performance (Shi and Liao, 2015). Thus, in need of applying the IS-novel concept—e-commerce *institutional* to captures this institutional environment to adopts an IOS in information and communication technology (ICT). The concept spawns that reflection on the trust structure (IOS-trust), to managing inter-firm relationships. Institutional mechanisms in the e-commerce environment have been widely used to define institutional mechanisms in the previous study, institutional structures (Pavlou and Gefen, 2004), perceived the regulative effectiveness of marketplaces (Pavlou, 2002) and structural

assurance(Mayer et al., 1995). The institutional explaining in broad social and economic situations(Shapiro, 1987), structural assurance defined as general beliefs that contextual conditions such as promises, contracts, regulations, and guarantees are in place to assure success in an organizational context(Mayer et al., 1995). For that, the extended institutional environment and adapted to (e-commerce institutional mechanism) in relationship to firm collaboration performance through IOSs-trust relationship and IOS-Enable information sharing which providing comprehensive finding from the existing studies (Pavlou and Gefen, 2004, Shapiro, 1987, Scott, 2013, Dong et al., 2017).

III. RESEARCH MODEL AND HYPOTHESES

Drawing on institutional theory and organization trust which conceptualized as (e-commerce instructional mechanism (EIM), IOS-trust) to explain our model. Firm performance adopts from (Saraf et al., 2007), IOS-Enable Information sharing(Shi and Liao, 2015), IOS-trust (Pavlou et al., 2003, Shi and Liao, 2015),and e-commerce instructional mechanism(Pavlou, 2002).We expect that IOS-Enable information sharing has a positive impact on firm performance which strengthens by IOS-trust and EIM relationship ,in addition, we also text the moderating EIM and IOS-trust relationship. Figure 1 shows the research model.

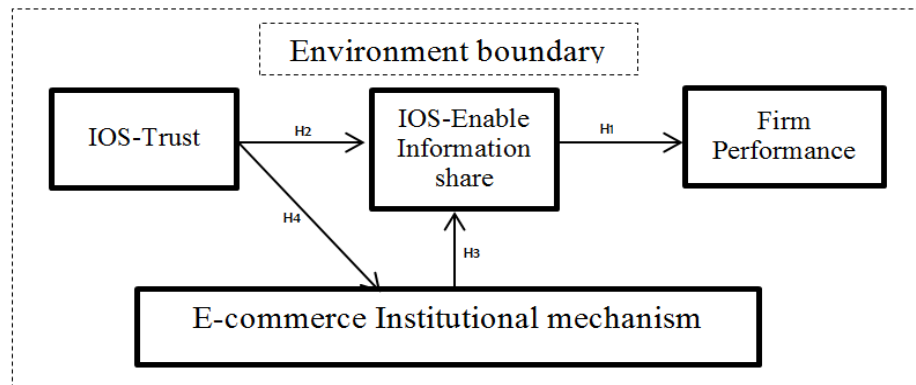


Figure 1. Research model

The main barriers that organizations encounter in upgrading information sharing in relation to trust include information privacy, incentive issues, reliability, cost and complexity of technology, timeless, accuracy and effective utilization of information (Shi and Liao, 2015, Abdullah and Musa, 2014). It is not surprising that these barriers correspond to the main information-sharing relations to IOS-trust relationship. Indeed, prior research generally agrees that information sharing and firms performance collaboration which the supports of IOS, can improve firm performance (Saraf et al., 2007, Sodero et al., 2013) and IOS-Enable information sharing in institutional environment refers to institutional structure within IOS relationship and assimilate trust relationship (IOS-trust) which enable to sharing information (technology) within inter-firm collaborations. Based on this empirical theory and finding, we propose: H1, H2, and H3

H1: IOS-information sharing positively related to firm performance

H2, H3: Relationship IOS-information sharing and firm performance strengthen by IOS-trust and EIM relationship

E-commerce instructional mechanism (EIM) compromises a firm's performance through interactions in which social environment and information are embedded (Scott, 2013, Scott, 2003). A firm that perceives its partner to be advance professional in channel management

will be increasingly engaged in cooperating with this partner to execute a new practice because it is an institutional structure within IOS relationship increase their trust relationship to judge the practice as legitimate boundary spanning (Malhotra et al., 2007). The theories use the relational, organizational trust, played out within an inter-organizational relationship which a purpose of achieving a common understanding. As such, firms may reach comments goal to propose collaborative actions based on IOS-trust relationship, because legitimate boundary institutional structures of channel partners; this could also promising the outcome of their collaborative efforts. Thus, we hypothesize the following:

H4: E-commerce instructional mechanism (EIM) is positively influence by IOS-trust enabled in turn relationship with firm performance.

IV. RESEARCH METHODOLOGY

4.1 Data collection

Respondents instructed to complete the questionnaire only if, the company has sell product online or e-commerce partnership (e.g., Amazon, PC-Home, TripAdvisor) in Taiwan. A total of 310 questionnaires distributed to a random sample to the staff and manager who has work experience on e-commerce. We sent questionnaires from Feb 1- 30 - 2017 to the respondents. There were 246 useable responses. The final respondent's rate analysis 80% (n=246) and the response were discarding missing rate 20% (n=64. The respondent's female rate 64.9 % and male were 35.1%. The higher age was response higher than 25 years old, 61.6%. The education background university degree with respondents rates 52.7%, and master 36%, and others 3.3%. The Manager with respondent's rates 30.6 %. And staff 69.4%. The respondent's rates 51.8% were mostly ≥ 3 years' work experience and 49.2% was mostly ≤ 3 years, work experience.

4.2 Data Analysis Technique

The research model was tested adopted partial least squares (SmartPLS 3.0), a component-based structural equation modeling technique that enables path analytic modeling using latent variables (Chin et al., 2003). PLS is regarded as an appropriate statistical tool for theory exploration (Podsakoff et al., 2003) which is the case in our study. Path significance was assessed using bootstrap statistics with a total of 1000 resamples and 246 cases per sample (Ringle, 2015).

V. RESULTS

5.1 Measurement Model

The measurement model for convergent and discriminate validity, Convergent validity can be established by examining standardized path loadings items, Composite reliability (CR), Cronbach's and the average variance extracted (AVE) of constructs (Gefen, 2003) All variables were greater than the alpha value almost 0.7, CR value greater than 0.8, and AVE value was greater than 0.5., all are accepted.

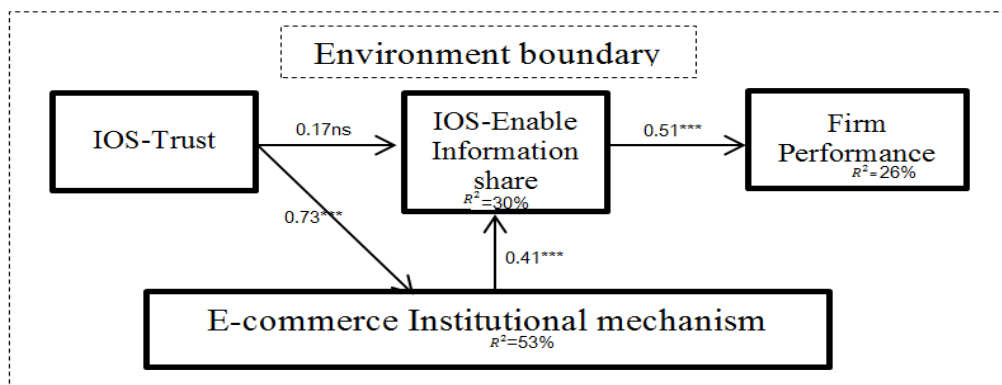
Table 1, shows that Composite reliability (CR) value greater than 0.8, and each of the latent variables alpha value exceeded greater than 0.7, suggesting good reliability (MacKenzie et al., 2011) and the square root of average variance extracted (AVE), a measure of convergent validity, for each construct was greater than the recommended level 0.5. (Fornell and Larcker, 1981). These test results demonstrate good convergent validity. The correlation discriminate the square root of AVE list in table 1, the square root of AVE correlations was higher than constructs.

Constructs	Cronbach's Alpha	CR	AVE	EIM	FP	IOS-E	IOS-T
E-commerce Institutional mechanism	0.85	0.90	0.70	0.83			
Firm performance	0.72	0.82	0.54	0.60	0.73		
IOS-Enable Information share	0.76	0.85	0.58	0.54	0.51	0.76	
IOS-Trust	0.82	0.88	0.65	0.72	0.68	0.47	0.81

Table 1. Correlations between constructs and reliability of (CR) and (AVE)

5.2 Structural Model

The results of the structural model provided Figure 2; the model explains 30% of the variance in IOS-Enable information sharing, 53% of the variance E-commerce institutional mechanism and 26% of the variance in firm performance. The Model path of coefficients and the validity of model H1, which explaining that the relationship between Firm performance and IOS-Enable information sharing was supported H1 ($\beta = 0.51, t = 11.75^{***}$), the relationship between IOS-Enable information sharing and IOS-trust was not supported H2, ($\beta = 0.17, t = 1.8$), the relationship between E-commerce institutional mechanism and IOS-Enable information sharing was supported H3, ($\beta = 0.41, t = 4.22^{***}$). And the relationship between IOS-trust and E-commerce institutional mechanism was supported H4, ($\beta = 0.73, t = 25.9^{***}$) with one-tailed. The structure model shows in figure 2.



Figures 2. Result hypothesis testing

VI. DISCUSSION AND CONCLUSION

Our finding confirms that IOS-Enable information sharing is positive influence relationship on firm collaboration performance. IOS-trust has no significant relationship with IOS-Enable information sharing but strengthens the impact of E-commerce institutional mechanism in relation to IOS-Enable information sharing. In addition, EIM is a positive relationship in IOS-Enable information sharing in turn to the impact of firm collaboration performance. Drawing on E-commerce institutional theory and organization trust, we propose E-commerce instructional mechanism (EIM) and IOS-trust which contributes not only IOS-enabled information sharing but also on E-commerce institutional literature which differences from the existing literature (Pavlou and Gefen, 2004, Shapiro, 1987, Scott, 2013, Dong et al., 2017, Sodero et al., 2013, Saeed et al., 2005). Prior IOS literature has addressed Information Sharing in general through several theoretical angles, such as the relational view of the firm (Saraf et al., 2007, Sodero et al., 2013, Saeed et al., 2005) organizational learning (Rai 2008), and boundary spanning (Malhotra et al. 2007). These study findings make an important contribution to the IOS literature by advancing our understanding of

IOS-trust, IOS-enabled information sharing and its impact on the firm collaboration performance.

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FEASIBILITY OF FOOD LOSS REDUCTION WITH BLOCKCHAIN IN THE EMERGING ECONOMY CONTEXT

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ABSTRACT

This paper analyses the feasibility of food loss reduction in emerging economy context along sides the adaptation challenges of blockchain technologies. Furthermore, to understand barriers the study develops blockchain adoption model as per technology acceptance model and the perception of food sector practitioners'. The pilot study relies on the data collected through a survey carried out in farm to fork Turkish dairy food chain. The result of this research shows that the adoption barriers such as inter-organizational trust, technology trust, standards, consumer perception, legislation and regulation are the key to reduce food loss in the farm to fork supply chain.

INTRODUCTION

Blockchain is a reliable and unalterable digital data ledger for monitoring transactions through distributed consensus process. In financial services, blockchain technology is recognized for secured crypto money transaction (Crosby et al., 2016), and potentially its applications in other sectors can deal with asset ownership, acceleration of transaction time, cost reduction and lowering fraud risks. Hence, this technology has a greater viability in the food industry to reduce food loss along global supply chain stages to monitor temperature variation during transport, food processes transparency and so on. However, pilot studies are ongoing globally at the same it is not so obvious what are the typical issues that prevents the implementation of this technology and to what extent it is adaptable to the emerging economies context. Hence the major aim of this study is to understand adoption barriers in the emerging economy context from the food sector practitioner perspective.

This study adds novel technology application knowledge from the emerging economy perspective in a specific food context - dairy sector. This research would be the first research in the food context and also it gives practitioners (food professionals) a perspective to adapt this technology in their sector. A survey is conducted in the Turkish agricultural sector that involves multiple stakeholders in food cold chain. The survey is cross sectional in nature and has its own limitation such as single respondent and common method bias. This study has several practical implications to the food sector such as loss reduction and deals with one of the societal issues.

The study contributes the field by grouping the various barriers to integration and adaptation of blockchain technology in food supply chain. It also categorizes each barrier to implementation in the technology acceptance model proposed by Davis (1989), which is widely used approach for modelling adoption behavior by stakeholders of food cold chain.

VISIBILITY CHALLENGES: FOOD LOSS DUE TO INVISIBILITY

Food loss is the global challenge in developing and developed countries (de Lange, Nahman, 2015). Food loss is often described as a "farm-to-fork" problem damage (Aung and Chang, 2017), and it is defined as any food substance, liquid or solid, cooked or uncooked, that is thrown away or discarded. UN Food and Agriculture Organization

estimates that around 40 percent of food production is lost or wasted throughout the entire food chain (Warker, 2018). This percentage is even higher in the developing countries. Most food loss occur throughout the food system starting from farms to households during post-production, harvesting, processing (warehouses, packaging), transportation, distribution, in the supermarkets and by the consumers. Food loss in developing countries is much more prevalent in the early and middle stages of the food supply chain, and it is primarily related to inadequate supply chain and logistics infrastructure and management, low levels of technology use and low investment in the food production systems, while a significant amount of food is wasted at the marketing and consumption stages in more developed countries. This study is based on Turkish context since Turkey is one of the leading producers for fresh fruits and vegetables, however 25-30% of Turkey’s fresh food production get lost or wasted before those even reach the consumer. The major reasons for food loss are lack of transparency and security.

VISIBILITY CHALLENGES: FOOD LOSS DUE TO CHALLENGES IN TECHNOLOGY INTEGRATION

Blockchain technology is firstly used in finance sector but it has gradually expanded in other sectors such as healthcare, insurance and also agricultural industry. Food safety is becoming increasingly important, where a failure to implement rigorous monitoring and traceability processes can lead to illness and severe reputational damage (Aung and Chang, 2017). Recently several food chains are caught into safety scandals such as horsemeat scandal, salmonella peanut butter outbreak (Crossey, 2017). If consumers cannot be certain that the food they are eating is safe and has been authentically sourced, they’re likely to shop elsewhere, which can profoundly impact a business’s bottom line. Monitoring food supply chain and control food loss with blockchain technology is challenging. There are currently only a few Blockchain based pilot applications in food industry. The first pilot application for blockchain based food supply chain traceability was carried out by start-up provenance (Provenance, 2016). Yellowfin and skipjack tuna fish were tracked throughout the entire supply chain, from fisherman to distributors and retailers, from shore to plate. The digital record was held on the blockchain, accessible to anyone with the unique identifier attached to the item as a QR Code, RFID tag or using any other hardware technology, so that the end users could track the whole journey of their tuna fish sandwiches on a smartphone and get information about producers, suppliers and all relevant procedures. With another pilot, 10 major food suppliers included Walmart, Nestle, Unilever with IBM built a consortium to apply Blockchain to the food supply chain to improve food safety and transparency and to detect sources of contamination quickly (Barnard, 2017). Maersk and IBM have started a venture to establish a global blockchain-based system for digitizing trade workflows and end-to-end shipment tracking (Allison, 2017; DHL, 2018). Their blockchain concept has been tested using shipments of flowers to Royal FloraHolland from Kenya, Mandarin oranges from California, and pineapples from Colombia into the Port of Rotterdam. Another “Foodchain” prototype was developed by Deloitte (2017) which could be capable of tracking all ingredients in a particular product along the length of the supply chain. Such technology could potentially allow a consumer in China to pick up a product, scan an RFID tag on a mobile app and have the ability to see where each ingredient in that product came from.

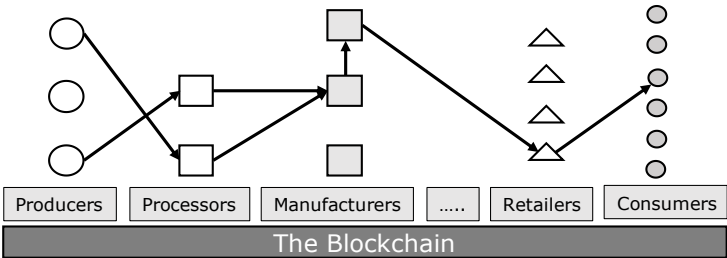


Figure 1: Blockchain in Dairy Sector

Food supply chain on blockchain is a completely transparent system. Not only the supply chain members and authorities have access to traceability information, but through the public mobile application the consumers have the opportunity as well as to access all food history information. Blockchain can be used in the food sector so that each and every party along the length of the supply chain (producers, processors and distributors) can provide traceability information about their particular role and for each batch (dates, places, farm buildings, distribution channels, potential treatments etc.). Figure 1 shows the blockchain in dairy sector where for example, large commercial dairy companies have a challenge tracking provenance of their milk as they often source from multiple milk producers (Deloitte, 2017). Further, the internet of things could potentially play a role here. Internet connected equipment such as trucks and storage coolers could monitor which objects they are housing and tag those objects with relevant environmental conditions like temperature or location, providing assurance that a product is safely handled through the entirety of its journey.

STATE-OF-THE ART OF THE MODEL AND TECHNOLOGY

Examining the blockchain technology adaptation is done through Technology Acceptance Model (TAM), which is well known information systems theory in the literature as a means of explaining user acceptance of technology. TAM has been extensively researched since first introduced by Fred D. Davis (Davis, 1989). TAM suggests that usefulness and ease of use are beliefs about a certain technology that have influence over an individual's attitude toward actual use of that technology (Porter and Donthu, 2006). TAM provides a foundation for measuring beliefs and attitudes that may behavior predict future behaviors (Hubona and Burton-Jones, 2002). Perceived usefulness and perceived ease of use are two central beliefs in TAM for predicting behavior. These beliefs constitute an individual's cognitive response and decision to use a particular technology, which affects the response or attitude towards that technology, and ultimately drives the behavioral response about whether to use the technology.

The theoretical framework is composed of the following key constructs, which are listed below:

- (i) *Perceived usefulness (U)* is defined as the degree to an individual believes that using the system will help him/her attain gain in job performance.
- (ii) *Perceived ease of use (E)* refers to the degree of ease associated with the use of the system.
- (iii) *Attitude (A)* toward using indicates the individual's positive or negative feeling about performing the target behavior.
- (iv) *Behavioral intention (B) to use* the system is defined as an individual's apprehension, or even fear, when she/he is faced with the possibility of using technology.

METHODOLOGY

Extensive search through academic databases by using search criteria of "Blockchain + food", "Blockchain + agriculture", "Blockchain + supply chain", "Blockchain + cold chain", "Blockchain + dairy sector", "Blockchain + agri-food", "traceability + food", "internet of things + food" were conducted to select the most relevant literature related to the research topic including journal papers, conference proceedings, workshop papers, symposium papers and ACM/IEEE bulletins. Twelve articles were selected. Though not much purely academic papers are written in this field, most of the papers are industry reports or white papers. In a round table discussion with five industry experts including two research analysts, one technology advisor, consultant and project manager from food industry with average six years technology project experience, nine adoption barriers were determined and listed as major barriers. These barriers are related the listed twelve articles to the adoption of Blockchain in food supply chain, seen in Table 1. However, this list is not limited, as Blockchain technology is still in the early stage and it continues to expand, therefore additional studies might be conducted to this research. In addition, industry

experts were asked to share their opinions to align the Blockchain adoption barriers with the TAM framework. After reaching consensus, the adoption barriers are engaged with the four TAM items, respectively: interoperability challenges with (E), standards with (U), legislation and regulations, consumer perception, Authentication and product characteristics with (A) and inter-organizational trust, technology trust / data confidentiality, technology adoption rate and cost of implementation with (B). Beside this, during the round discussion, traceability, transparency and threat are defined as major motivators of Blockchain, but these factors are kept out of the scope of the study.

Adoption barriers	Pant et al. (2015)	Christidis and Devetsikiotis (2016)	ESC (2017)	Hofman et al. (2017)	O'Leary (2017)	Hackius and Petersen (2017)	Crosseyb (2017)	World Energy Council (2017)	Barnard (2017)	Deloitte (2017)	Casey and Wong (2017)	Francisco and Swanson (2018)
Interoperability		x		x	x			x	x	x	x	x
Standards	x	x		x	x	x		x		x	x	
Legislation and Regulations				x		x	x			x	x	
Consumer Perception	x							x	x	x	x	x
Product Characteristics	x									x		x
Inter-organizational Trust		x	x	x	x		x	x			x	x
Technology Trust		x	x		x		x	x			x	x
Technology Adoption Rate			x		x	x		x	x			
Cost of Implementation			x				x			x		

Table 1: The adoption barriers of Blockchain in food supply chain and related literature

The nine major barriers to implementing Blockchain technology in food supply chain are explained as follows:

- *Interoperability Challenges:* Blockchain as a core solution isn't enough alone, it should be used with existing technologies including hashing, EDI, RFID, NFC tags, wireless sensor networks, ERP, data warehouses and control and other digital applications enabled by the Internet of Things (Christidis and Devetsikiotis, 2016; O'Leary, 2017; Deloitte, 2017; Francisco and Swanson, 2018). Interoperability refers to the ability of different digital objects to acknowledge and communicate with one another and store the collected data in a blockchain, this data (event ledger) is distributed to all stakeholders (or cloud storage service providers) via smart contracts/chain code and associated with operations and data semantics (Hofman et al., 2017). Interoperability is considered crucial in the long-term goal of connecting objects, humans, data and business processes.
- *Lack of Standards:* the standards and regulatory protocols are required for data transfer and security issue (Christidis and Devetsikiotis, 2016; Deloitte, 2017). That's why developing broadly accepted blockchain standards is critically important to driving adoption (Pant et al. 2015; Hackius and Petersen, 2017; Hofman et al., 2017). However, there is not a unique standard for blockchain technology yet (Casey and Wong, 2017), there are some initiatives to define industry standards for blockchain, such as the Blockchain in Transport Alliance (BiTA, <https://bita.studio/>), which has more than thousands of companies in the transportation and logistics industry participating, or Spain's Alastria Consortium (<https://alastria.io>) (O'Leary, 2017).
- *Lack of Legislation and Regulations:* Changing standards and implementing an entirely new system require legislative frameworks to be put in place for its use. The inadequate

regulation around implementation of blockchain technology in supply chain also poses a challenge (Hackius and Petersen, 2017; Deloitte, 2017). The policy makers and officials need to set priorities and concerns with associated rules and regulations to adopt the blockchain in food supply chain (Hofman et al., 2017; Crosseyb, 2017).

- **Lack of Consumer Perception:** Tracking food in the supply chain is no longer a request, but a demand from customers that is growing stronger. If consumers cannot be certain that the food they are eating is safe and has been authentically sourced, they're likely to shop elsewhere, which can profoundly impact a business's bottom line (Pant et al. 2015). Therefore, blockchain needs to be implemented if consumer preference and demand for traceable food is high (Barnard, 2017; World Energy Council, 2017; Deloitte, 2017; Francisco and Swanson, 2018).

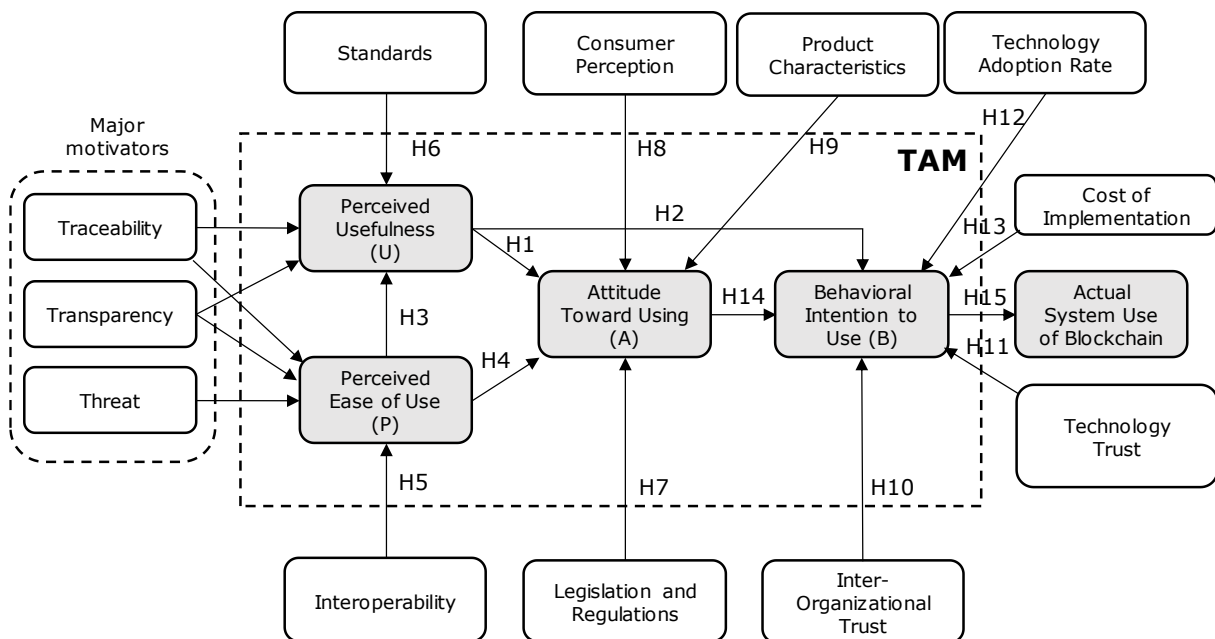


Figure 2: Blockchain adoption model

- **Authentication and Product Characteristics:** All product characteristics such as provenance, components, material, and specifications which are recorded on blockchain are needed to verify by supply chain parties (Pant et al. 2015; Francisco and Swanson, 2018). Each ingredient or product component would have a unique ID number and be traceable at each stage of the supply chain, even as ingredients from different sources are added and the product is developed (Deloitte, 2017). As the blockchain database is publicly accessible, the process would be completely transparent and allow numerous people to carry out verifications.
- **Lack of Inter-Organizational Trust:** Trust is achieved as an emergent property from the interactions of different participants in the system (Christidis and Devetsikiotis, 2016), therefore the consortium of blockchain should be fit in terms of trust (Francisco and Swanson, 2018). The size and also homogeneity of consortium stimulate the inter-organizational trust (O'Leary, 2017). If the consortium has a big partner (like Maersk), mainly the rules of big partner in the consortium are followed, which could cause inter-organizational trust problems (ESC, 2017; Crosseyb, 2017; Hofman et al., 2017).
- **Lack of Technology Trust / Data Confidentiality:** Product status at each stage of production can be recorded using blockchain. The records are permanent and inalterable. They also allow the tracing of each product to its source. The data confidentiality and technology trust are important (Francisco and Swanson, 2018). To enable that trust, the technical solution also requires minimum of four – or preferably more – parties to separately verify every transaction on the distributed database before

the data becomes the “undeniable truth” (O’Leary, 2017; Crosseyb, 2017; Francisco and Swanson, 2018).

- *Low Rate of Technology Adoption*: The higher the rate of technology adoption for new technologies, the higher the acceptance and implementation (O’Leary, 2017; Hackius and Petersen, 2017; ESC, 2017).
- *High Cost of Implementation*: Cost-saving has been the most important driver for technology adoption by companies (Crosseyb, 2017). The blockchain technology currently requires high capital cost, as the proof-of-work algorithm used by most blockchains requires significant computing power to process transactions (ESC, 2017).

HYPOTHESES

Finally, a conceptual blockchain adoption model is constructed with four TAM items and nine adoption barriers seen in Figure 2. All are engaged each other with hypotheses seen below. The hypotheses for TAM items, H1, H2, H3, H4, H14 and H15 were defined from prior researches (Davis, 1989; Porter and Donthu, 2006). The other hypotheses for adoption barriers were constructed by consensus of industry experts.

- (i) Perceived usefulness (U): H1: Perceived usefulness of blockchain is positively associated with attitude towards blockchain, H2: Perceived usefulness of blockchain is positively associated with behavioral intention towards blockchain
- (ii) Perceived ease of use (E): H3: Perceived ease of use of blockchain is positively associated with perceived usefulness, H4: Perceived ease of use of blockchain is positively associated with attitude towards blockchain
- (iii) Interoperability (I): H5: Lack of interoperability is negatively related to perceived ease of use of blockchain
- (iv) Standards (S): H6: Lack of standards is negatively related to stakeholders' perceived usefulness of blockchain
- (v) Legislation and Regulations (LR): H7: Lack of legislation and regulations is negatively related to stakeholders' attitude towards blockchain
- (vi) Consumer Perception (CP): H8: Lack of consumer perception is negatively related to stakeholders' attitude towards blockchain
- (vii) Authentication and Product Characteristics (PC): H9: Lack of authentication and complex product characteristic is negatively related to stakeholders' attitude towards blockchain
- (viii) Inter-organizational Trust (IT): H10: Need for inter-organizational trust is negatively related to stakeholders' behavioral intention towards blockchain
- (ix) Technology Trust / Data Confidentiality (TR): H11: Need for technology trust is negatively related to stakeholders' behavioral intention towards blockchain
- (x) Technology Adoption Rate (TAE): H12: Low technology adoption rate is negatively related to stakeholders' behavioral intention towards blockchain
- (xi) Cost of Implementation (CI): H13: High implementation cost is negatively related to stakeholders' behavioral intention towards blockchain
- (xii) Attitude (A): H14: Attitude positively impacts behavioral intention towards blockchain
- (xiii) Behavioral intention (B): H15: Behavioral intention positively influences the actual system use of blockchain

PILOT STUDY IN DAIRY SECTOR

A pilot study in dairy industry is pursued to understand the model and the face validity. A well-known and big dairy company from Turkey and its five supply chain partners (one third-party logistics provider, one warehouse service providers, one processors, two retailers) are invited to participate in this study. A questionnaire was created in Google docs platform included Likert scale, where items included for defining the constructs. The links was sent to each participant by an email. In every company at least two pre-selected

participants were invited. All items were measured using a five-point Likert-type scale with anchors ranging from (1) strongly agree, (2) agree, (3) neither agree nor disagree, (4) disagree and (5) strongly disagree. Fifteen completed responses were received from participants. The reliability analysis verified the precision of the survey instrument and the internal consistency of the measure. As summarized in Table 2, Cronbach's alpha was used for testing the internal consistency of the measurement. The result shows that all multiple item construct achieving Cronbach's alpha ranged between 0.829 and 0.975, exceeding the 0.7 threshold commonly suggested for exploratory research.

Const- ructs	Items	Load- ings	CR	AVE	Cronbach Alpha
U	Blockchain makes it easier to trace and track supply chain and to reduce food loss Blockchain protects the supply chain against counterfeits	0,862 0,886	0,921	0,796	0,871
E	Learning to use Blockchain in terms of reducing food loss is easy Blockchain for reducing food loss is easy to use	0,920 0,891	0,942	0,844	0,907
I	Blockchain's interoperability capability to adapt existing ERP systems is easy	0,855	0,909	0,770	0,851
S	Blockchain's standard and protocols support its usefulness to reduce food loss in supply chain	0,872	0,898	0,746	0,829
LR	Adequate legislation and regulations to reduce food loss in supply chain supported by Blockchain support to attitude	0,902	0,904	0,825	0,848
CP	Consumer demands to track food history and to reduce food loss in entire supply chain support to attitude	0,898	0,918	0,738	0,881
PC	Product characteristics for reducing food loss are important to use Blockchain	0,821	0,874	0,893	0,904
IT	Trust among supply chain partners supports to adopt Blockchain to reduce food loss	0,936	0,934	0,899	0,942
TR	Technology trust is necessary to adopt Blockchain to reduce food loss	0,915	0,919	0,882	0,899
TAE	Technology adoption rate motivates to adopt Blockchain to reduce food loss	0,876	0,943	0,956	0,975
CI	Implementation cost of Blockchain is important to adopt and to reduce food loss in supply chain	0,898	0,921	0,902	0,943
A	Using Blockchain to reduce food loss in whole supply chain is good idea	0,802	0,932	0,941	0,975
B	Company will adopt Blockchain in the future in order to reduce food loss Company has ability to adopt Blockchain in the future to reduce food loss	0,881 0,864	0,901	0,832	0,882

Table 2: *Assessment* result of Blockchain adoption model

The data were analyzed by hierarchical regression analysis using SPSS 20.0 software. Behavioral Intention (B) to adopt Blockchain technology to reduce food loss is significantly correlated with U, E, I, S, LR, CP, PC, IT, TR, TAE, CI, and A. The result of regression analysis shows that U (20.6%), E (11.5%), S (9.6%), LR (8.2%), CP (9.7%), IT (10.9%), TR (10.1%), and A (16.5%) are found to be significant and contribute towards variance of B, whereas I (3.2%), PC (1.1%), TAE (1.7%) and CI (3.8%) are not significant. This is an ongoing work and a full-fledged survey will be carried out in a due course of time.

CONCLUDING REMARKS

The study explored barriers influencing adoption of Blockchain technology in food supply chain. The study proposes interoperability, standards, legislation and regulations, consumer perception, product characteristics, inter-organizational trust, technology trust, technology adoption rate and cost of implementation as major barriers to adopt Blockchain and the test the impact of these concepts using a Technology Acceptance Model (TAM). Dairy sector was chosen to test the Blockchain adoption model as a case study. According to model, the relationships among given items were examined. Trust among consortium and technology are most relevant barrier to adopt Blockchain, beside this, standards and protocols and consumer perception are found also as important barriers. However, this is

a pilot study to check the face validity of the model and hypothesis. A full fledge survey will be carried out in the due course of time.

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Session 7: Inventory and Warehouse Management

THE EFFECT OF RESPOND TO REQUEST ABILITY ON QUANTITY ORDER FOR DETERMINISTIC MODEL OF PERISHABLE ITEM: CASE STUDY OF INDONESIAN SUGARCANE INDUSTRY

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Abstract

Purpose – This article applies a deterministic model of a perishable item for sugarcane inventory on sugar manufacturing considering some parameters. In the model of this study, unit time cost and ordering cost that are kept constant but the holding cost is treated as a nonlinear function of the length of time for which the item held in stock. This study also investigates the impact of the changes of respond request ability on the results obtained so that optimal results can be determined.

Design/methodology/approach - The model in this article used a mathematical model developed by Giri & Chauduri (1997) which was explored further in term of its effect of applying the different value of the ability of respond request to obtain the optimum quantity order. The model has considered the expiration period of the product for deterministic demand and non-linear shortage cost on the period of time ahead. The calculation which was done by using those parameters in this article was supported by Maple® software.

Findings - The results showed that the ability of respond request (β) affect order quantity of sugar cane and the costs incurred. The results obtained by using MAPLE software also indicates that the quantity of raw materials issued during 1 milling period is reduced by 11% with a decrease in the cost of 35%.

Keywords - inventory, perishable item, nonlinear holding cost, deterministic model

Paper Type – Case Study

1. Introduction

Inventory is one of the company's most important assets because the inventory's value reaches 25% of all capital investments (Lutz, Löedding et al., 2003). Inventory control for a perishable item is more difficult to maintain than ordinary products because it has due time limits. Many companies deal with the lack of raw materials by providing a large stock of raw materials, however, that does not apply to perishable items. Supply of excess raw materials, incurring large expiry costs and losses due to loss of sales (Suryajaya, Octavia et al., 2012). Here, perishable items are defined as decay, scrap, or deterioration that items are not able to remain the normal utilities with the passage of time and can not be used for their original purpose again (Shiue, 1990). Although the rate of impairment on some products is quite slow, it still affects the storage system and can not be ignored.

Inventory planning for perishable products has a different treatment with other products because of limited shelf life. Sugarcane which is a raw material of sugar including perishable items so that the management of sugarcane inventory needs to be maintained well. In the production process, Sugar cane that has arrived must be milled immediately; the sugarcane's waiting time before processing is suggested not more than 36 hours as the quality decrease reason. As the sugar cane is kept over the time, the cane's juice will evaporate (Supriyadi, 1992). The evaporation of the cane juice was carried out in large open cauldrons or kettles, and the steam and vapors escaped into the building (Panda, Saha et al., 2009). The problem that often happens is sugar cane that comes to the production site cannot be milled as soon as possible because there is a series of previous processes that must be passed so that the waiting period before milling takes a long time. Unfortunately, fresh cane juice cannot be stored normally for more than six hours due to the presence of simple sugars in Sugarcane juice extractor, which spoils the juice quickly (Hsu, 2012).

In this paper, we apply a model developed by Giri dan Chaudhuri (1998) into sugar cane inventory management. In their model, the traditional parameters such as unit time cost and ordering cost are kept constant but the holding cost is treated as a nonlinear function of the length of time for which the item held in stock. Nonlinearity time for holding cost is justified for the inventory system, in which the cost of holding a stocked item increases while the value of the unsold inventory decreases with each passing day (Giri and Chaudhuri, 1998). The same topic was once discussed by previous researchers who developed inventory model by considering the expiration period and the decrease of the selling price due to the product approaching the expiration period. In the study, a mathematical model was developed to determine the quantity of purchased and at certain inventory levels of price reductions is made to minimize the annual inventory cost (Ziukov, 2015). In this model, some parameters will be used to determine the impact of the changes on the results obtained so that optimal results can be determined. The quantity of order and costs are the basis of decision making. The parameters that provide the lowest quantity and cost will be selected for the best solution.

2. Literature Review

The inventory problem is caused by the amount of demand that is not the same as the inventory and the time it takes to process the raw materials into the product. The purpose of inventory planning and control is to keep production and marketing processes stable even as demand increases or decreases. Inventories of raw materials are used to reduce production uncertainty due to fluctuations in raw material supply; inventory and component inventories are used to reduce production uncertainty due to engine failure; and the supply of products used to meet demand fluctuations that are not immediately met by production requires raw materials (Chopra and Sodhi, 2004, Gupta and Maranas, 2003). Inventories are created to carry the normal activities in the company. Proper and timely determination of the optimal inventory control strategy allows freeing a significant amount assets which ultimately increases the efficiency of resources used, there are only two fundamental decisions that one has to make when controlling inventory (Ziukov, 2015) for how many inventory replenishment order should be done and when inventory replenishment order should

be placed. The problem arising from inefficient inventory management is the inefficiency of inventory systems throughout the supply chain. The companies are often faced with varying degrees related to individual or organizational behavior. Some of the obstacles in inventory management are no clear metrics; inadequate customer service; inaccurate order status; unreliable information systems; ignoring the impact of uncertainty; too simple policy; incomplete delivery method analysis; unsuitable inventory costs (Lee and Billington, 1992).

Problems in inventory decisions can be overcome by using economic criteria, where the cost structure becomes an absolute requirement. The cost structure includes inventory costs which include all expenses and losses due to inventories. The cost of this inventory within the company is generally divided into four types: purchase cost, procurement cost, storage cost and inventory shortage cost (Tersine and Tersine, 1994). The cost component of each product type has little difference. Perishable items have relatively short shelf times, so expiration costs and lost sales due to damaged products must be calculated.

Some products require more handling, one of them is perishable items that have a relatively short storage time limit. This kind of product will deteriorate. Deterioration, in general, may be considered as the result of various effects on the stock, some of which are damage, spoilage, obsolescence, decay, decreasing usefulness and many more (Panda, Saha et al., 2009). Consuming products that has past the expiration date will cause adverse health effects. In addition, products that have expired obviously detrimental to the company because once the product is entering the expired period, the product cannot be sold anymore. Moreover, the customer demand declines as the product is close to its expiration date (Hsu, 2012).

3. Deterministic Model

Basically, the model for raw material planning that does not have an expiration time or that has a long expiration time is widely used, however inventory model for products that have short expiry time is still rarely discussed. This study adapted inventory model developed by Giri and Chaudhuri (1997). In this model the main focus is to minimize the total cost function of inventory system over a long period of time using several assumptions and notations for the models such as follow:

Assumption 1. Item cost does not vary with order size.

Assumption 2. The delivery lead time is zero.

Assumption 3. Replenishments are done instantaneously.

Assumption 4. Replenishment costs are known and constant.

Assumption 5. Inventory system considers for single item.

Assumption 6. There is only a stocking point in each cycle.

Assumption 7. The time horizon of the inventory system is infinite. Only a typical planning schedule of length T is considered, all remaining cycles are identical.

Assumption 8. The demand rate is a deterministic and known function of the instantaneous level of the inventory q. The relationship function between demand rate R(q) and the instantaneous inventory level q(t) is given by the following expression:

$$R(q) = Dq^\beta, \quad D > 0, \quad 0 < \beta < 1, \quad q \geq 0,$$

Where, β denotes the shape parameter and the measure of the responsiveness of the demand rate to changes in the level of the on-hand inventory. The variable q is assumed as continuous in time.

Assumption 9. A constant fraction θ assumed small of the on-hand inventory that gets deteriorated per unit time

Notations :

Q : Order quantity of the time (ton)

- T : Cycle time
- h : holding cost per item
- D : Demand (ton)
- q (t) : On hand inventory level at any time t
- K : Ordering Cost per order
- C : Cost per unit item
- θ : Deteriorating fraction
- HC : Holding cost per cycle
- DC : Deteriorating cost per cycle
- TCU : Total relevant inventory cost per unit time

At the beginning of each cycle, the inventory level decreases rapidly because the demanded quantity is greater at a high level of inventory. As the inventory is depleted, the decreased rate of inventory level slows down. Ultimately, the inventory reaches the zero level at the end of the cycle time T. The graphical representation of the inventory system is depicted in figure 1.

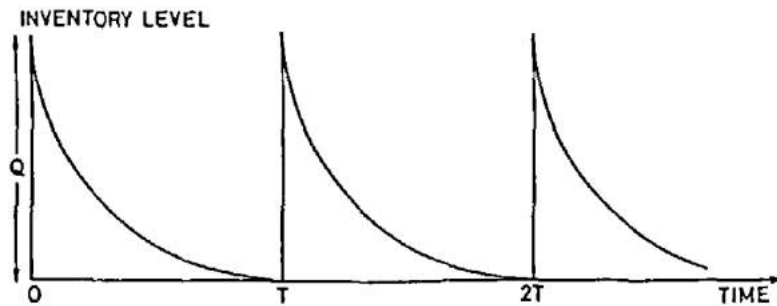


Fig 1. The inventory system

The instantaneous states of $q(t)$ over the cycle time T is given by the following first order nonlinear differential equation.

$$\frac{dq(t)}{dt} + \theta q(t) = -D(q(t))^\beta; \quad 0 \leq t \leq T \quad 1)$$

With the initial condition $q(0)=Q$. By solving equation 1, we get:

$$(1 - \beta) = \ln\left(1 + \frac{\theta}{D} Q^{1-\beta}\right) - \ln\left(1 + \frac{\theta}{D} q^{1-\beta}\right)$$

On expansion of the right-hand side, the first order approximation of θ gives:

$$t = \frac{Q^\alpha - q^\alpha}{\alpha D} \left[1 - \frac{\theta}{2D} Q^\alpha + q^\alpha\right], \quad 0 < \alpha < 1 \quad 2)$$

For this model, Giri and Chaudhuri (Giri and Chaudhuri, 1998) assumed that the holding cost amount $d q$ of the item up and including time t is ht^n where $n \in Z^+ \setminus \{1\}, h > 0; n = 1$ implies linear time dependent holding cost. Therefore,

$$HC = \int_0^Q ht^n dq \quad 3)$$

Substitution of 2) and 3) yields:

$$HC = \frac{h}{\alpha^n D^n} \left[\left(1 - \frac{n\theta}{2D} Q^\alpha\right) \int_0^Q (Q^\alpha - q^\alpha)^n dq - \frac{n\theta}{2D} \int_0^Q (Q^\alpha - q^\alpha)^n dq \right] \quad 4)$$

(to the first order approximation of θ)

To evaluate the above integrals on the right-hand side, they put $Q^\alpha - q^\alpha = Q^\alpha Z$ and obtain:

$$HC = \frac{h}{2\alpha^{n+1} D^{n+1}} \times \left[2DQ^{n\alpha+1} - \frac{n(n\alpha+2)\theta}{n\alpha+1} Q^{n\alpha+1} \right] \beta \left(n + 1, \frac{1}{\alpha}\right) \quad 5)$$

The deterioration cost in $(0, T)$ is given by

$$DC = C \left[Q - \int_0^T Dq^\beta dt \right] \quad 6)$$

Using 2) and 6) can easily find:

$$DC = \frac{c\theta Q^{\alpha+1}}{(\alpha+1)D} \quad 7)$$

Total relevant inventory cost per unit time is, therefore, given by

$$TCU = \frac{K+HC+DC}{T} \quad 8)$$

The problem is to determine order quantity Q which minimizes TCY of the inventory system. For fixed n, the necessary for TCU to be minimum is

$$(Q)^{n\alpha+1} = \frac{KD^n \alpha^{n+2}}{h(n\alpha-\alpha+1)B\left(n+1, \frac{1}{\alpha}\right)} \quad 9)$$

4. Results and Discussion

Data cost of Sugarcane

The cost used for ordering (K) is derived from the total assumption PG payments to farmers divided by total days in one period of milling. The price of sugar cane per quintal (C) is IDR. 65,000, - per kg. The cost of storage (h) is obtained from deteriorating of sugarcane percentage (loses) multiplied by raw material prices. Cost data used can be seen in table 1.

Table 1 cost structure of sugarcane

N	Deteriorating (%)	Holding cost/ cycle (h) (IDR)	Cost per Unit Item (C) (IDR)	Ordering Cost per Ordering (K) (IDR)
2	5%	3,250	65,000	23,456.729.32
4	11%	7,150	65,000	23,456.729.32
6	16%	10,400	65,000	23,456,729.32

The quantity order of sugar cane is not the same every year or every period of milling so it will affect the length of the rolling day in a period, it is also influenced by the performance of the plant (machinery and people) during the milling period. One period of cane milling is divided into into 13 periods with each period there are about 15 milled days. Table 2 presents data on Cane and Millet Sugar Cane received in last 12 periods.

Table 2. Cane and millet sugarcane record

Period	Amount (Kw)	Milled (Kw)	Time Of Sugarcane (Kw)	Σ Amount Of Sugarcane	
				Incoming Sugarcane (Kw)	Milled (Kw)
1	790,484	779,375	11,109	790,484	779,375
2	808,585	804,539	4,046	1,599,069	1,583,914
3	878,123	879,031	0	2,600,249	2,582,728
4	48,492	49,831.4	15,047.83	2,832,403	2,831,885
5	63,033.69	52,939.5	10,767.13	3,685,998	3,678,917
6	67,296.13	57,927.21	13,230.73	4,503,596	4,489,898
7	79,016	61,793.88	17,222.13	5,495,445	5,478,600
8	68,407.8	55,558.53	13,767.07	6,327,011	6,311,978
9	63,489.33	55,681.43	12,342.86	7,107,944	7,091,518
10	66,638.93	55,304.93	11,334	7,935,918	7,921,092
11	71,052.6	85,825.74	13,625.53	8,868,965	8,858,878
12	67,465.5	56,073.29	11,392.21	9,652,492	9,643,904

The fulfillment of sugarcane supply according to the capacity of the factory has several constraints, so that as sugar cane enter the factory often does not meet the capacity.

Constraints that usually occur that the machine cannot operate properly. Other constraints that often occur due to the quality of sugar cane in the factory. The low quality of sugarcane entering causes the plant to reject the sugarcane, thus affecting the amount of sugarcane received every day. Sugar cane that is processed daily does not experience stability. This instability occurs due to various factors one of which is due to the ability of a machine that has a usage limit. This results in a gap between quantities sugarcane that comes in with the quantity of proceeded cane. The rest of the cane is not proceed (leftovers morning) cause sugarcane to be stored much longer.

Raw Material Requirement Planning

Planning of raw material (sugarcane) requirement is done per cycle or per 24 hours. Some parameters are used as a comparison. Calculations have been done using 4 n parameters, where n is the length of time the cane waits until finally processed into sugar. n used are 2, 4, 6 and 8. The value of β indicates the size of the ability to respond to changing demand levels on-hand inventory levels.

Table 3 Planning of raw material needs in a milling period

N (hours)		β		
		0,1	0,3	0,7
2	Q (tons)	789,878	854,908	2,747,488
	TCU (IDR)	38,871,894	49,545,615	153,094,643
4	Q (tons)	769,793	1,093,028	3,417,459,860
	TCU (IDR)	57,894,963	94,690,624	629,983,257
6	Q (tons)	870,087	4,668,791	5,351,381,100
	TCU (IDR)	92,023,232	1,281,686,017	2,188,182,581

Table 3 shows the results of raw material demand calculation using several parameters. Q value increases as storage time increases. This also affects the costs that are the main issues in this research. The inventory cost (TCU) increases due to an increase in storage costs which is a non-linear function of raw material stock. Raw materials will decrease in value over time. The increase in Q value is the attributable fixed cost. Changes in β parameters also affect the magnitude of Q and TCU. The greater the value of β , the greater the Q obtained. This is because the demand received more quickly responds which will ultimately impact on the improvement of Q and TCU.

As the 3 type of β values is used in this study, the value of 0.1 indicates the best results. This is because that value indicates the smallest Q and TCU. This selection is based on the company's ability to respond to customer demand that has an impact on increasing material requirements raw. Requests received cannot be directly processed by the company because it must go through various procedures. Sugarcane is obtained from farmers who have become partners of the company and therefore, the firm can not order additional sugarcane from others.

Comparison Between current and Proposed Model

Based on table 3, which is selected by using the value of $\beta = 0.1$. Further results in table 4 show the comparison between current and proposed model on Q (quantity) and TCU (inventory cost) with different shortage time (n).

Table 4 Comparison between the current and proposed model with $\beta = 0.1$

N (hour)	Current model	Proposed model	% reduction
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2	Q (tons)	906,399	789,878	12.86%
	TCU (IDR)	64,674,129	38,871,894	39.90%
4	Q (tons)	906,399	769,793	15.07%
	TCU (IDR)	113,105,977	57,894,963	48.81%
6	Q (tons)	906,399	870,087	4.01%
	TCU (IDR)	110,340,377	2,023,232	16.60%

In table 4, it can be seen with $\beta = 0.1$, Q and TCU decrease significantly for the lower n value of the proposed model. This is because in the current model, quantity (Q) of order used is the quantity of ordering by the firm so it is no different in every change of n. Meanwhile, the value of Q of the proposed model is the result of the calculation used for obtaining the optimum quantity that has been considering the shelf life of cane and cost components of a fixed nature. Furthermore, table 4 shows the relationship between the decrease in the amount of Q to the cost of inventory. The comparison between the initial model and the proposed model on the decrease in Q shows that the higher the value of Q, the higher the decrease in inventory cost.

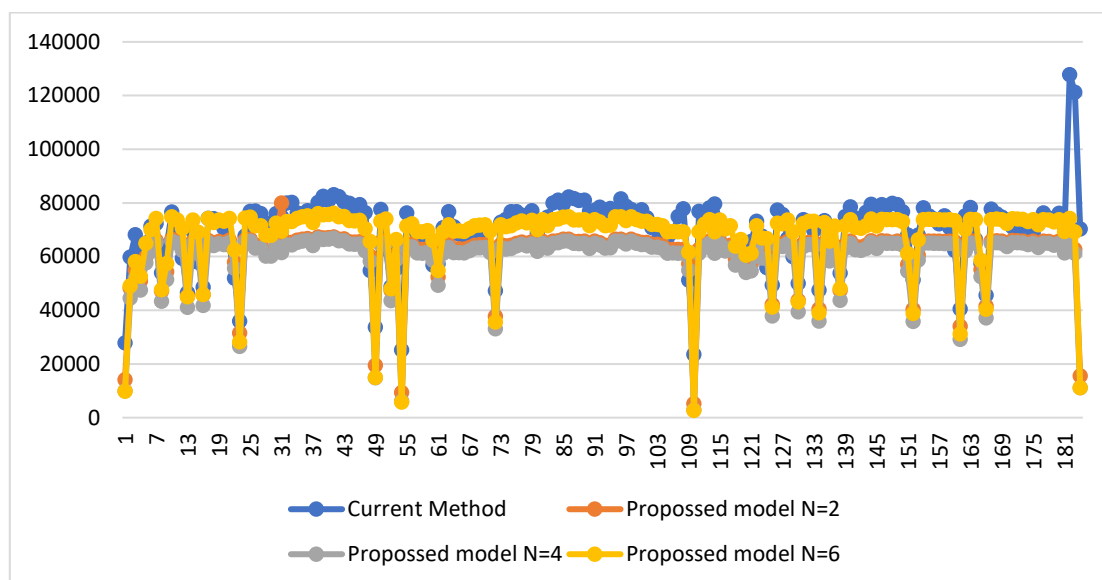


Figure 2 Comparison of Q

The graph in Figure 2 shows the order quantity comparison (Q) between the current and proposed model. On the graph on that seen order quantity (Q) of the proposed model is lower than the current approach. The length of storage time will affect the amount booking. The longest storage time that gives the lowest quantity 4 hours. Changes in the number of orders will impact on inventory costs which are issued. The graph in Figure 2 shows the required cost. Cost inventory of current approach for the different storage time of 2, 4, and 6 hours due to increased storage costs as time increases. Costs inventory of proposed model is lower than current approach because of the reduced order quantity.

5. Conclusion

The application of the proposed deterministic model provides a more optimal quantity of optimal sugarcane stocks, lower as compared to the current approach. Reduced quantity reservations cause the cost incurred was reduced. The quantity of raw materials issued during 1 milling period is reduced by 11% with a decrease in the cost of 35%. This model

only determines the quantity needed so that the researcher then is advisable to make a cane cutting scheme based on quantity optimal required and do the planting of sugarcane quantity planning. The use of lead time can also be included as a factor that made for obtaining optimum sugar cane quantity and planning of cutting scheduling as well planting sugarcane.

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A STUDY OF THE EXPANDED SEAT BOOKING SYSTEM APPLIED TO A JAPANESE WIREFRAME MANUFACTURING COMPANY

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Abstract

Purpose of this paper:

In a general scene at a manufacture company, a sales person receives order from users and a product section starts to make according to a schedule. Many problems, however, has to take place in this process. For example, the sales persons concern that they don't have to come about an opportunity loss. Therefore, they order more than required volumes, making many useless stocks. The reason these biggest problems occur is all members of the company can't be shared accurate information. If they can contact truthful information, they have to make an optimal number of products and supply the correct number of raw materials.

Considering these situations, the purpose of this research is making a system for the production and the supplies' schedule. For achievement of this, a simulation model create to consider the scheduling efficiency and discuss a validity of the system. Using those outputs, a possibility of the system argues with persons in working at the wireframe manufacture company.

Design/methodology/approach:

This study introduces the concept to the wireframe manufacturing company (called WMC). Its company makes a plastic wire. Figure 1 is an overview of WMC.

One type of the raw material supplies from the supplier and three kinds of products manufacture through "a manufacturing 1." For determining the schedule, a standard production planning sets by using much information: stocks of the raw material, time and ability of the manufacturing, numbers of orders, prediction of the production demands, etc.

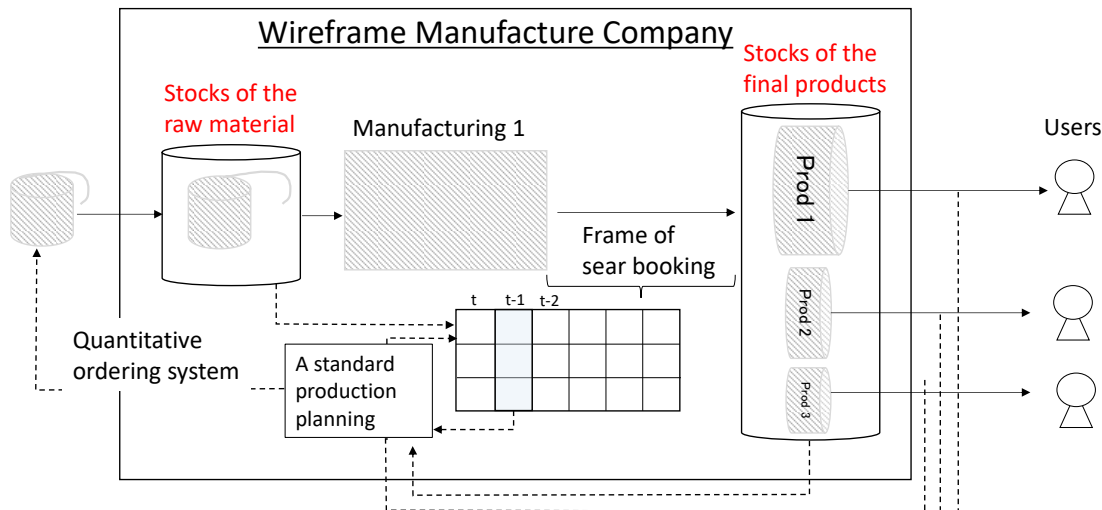


Figure 1. Fundamental Model of This Research

A standard production planning set a formula. Calculation results allocate to the seat, using "a dilated seat booking system (called DSB)." DSB has rules to assign seats. Using this model and the formula, the simulation conducts and its output analyse to study. Assessment values of outputs set two items:

$$\text{The rate of out of stock} = \frac{\text{The number of out of stock}}{\text{Results of the product order}}$$

$$\text{The average of the stock rate} = \frac{\text{Sum of one day Stock volume}}{\text{Results of the product order}}$$

Findings:

The simulation outputs learn a lot of things. For example, this model has three kinds of products, setting a different average and a standard division. As a result, they have to decide the optimal timing and volume of the raw materials in each scene.

Outputs of the simulation and utilization of DSB have shown to persons in working at PW company and been interviewed about the utility of model. From interview, the research model is useful to their company when making schedule, being prospect the number of products and supplying the raw materials.

Future research prospects are 1) reconstruct the model to more realistic situation, 2) comparison between simulation outputs and real data, 3) applied to the other industrial company.

INTRODUCTION

A make-to-stock concept is a management method whereby products are produced according to a forecast and corresponding demand order [1]. It has become a mainstream method in an era when a firm can sell as much product as it can make. This concept, however, does not work for strict economy or deflation circumstances. It is considered relevant not only with production but also with a sales view. For example, when a sales person receives an order from a user, the production department starts to make products according to the order. This is a common situation in a manufacturing company. Nevertheless, many problems can arise in this process. Sales persons are concerned that they do not want to miss opportunities for sales. Therefore, they order more than the required volumes. As a result, the production department makes more products than necessary. Therefore, some products become unused stocks and more raw materials are consumed than necessary. The reason for problems like these is that members of a company do not share accurate information. If they would convey truthful information about orders and stock, they would order the correct number of raw materials and produce

the optimal number of products. One method to solve such stocking problems is “a production seat booking system.” The production seat booking system is similar to a train or an airline seat reservation system. The production schedule assigns the manufacturing of a particular final product to a vacant seat through the production forecast before a receiving a final order. It is able to share information with sales and production staff. The sales person knows when the products can be delivered to customers. Likewise, the production person knows how many products will be made within a delivery date. This system results in efficient production and less variation in stock volumes.

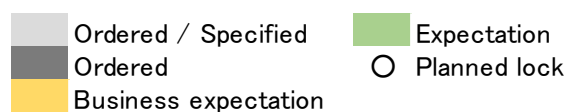
The production seat booking system’s previous studies already have many approaches. Tamura, et al. [2] compares with MRP concept. Akusawa [3] and Kuga [4] applied the seat booking system to real company. Kobayashi [5] makes the parameter of the seat size and analyse rates of requested delivery time and out-of-stock. Ohba [6] and Nakamura [7] set not only capacity margin ϵ but also reference stock parameter Φ , and discuss the optimize valance of two parameter. These researched, however, only discuss by using pseudo data. It goes to be a stage to apply a real company situation.

Recently, a new concept has emerged called an “expanded seat booking system.” This concept solves the problems for firms with multiple production plans such as for made-to-order products. Table 1 is an example of a plan to make seven products in one week. Each product has one seat. For example, a sales person gets an order to deliver a product in N-3 month. He changes the status to “business expectation.” This is an instruction used to make the product to be sold. Both the product and sales section are coordinated to make the products and see the indicated seat occupation.

From N-1 to N-2 month, the specifications of the customer’s product are finalized and the status is changed to “planned lock.” If there is a vacant seat in this term, the seat is changed to “planned lock” by the business management policy company. All the members of the company know the rate of the occupancy and the vacant seat. This concept is very useful to managing stock and unused production volume.

Table 1. The expanded seat booking system

Production		N month				N+1 month				N+2 month				N+3 month			
		W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4
Prod 1	PW1-1	○		○		○	■	■		■		■	■				
Prod 2	PW1-2	○	○	○			■			■	■	■					
Prod 3	PW1-3	○	○			○	■	○		■	■	■	■				
Prod 4	PW2-1	○		○		○	■	■	■	■		■	■				
Prod 5	PW2-2	○		○	○	○	■			■	■	■	■				
Prod 6	PW2-3			○			○	■		■	■	■	■				
Prod 7	PW2-4	○	○			○	■	■			■	■	■	■			



Considering these situations, this research constructs a product planning system for sharing a production schedule with different types of products. This system uses the expanded seat booking system concept. The research approach designs a model for a simulation to maximize scheduling efficiency. The model applies to a real company that makes plastic wireframes. The model is checked for validity by comparing the simulation outputs and the real output data offering from the wireframe company. Using these outputs, the model demonstrates how the system can be and the discussion executes with employs of the wireframe manufacturing.

ABOUT THE WIREFRAME COMPANY AND THE CONCEPT OF THE MODEL

The Japanese wireframe manufacturing company (hereafter WMC) makes a net from a plastic wire using the process described in Figure 1. 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 the make-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.

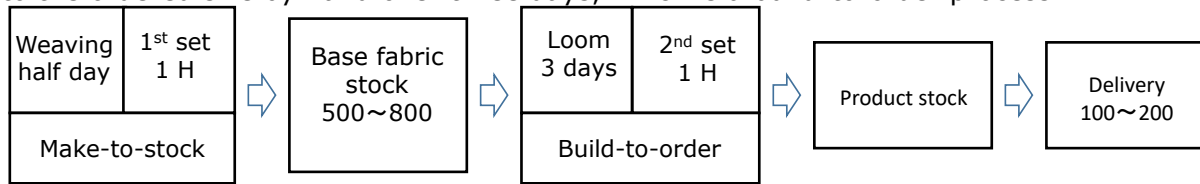


Figure 1. The process of making PW (current situation)

Referring to the WMC, the model concept follows as shown in Figure 2. The WMC makes three types of final products, Prod 1, Prod 2, and Prod 3. Users who buy each product are located in three different places and buy only one type of product. WMC forecasts the amount of the products to be sold in each week referring to past data. Each final product is made from one type of raw plastic material and their raw material are supplied by one supplier. From a raw material to final product, the manufacturing processes have two steps. First, they make a square net from the raw material. Second, according to the seat booking system, they cut the net into the size specified by the customer's order. A quantitative ordering system manages the raw material. The stock points are considered in two places, the raw material stage and the final products and the stock space can be infinite in the model. The delivery time from the supplier to WMC is one week.

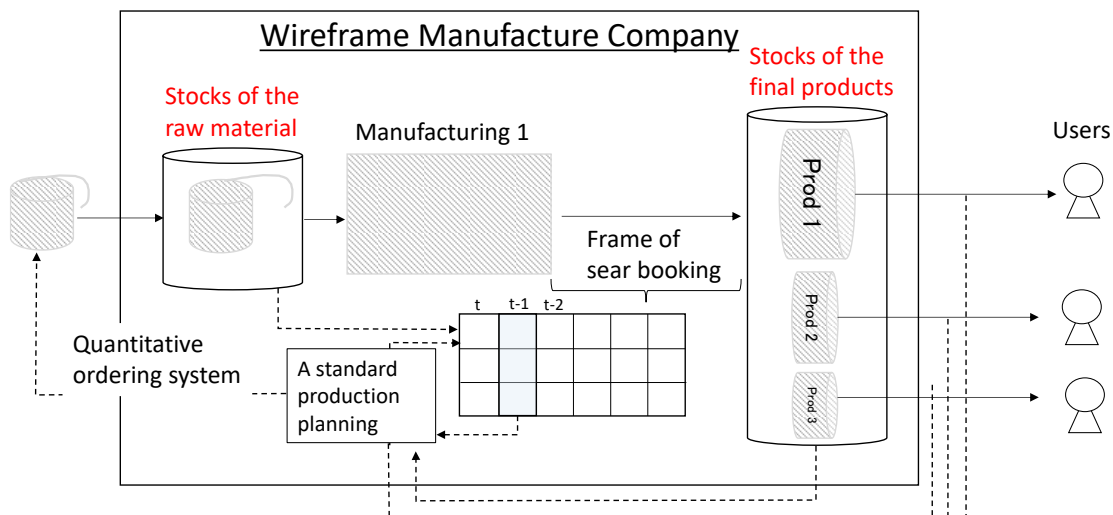


Figure 2. The research model

About a production plan

A standard production plan is determined using several pieces information as input: the final products' demand forecast, the stock of raw material and the reserved seats from the previous week of the seat booking system. The standard production planning is scheduled in $t-2$ terms. Calculation of demand is made from the product forecast and the amount of stock volumes. In this study, two parameters are set as follows: a capacity margin ε and a standard inventory parameter Φ . The mathematical model is as follows:

$$\hat{X}_{it} = \bar{m}_b \times ((1 + \varepsilon) \times \sum_{i=1}^I \hat{d}_{it} - \sum_{i=1}^I \hat{I}_{it-1} + \sum_{i=1}^I \bar{I}_{it}) \quad (1)$$

$$\hat{I}_{it-1} = I_{it-2} + \hat{p}_{it-1} - \hat{d}_{it-1} \quad (2)$$

$$\bar{I}_{it} = \bar{d}_{it} \times \Phi \quad (3)$$

- \hat{X}_{it} : Total operating time of the bottleneck process in term t
- \hat{I}_{it-1} : The amount of product estimated stock volume in term $t-1$
- I_{it-2} : The amount of product's actual stock volume in term $t-2$
- \hat{d}_{it} : The product demand forecast in term t
- \bar{I}_{it} : The amount of the standard stock volume
- \hat{p}_{it-1} : The production plans volume in term $t-1$
- \bar{d}_{it} : The expectation of product forecast volume
- \bar{m}_b : The expectation of product machining time in the bottleneck process
- ε : The parameter of the capacity margin
- Φ : The parameter of the standard inventory

About the seat booking system

The seat booking system in this study has certain rules, as shown in Figure 3. The seat size illustrates the weekly production capacity. If the firm needs to make more products this week than in the prior week, the seat size is enlarged. The seat is made smaller in the opposite situation. According to the standard production planning, the seat reserves a spot for making the final product. A seat allocation affords "a first-come first-served" rule. If the seat is full, the rest of the orders move to the next week. If a vacant seat exists, that remaining seat is occupied. A standard of the seat occupation is that seats are allocated automatically according to the rate of the average orders.

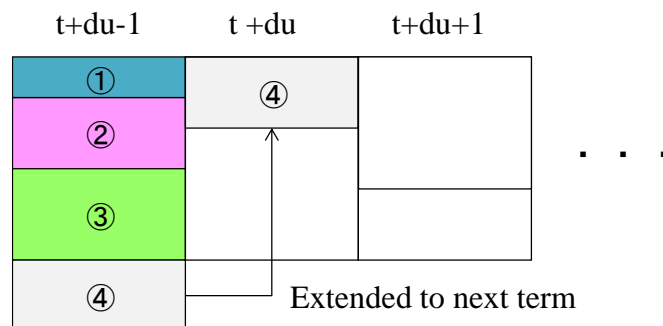


Figure 3. The allocation rule of seat booking

About the evaluation scale

The evaluation scale uses an out-of-stock rate α and an average stock volume β .

1. The out-of-stock rate α

$$\alpha = \frac{\sum_j U_j}{\sum_j d_j} \tag{4}$$

$\sum_j U_j$: The out-of-stock product volume in week j

$\sum_j d_j$: The demand record in week j

2. The average stock volume β

$$\beta = \frac{\sum_j I_j}{\sum_j d_j} \quad (5)$$

$\sum_j I_j$: The sum of the actual stock volume in week j

$\sum_j d_j$: The demand record in week j

Simulation conditions

The simulation is conducted under the following conditions:

- The real consumption of the raw material is used to calculate an average and a standard deviation from WMC's data. The initial volume of stocks and the order placement point is determined by using these data.
- Three kinds of final products also have data of the average and the standard division. By using these, the demand volume for each week applies to a probability variation. Its variation follows a normal distribution.
- The seat size and the number of the final products are a policy variable.
- Actual demand follows an Erlang distribution.
- The simulation period has 600 weeks. The first 100 weeks were removed and the remaining 500 weeks are evaluated and studied.

Table 2. Data of the WFC's three products

	Prod 1	Prod 2	Prod 3
Size	35	150	65
Ave (per week)	1378.0	905.5	126.4
SD	461	430	68

Table 2 shows the detail of the orders for the three kinds of products. Prod 1, the smallest-sized product, is the best seller at the WFC. Prod 2 is the largest-sized product and Prod 3 is the middle-sized product; these two have fewer opportunities to sell, as demonstrated by the average weekly sales numbers.

OUTPUTS AND STUDIES

The simulation is conducted with several options. First, a former research model is executed; that is, an infinite volume of the raw material and only one product. The product's data illustrates Prod 1.

Figure 4 shows the outputs of the out-of-stock rate (left) and the average stock volume (right) between the capacity margin and the standard inventory parameter. This output moves rationally; the out-of-stock rate has to decrease when both the capacity margin and the standard inventory parameters are high. In the same way, the capacity margin is high when both parameters increase. These two parameters influence the production planning.

The higher the capacity margin parameter, the smaller the gap between the product demand forecast and the actual production volume. As a result, the out-of-stock rate becomes small and the average stock volume becomes large. This is why additional stock has to be created.

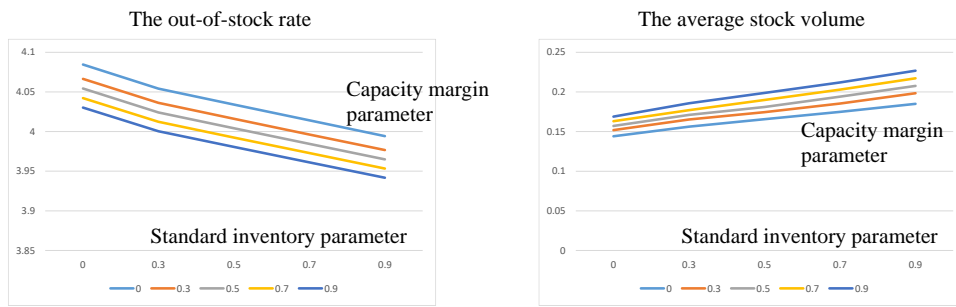


Figure 4. Outputs of the out-of-stock rate (left) and the average stock volume (right)

Figure 5 shows the outputs of the model for the three final product types. The figures are complicated depictions to analyze. As a result, the outputs of each product are shown as follows, in Figure 6.

The out-of-stock rate is a variable shape for each product. Production of Prod 1 and 2 rationally decrease the out-of-stock rate. The reason is that the average number of orders is larger. However, Prod 3 increases the rate. Similarly, the average stock volume of Prod 3 decreases. The notable feature of Prod 3 is that there are fewer orders in a week. Therefore, it is not adaptable to the make-to-order concept.

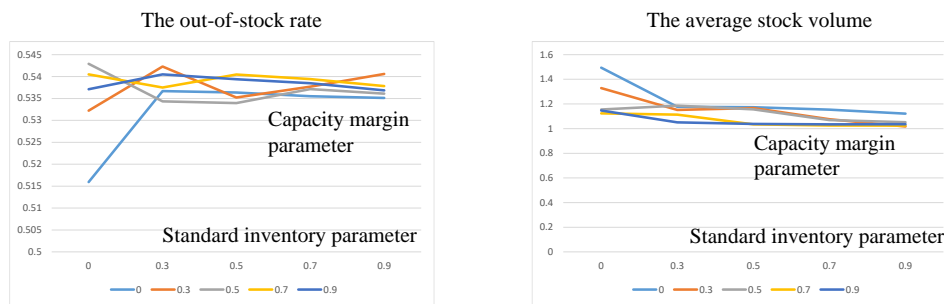


Figure 5. Outputs of this research model consist of the three products types

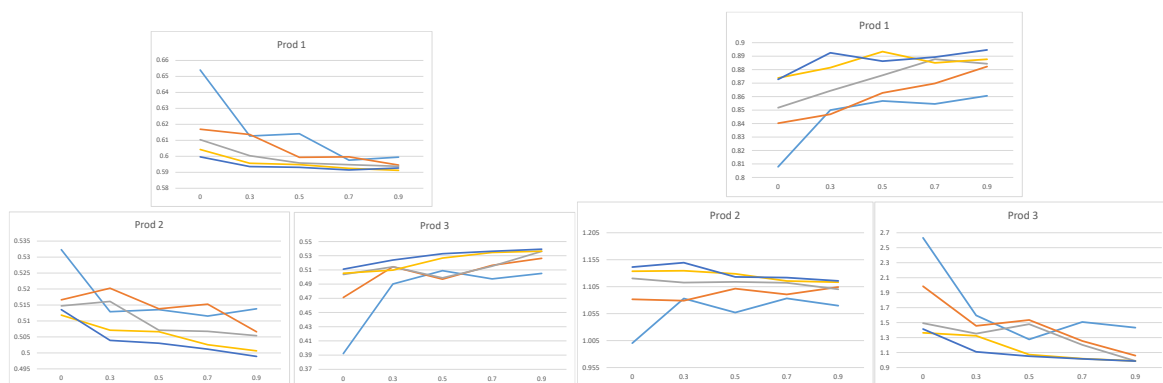


Figure 6. The outputs of each product

Fig. 7 is the out-of-stock rate and the average stock volume depending on the seat size. Figure 8 is the out-of-stock rate and the average stock volume depending on the Erlang distribution from $K=1$ to 5. The capacity margin and the standard inventory parameters are both 0.5.

From these outputs, a larger seat size results in more stock. The Erlang distribution also makes it difficult to forecast the production. As a result, the setting of the production plan needs to consider the sales forecast, optimal seat size, and standard production.

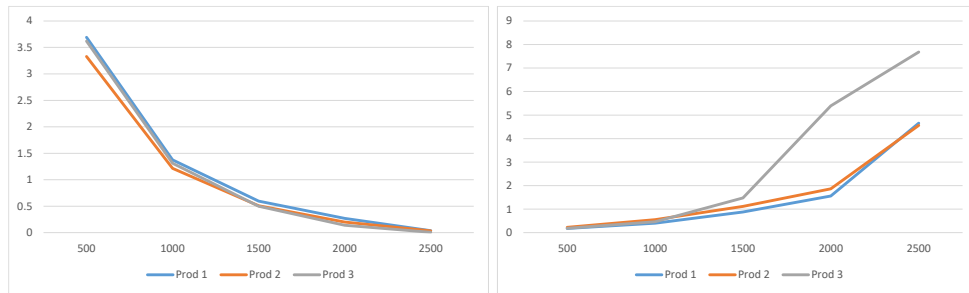


Figure 7. The out-of-stock rate and the average stock volume depending on the seat size

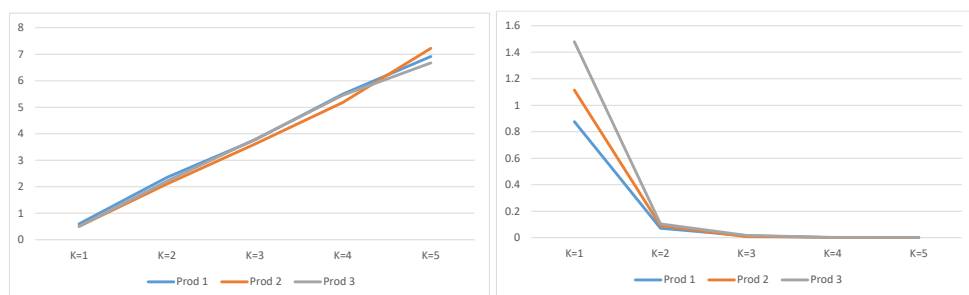


Figure 8. The out-of-stock rate and the average stock volume depending on the Erlang distribution from K= 1 to 5

Table 3 is the comparison of the simulation data and WMC’s real data of the final products. According to the model, the larger the size of the seat, the smaller the difference has to be. Prod 2, however, does not fit the model well. One of the reasons is that Prod 2 is a larger size than the other two products. The bigger product needs a bigger seat size and more raw material. Therefore, it is difficult to allocate the bigger size of the final product, resulting in numerous gaps between the real and the simulation data.

Table 3. A comparison of the simulation data and WMC’s real data

	Seat size	Prod 1	Prod 2	Prod 3
Hypothesis testing for a population mean	1000	**	**	**
	1500	**	**	**
	2000		**	
	2500		**	
	3000		**	

CONCLUSION

The effects of the new model are discussed in this section. The new model introduces the expanded seat booking system. It allows a firm to carry out production without having to be conscious of demand information. It can also control the production ability by seat size and manage the inventory quantitatively. That is to say, it can schedule and prevent product manufacturing, as needed. Under the original seat booking system, a firm measures outputs by the balance of the parameter between the capacity margin and the standard inventory. This research, however, introduces a model with multiple products. Consequently, the outputs can be irregular. That is to say, it is closer to the real situation of the WMC. Concretely, the following things are demonstrated:

- 1) Raw material must be considered to manage the production. This model clearly shows the timing to obtain the supply of raw materials and to make a product.
- 2) The model introduces three products with the option to produce various quantities of Products 1, 2, and 3. It offers the optimal combination in each week.
- 3) Changing seat size manages the quantity of stock. The firm can also provide, from a management view, things such as trends in product sales or seasons with more vacant seats.

Future studies are as follow:

- 1) The model must expand to the other industry and company.
- 2) Consideration points have to extend to an optimization problem. They, for example, add the cost problem of the production volume and the inventory quantity to the mathematical model.
- 3) A method of information visualization has to make by using the expanded seat booking system.

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SLAM FOR AUTOMATED UNMANNED GROUND VEHICLE WITH ROS

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ABSTRACT

Automated Unmanned Ground Vehicle (UGV) can be used for warehouse materials handling and transport. Their purpose is to carry goods from place to place in the minimum operating time. Normally a warehouse is a GPS-free environment where GPS navigation fails. Therefore, Simultaneous Localization and Mapping (SLAM) tests are conducted in this paper. The objectives are: (1) UGV navigation in a known environment (warehouse); (2) path planning to the desired location; and (3) static and moving object avoidance during navigation. How SLAM works in Robot Operating System (ROS) is described in detail.

KEYWORDS

SLAM, automated UGV path planning and navigation, UGV obstacle avoidance, ROS

INTRODUCTION

The purpose of implementing SLAM algorithm is to create a map of the area for unknown places. SLAM together ROS is proposed as a means to navigate a UGV to the destination in the shortest possible way while avoiding static and moving obstacles in the known and dynamically changing warehouse environment.

The UGVs need to navigate itself to arrive at the goal location by avoiding obstacles. Moveable racks may locate in any area on the warehouse floor. Humans and other vehicles constantly move around the warehouse. Unmovable objects such as conveyors, heavy machines, and heavy racks may also be on the warehouse floor. UGV navigation can be initialized by the operator or by the system.

UGV navigation can be assumed as the robot navigation. ROS can be integrated with a variety of commercial off-the-shelf mobile robot frames, as well as with customized robot frames of various sizes and capabilities. ROS can run the mobile robot functions as a separate node, therefore the whole system can be processed even if one of those functions encounters a failure. Functions include the sensing, navigation, path planning, avoidance, motor speed controller, and other operations defined according to the project goal. ROS provides robotic control packages which are controlled by C++ or python.

In this paper, a gmapping SLAM is provided in combination with the ROS package. Working steps are explained in order to understand how SLAM achieves localization (UGV location), mapping (exploring the environment), and navigation (approaching the target location). The simulation is achieved with Gazebo and Rviz simulation environments which provide the realistic robot frame with the sensor odometry.

BACKGROUND

SLAM theoretically and practically succeeds in the known as well as unknown environment because of its simultaneous mapping and localization. A Kalman filter approach to the SLAM problem was used to map automatically in the unknown environment by Dissanayake et al. (2001). They implemented SLAM on a real standard road vehicle by equipping it with millimetre wave radar (MMWR). MMWR detects the location of landmarks with respect to the vehicle and draws a corresponding map. Simultaneously, SLAM navigated the vehicle in the unknown environment.

Araújo et al. (2015) presented the full integration of educational mobile robotic platforms with an Arduino controller board with ROS. The robot movement relied on odometry from Laser Range Finder (LRF). They experimented with the integration of multiple Arduino-based robotic platforms in ROS. All three robots were able to coordinate themselves in the environment without colliding into each other due to the integration of the ROS navigation stack.

Krinkin et al. (2015) presented a hardware design and control software for small size Raspberry Pi-based omni-directional robot-implemented wheels for indoor SLAM algorithms. Omni-wheel robots can move instantly in any direction from any pose, but they require more complex control algorithms and are sensitive to underlying surfaces. That paper described not only hardware design and odometry sensors, but also software design to define the motor controller, UART communication, commands execution, and pulse-width modulation to make vehicle movement. The motion control was tested by experiments. Adding sensor feedback, using extra ultrasonic sensor, and calibration were suggested to improve vehicle motion control.

Pajaziti & Avdullahu (2014) presented the SLAM via ROS by using turtlebot. That paper used gmapping, Adaptive Monte Carlo localization (AMCL), and move_base navigation of ROS to control the turtlebot for mapping and navigation. ROS supports the customized vehicle frame like realistic industrial vehicle was built by Vasiljević et al. (2016). ROS gmapping SLAM and AMCL were used to control the vehicle. Two ROS packages (AMCL and gmapping) together with their proposed algorithm can control the ground vehicle even to achieve the accuracy up to centimeter for vehicle localization by using only the wheel encoders for odometry information and range reading from an onboard laser scanner.

Wang and Thorpe (2002) presented the integration of SLAM and Detection and Tracking of Moving Objects (DTMO), which outperformed SLAM or odometry only. They used CMU Navlab8 Navlab11 vehicles with SICK PLS 100 LRF and a maximum speed of 45 mph for indoor and crowded outdoor environments. In their experiment, detection of the approaching object and detection of the leaving object, the tracking object were performed by using SLAM and DTMO. After the experiment, results showed that SLAM with DTMO can obtain a better mapping result and accuracy of localization. This is due to the possibility of improving global ranges by the scan matching alignment method.

Beyond the ground vehicle, SALM can be applied to air vehicle navigation. Murray and Schukat (2017) applied the parallel tracking and mapping algorithm (PTAM) to Micro Air Vehicle to control systems together with SLAM algorithms. They evaluated the ideal parameters (resolutions, reduced tracking corners, processor capability, and image noise) to increase mission efficiency in power limited operations. That research conclusively proved that the minimum computational and power requirements for a computer. It is feasible to operate PTAM on a 5 watt computer (a low power computer such as Raspberry Pi 2).

ROS

ROS is used as the middleware between the operating system and hardware components. ROS is useful for its reusable libraries and its ability to operate independently. There are existing ROS-compatible robots, such as turtlebot, Willow Garge PR2, and Lego NXT. Moreover, UGV can be customized by design and size to achieve particular purposes.

ROS SLAM Gmapping or exploring the environment: ROS provides gmapping ROS package which uses the 2D occupancy grip map. For the ground vehicle, the 2D map suffices because the UGV navigates on a given floor. The map defines the warehouse floor by marking the obstacles as occupied blocks in the grid. Therefore, laser odometry is used to detect the surrounding obstacles for observation purposes. An occupancy map can be updated according to environmental changes in real time.

Global path-planning or navigation: It performs with complete knowledge of the environment. Global path-planner is responsible for navigating UGV to the target location. In that case, the planner works over the 2D map from gmapping of previous data. The planner produces the path by considering the obstacles of a posted map and location-specific approach path. The planner uses A* algorithm to achieve the goal by avoiding occupied cells.

Local path-planning or avoiding static/moving obstacles: This path planning performs in the incomplete knowledge of the environment. Its path-planner is responsible for the real-time navigation based on laser odometry data. First, UGV navigates with the lead of the path given by global-path planner. During the navigation, if the environment is changing, new obstacles appear or old objects disappear, local path-planning produces a new path to evaluate the global-path. That means the local path tries to optimize the global path depending on the real environment situation as the new route by using A* algorithm, as well.

ROS AMCL Localization or defining where the UGV is: Adaptive Monte Carlo localization (AMCL) is used for localization of the UGV. AMCL uses a particle filter to track the pose of a vehicle with respect to a known map. AMCL fuses odometry data with a laser to localize the vehicle location in real time. By implementing AMCL, the robot can associate the global path defined by post sensor data and the local path defined by localization algorithm of current sensor data.

AMCL covers 3 steps: prediction, update, and resample. In the prediction step, the UGV takes each particle and adds a random sample from the odometry values. The resulting distribution estimates the anterior distribution. In the updating step, the UGV takes the data from sensor and assigns each particle according to weight, which is the probability of sensor measurements from allocated particle's state. Lastly, in the resample step, a new set of particles is chosen so that each particle remains in proportion to its weight, which means that highly probable particles are selected for posterior distribution. By those means, warehouse floor changes are updated in the real time as a known map for localization.

SLAM grants localization, mapping, and navigation at the same time. SLAM is like the chicken and egg problem. First, SLAM tries to know the floor partially and saves it as a map, and then localizes and navigates. At the same time the map is updated. Then SLAM localizes and navigates till UGV reaches the desired place. Figure 1 describes SLAM's working nature. Real time odometry laser inputs into SLAM, then maps via gmapping as the 2D occupancy map. At the same time UGV navigates according to the global path planner of the known 2D map. Localization is done via AMCL to update the UGV position. At the same time, new floors are mapped via laser. Global path planning ensures reaching of the desired floor location, while local path planning ensures obstacle avoidance.

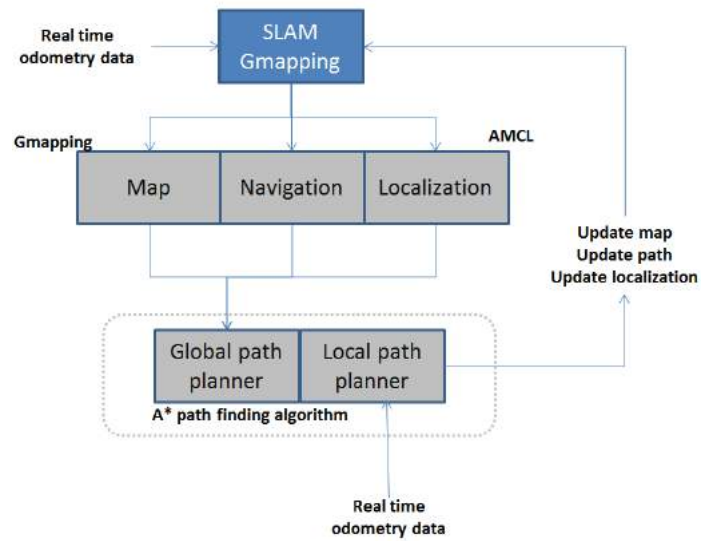


Figure 1: SLAM by ROS for UGV

TESTING AND SIMULATION

Test beds were taken under ROS Gazebo and Rviz simulation environments. There are static obstacles and moving obstacles on the warehouse floor. UGV was created with the robot frame with two wheels of diameter 0.2 and torque 10. A Hokuyo laser was attached to the UGV with a scan range from 0.10 into 3.0 with Gaussian noise distribution. The testing procedure requirement and ROS command are described by MooreRobots.

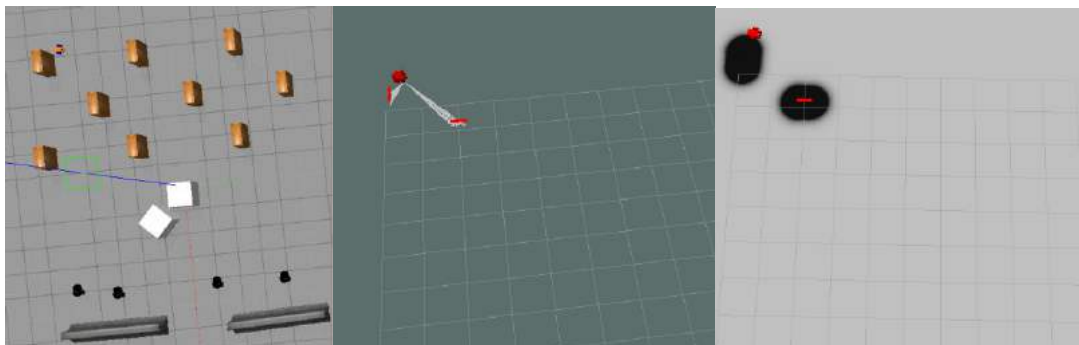


Figure 2: Warehouse floor in Gazebo (left); UGV scanning with Hokuyo laser (middle); 2D occupancy map of current laser odometry on Rviz (right)

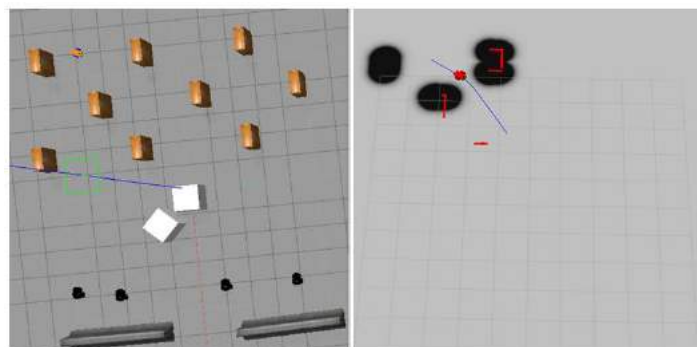


Figure 3: Navigation with partially known map

UGV initializes the navigation over little known map. The laser scans the environment and detected areas are highlighted by red line as shown in Figure 3.

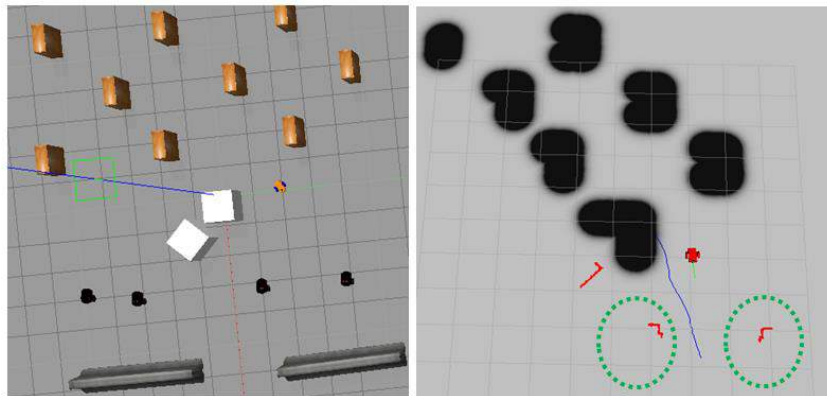


Figure 4: Navigation to the desired place

Gmapping updates the map. AMCL updates the localization. The blue path represents the global path planner. The green path ahead of UGV represents the local path planner. Other moving UGVs are detected and highlighted by the green dotted circles, as shown in Figure 4.

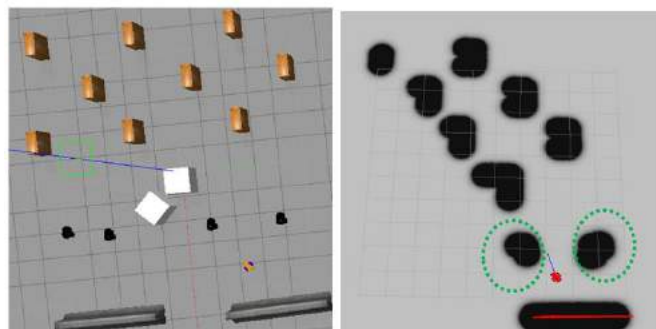


Figure 5: Reaching at the desired place

Finally, the UGV reaches its desired position. The actual warehouse floor in Gazebo can be seen in the left image. The 2D map drawn can be seen at right. There are two extra occupied cells because of the moving UGVs. Therefore the map assumes the moving obstacles as the occupied cells even though there are no more objects in the real operation, as shown in Figure 5.

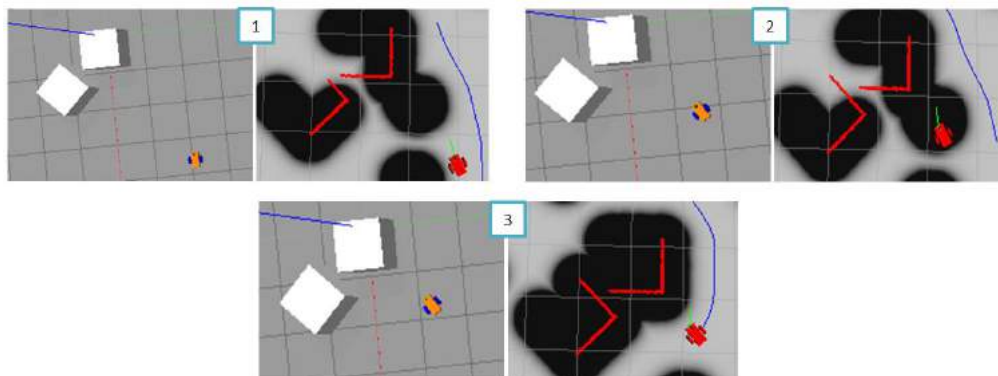


Figure 6: Erase the extra occupied cells in 2D occupancy map

As shown in Figure 5, the 2D map resulted with the extra occupied cells which are not actually loaded with objects. Those cells will be erased only after the UGV laser odometry detected those areas again. Then SLAM will update the map by erasing those cells. Figure 6, step 1 shows that there is an extra occupied cell near the two white rectangular boxes. This is because there was previously a moving or static object. After UGV detected that environment again as shown in Figure 6, step 2. SLAM found there was no more object and the map was updated, as shown in Figure 6, step 3. Figure 7 shows the simulation of moving obstacle avoidance by using PR2 robots. The UGV can scan and avoid those moving PR2 UGVs with the constant speed.

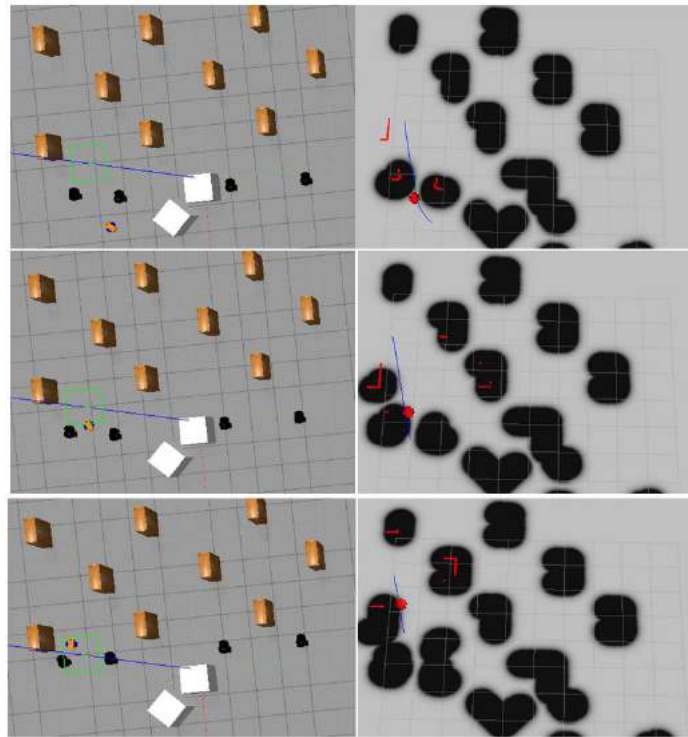


Figure 7: Moving obstacle avoidance by SLAM

ANALYSIS

ROS is one straightforward way to develop a robotic system, even for the beginner, by reducing the development time through code reuse. The functions are defined as nodes which can operate independently; therefore the errors can be traced easily. SLAM itself is a very powerful technique for robot navigation in unknown and known environments because of its simultaneous and real time response capabilities.

However, the drawbacks of grid-based mapping are high computing and memory requirements, as it continues saving the occupied map till those environment data are received again. Object avoidance is likely to fail when the acceleration of UGVs is too fast, due to limited on-board processor manipulation performance. Thus ROS SLAM needs a computer for a fast and reliable computation.

Due to the extra occupied cells, global path may lead extra time taken for path planning, which be solved by the local path planner in real time. Heuristic path planning algorithms can be used for pose position estimation to attain more efficient planning.

The nature of unknown places makes SLAM difficult. When using the SLAM algorithm, UGV first checks its position by landmarks and then moves to the destination and recognizes its current location through odometry, such as motor movement from the wheel encoder or laser range. But there is the problem related to odometry data

credibility: it leads SLAM to have a recursive filter for prediction and correction. There are some methodologies can be applied to SLAM to improve its capability of localization. The Extended-Kalman-Filter (EKF) is one solution.

CONCLUSIONS AND FUTURE PLAN

This paper has described the automated UGV navigation and obstacle avoidance in the ROS Gazebo and Rviz simulation environments. The working nature of SLAM was also described with simulation test beds. The future plan is to implement the hardware of UGV in order to navigate to the exact warehouse floor position by using the wheel encoder and laser range sensor. This research is ongoing and aims to build a real UGV frame to navigate together with ROS SLAM.

ACKNOWLEDGMENT

This work was supported by the Korea Agency for Infrastructure Technology Advancement (KAIA) grant funded by the Ministry of Land, Infrastructure and Transport (Grant-18TLRP-C127006-02/Name-Development of flexible Lego type shuttle and packaging system against operational environment). The authors would like to thank Dr Julian Baker from the Department of General Studies, Korea Aerospace University for proofreading this paper.

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Available at: MooreRobots <http://moorerobots.com/blog/post/3>

Session 8: Complexity, Risk and Uncertainty

HYBRID CATEGORY MANAGEMENT IN A MUNICIPALITY

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Abstract

Purpose: This paper considers how should a hybrid procurement structure of the studied municipality be designed to improve its category management initiative?

Design: A single case study was conducted at a municipal government in Norway providing insight in this organization's actual purchasing practices. These practices are analysed in light of literature of category management. .

Findings: The studied municipal government in Norway purchased for more than NOK 443 million in goods and services in financial year 2015. This spending is found to be not being managed efficiently. Qualitative analysis reveals that a hybrid category management structure provides a logical mixing of centralized and decentralised purchase based on its empirical features.

Value: Provides foundation for further studies on using a hybrid structure of category management in the public sector.

Keywords: Category management, Public procurement, Reducing uncertainty, Integration

Introduction

Category management represents the bundling of similar purchases into a single contract (Webb 2015). This implies also a change in purchasing organization, a simplifying by re-grouping purchases so that they may be handled simultaneously, or at least in a similar way. This implies increased organizational simplicity since similar types of purchase can be handled both in a unison manner and in a same process, reducing the number of purchasing processes, from many small to fewer larger processes. This also leads to reduced purchase handling uncertainty since this simplification enables the purchasing manager to better cognitively grasp the overall purchasing status quo at any given point of time. In societal terms, this means saving taxpayers' money. In 2011/12, the UK government's category management efforts on IT spend have delivered £140 million price savings (Gov.UK 2012). While the US government's category management initiatives have generated \$2 billion in savings (Rolfe 2016). Studies have shown that category management creates purchasing synergies including the purchasing process itself, economies of scale, and economies of information and learning, total spend under management, reduced supply chain risk, improved financial performance, and the total cost of ownership (Rozemeijer 2000, O'Brien 2015, Mitchell 2012). According to Van Weele (2014), decentralizing procurement is used when items purchased by a business unit within the firm is different from that purchased by other business units in the same organization.

Trautmann et al. (2009) propose a hybrid purchasing structure, a mixing of these principles of category management. This implies belief that the way an organization's procurement structure is designed is dependent on search for product category synergies across dispersed business units. This leads to the fundamental research issue of this case study of a particular municipal government to: "How should a hybrid procurement structure of the studied municipality be designed to improve its category management initiative?"

The research question also implies considering particularities of public purchasing in relation use of hybrid-organized category management in its purchases.

Frame of reference

An organization's procurement structure is designed dependent on the category related synergies across dispersed business units. Monczka et al. (2011) affirms that deploying procurement strategies should start at the category level; "bottom up" in amnner. Trautmann et al. (2009) showed through a study of large multinational enterprises that companies with hybrid procurement structures had success with their use of category management. Their research concludes that different categories require different ways of integration; integration implies also how centralized purchasing is organized. Supply chain management (SCM) efforts, of which the procurement function is a part of, indicate a norm to integrate to collaborate supporting production coordination. This SCM process of different groups, functions, or organizations working together, either formally or informally, physically or by information technology, on a strategy or problem to accomplish a common business-related goal (Monczka et al. 2011). A framework is developed as basis for this study on using category management in the public sector; we look at however, a local municipality government. This implies considering two novel aspects of this approach: (1) use to smaller enterprises, and (2) adaptation to public procurement.

According to (Trautmann et al. 2009), three contingencies impact on the level of integration in dispersed purchasing business units, (1) category characteristics, (2) supply environment characteristics and (3) interdependence of purchasing business units. Category characteristics include purchase novelty, purchase importance, category complexity and demand volatility. These are internal to the organization and relate to an organization's purchasing experience on an item, degree of product customization, risk perceived and purchase volume, and demand fluctuations (Trautmann et al. 2009). These contingencies affect how purchasing organizations are designed across different categories. Supply environment characteristics are external to the organization. This includes the degree of item availability, uncertainty of supply as well as stability of supply (Trautmann et al. 2009). Lastly, existent interdependence of purchasing business units relates to the power structure exposed through supply chain. Interdependencies is an expression of relational power found in exchange rather than production operations; how and why networked actors need to do trade with each other (Emerson 1962).

In the case of buyer and supplier, power does not necessarily have to be zero-sum since buyer and supplier can each have power over each other making them interdependent. This type of contingency is internal to the organization and creates higher task uncertainty (Tushman and Nadler 1978). Jain (2005) defines the three types of interdependence based on (Thompson 1967)'s contingency theory: (1) pooled interdependence requires no interaction among purchasing business units because each unit performs separately, (2) sequential interdependence requires one unit to complete its task before another unit can perform its task, and (3) reciprocal interdependence requires each unit's output to serve as input to other units in the organization (Jain 2005). Integration mechanisms are divided into vertical and lateral (horizontal) mechanisms (Galbraith 2000). Vertical mechanisms include centralization, formalization, and information systems, these follow a chain configuration evoking the fundamental sequential interdependency of production (value transformation of produced resources in time, place and form).

Centralization is the degree to which decision making is delegated to the top level in an organization, while formalization describes the extent to which rules, procedures and communications are written down (Bozkurt, Kalkan, and Arman 2014). Lateral mechanisms

are characterized by cross-functional teams in the form of category teams and a category manager (Trautmann et al. 2009). These are mainly pooled interdependent implying utilizing a logic of combining heterogeneous resources to produce. Pooling is accordingly a search for synergies. Both mechanisms vary in their capacity to facilitate information processing in an organization and the costs of use (both managerial time and monetary costs). For instance, the use of vertical integration mechanisms like centralization requires less investment but their capability to facilitate information processing is lower than that of lateral mechanisms. The use of numerous complex lateral mechanisms may require high investments to integrate the vertical chain structure. This is due to the supply chain having different purchasing and therefore also information processing requirements spread across the chain (Trautmann et al. 2009).

Purchase of goods or services conducted by governments or state-owned enterprises is termed "public procurement" (Uyarra and Flanagan 2010). Similarly, the (European Commission 2017) defines public procurement as "the process by which public authorities, such as government departments or local authorities, purchase work, goods or services from companies". Procurement in public sector demands a balance between internal efficiency as well as external conditions regarding corporate social responsibility. The overriding principles are public accountability, transparency, open to competition, confidentiality, integrity and value for money (Ekambaram, Kumaraswamy, and Ng 2003). Expenditures by governments are funded by taxpayer money implying that they are expected to operate with a sense of efficiency and accountability on the way public funds are managed (Matthews 2005).

All necessary information, including the selection procedures and evaluation criteria, should be provided to the tenderers for increased transparency (Ekambaram, Kumaraswamy, and Ng 2003). To promote open and fair competition, the government should treat all tenderers in an equitable manner without any discrimination or bias (Ekambaram, Kumaraswamy, and Ng 2003). Information like trade secrets of tenderers should also be protected to ensure adequate confidentiality (OECD 2009). Specific measures and mechanisms for the monitoring of public procurement and the detection and sanctioning of misconduct are to be put in place to prevent risks to integrity in public procurement (OECD 2009). Clear integrity standards should be set, and be followed. To improve value for money, selection of supplier should consider competitiveness, compliance with requirements, reliability of performance, qualitative superiority, and life-cycle costs (Ekambaram, Kumaraswamy, and Ng 2003). Value for money is to pay for a good or service only to the extent that its quality or availability is justified (Glendinning 1988).

In large-scale projects, value for money can be derived through comprehensive tendering process, which occurs in two distinct stages: 1) identifying properly the competent bidders based on assessment of their best value delivery potentials, and 2) selecting the optimal bid based on an assessment of identified best value parameters (Ekambaram, Kumaraswamy, and Ng 2003). On the other hand, in simple or small projects, price-based competition is often preferred since analysing all value elements in detail may be complicated and therefore time-consuming. Although tendering is a valuable tool for the public sector, it is a considerable cost to the government as it requires time and resources (Emmett and Wright 2011). It is a burdensome process since to send information, handle queries, and read and evaluate tenders can be extensive, increasing with the number of received tenders (Heijboer and Telgen 2002). According to McCue and Pitzer (2000), in the public sector where the policy making, authority and process are established according to hierarchy, the three common procurement structures are (1) centralized, (2) decentralized and (3) centralized/decentralized. This coincides with the

classification of purchasing in general discussed previously. This implies that category management organized as a hybrid structure may be treated likewise as in the private sector. In a study conducted by Karjalainen (2011) it is suggested that centralizing the procurement structure in public sector eliminates this burdensome process, and at the same time significant volume discounts from pooling can be achieved. This implies that economizing purchasing follows a wider societal agenda in the public sector, where society is more a contingency that an organizationally intertwined force in designing purchasing processes and their networked chain structure. The research issue at hand therefore now directs focus to how a *hybrid* structure in public procurement is adapted to meet issues regarding primarily the need for societally demanded purchasing process transparency.

Method

The following case description is based on a single case study. It provides an 'as-is' description of procurement in the studied municipal government. Semi-structured interviews were carried out with informants lasting 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. Documents including purchasing statistics from the municipal government were provided and used in the study. The study followed 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. Applying a case study strategy involves limitations regarding the transferability of findings to other business cases.

The case

The procurement structure of the studied municipality government is already organized as a mixed hybrid model as the purchasing function is shared between the central procurement unit and the 184 business units, but the management structures in contracting and procurement are centralized as shown in figure 1:

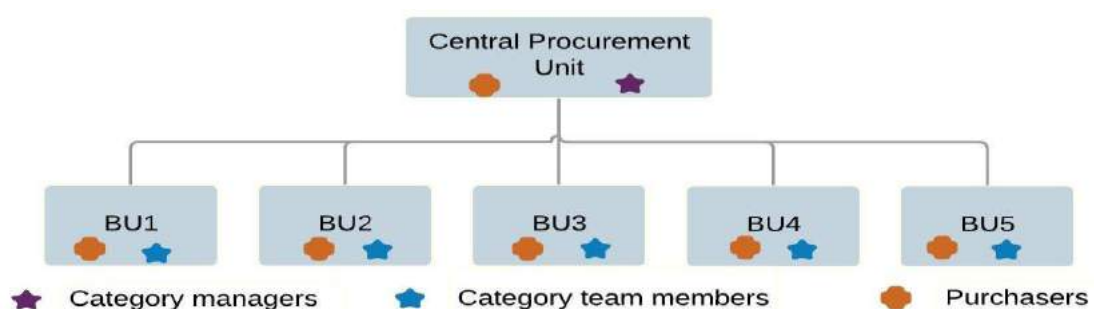


Fig. 1. Hybrid procurement structure in principal

Each of these business units control their purchasing budgets allocated by the municipality's city council. The daily purchasing is decentralized. The central procurement unit is under the umbrella of the municipal's Finance Division which is headed by the assistant chief municipal executive. It has a procurement manager and three other procurement professionals at the functional level, where these two functions exclusively

for the municipality and the other two works for the group of municipalities where the municipal government has a collaborative procurement arrangement. These are the same people who also generate the procurement procedures and guidelines for the hybrid organization to follow. In addition, they serve as the category managers with spend on specific categories like office supplies, IT hardware and consultancy services, and facilitate the tendering procedures for framework agreements normally valued above the Norwegian national threshold of NOK 1.1 million. All the municipality's units, such as finance, health and care services, technical and cultural affairs, personnel and administration, and education, are recommended to use these framework agreements. The major contributing factors for using framework agreements are the desire to gain purchasing savings by pooling the large volumes of the municipality's purchases and standardization of processes. In spite of these facts, the framework agreements have, however, been estimated by the municipality's Procurement Manager to have a low usage rate. The rest of the purchasing organization is distributed on divisions and business units throughout the organization. 138 purchasers are responsible for the small value purchases and 30 purchasers are delegated the purchasing role for high value items. The category team members also come from the different purchasing business units.

Purchase of capital expenditures like IT systems, cars and furniture are carried out by these business units with one purchaser from the central procurement unit to assist them in making the specification and criteria, or the RFQ, and send the offers to qualified suppliers. They are also allowed to purchase goods or services without informing the central procurement unit as long as the transactions are below the Norwegian national threshold of NOK 1.1 million. Currently, the studied municipality has an intercommunal procurement cooperation with eleven other municipalities. The main motivation for this is to streamline the procurement processes through framework agreements and with increased volume gives greater bargaining power and reduced transaction costs for them.

The category core team used by the municipal government purchasing organization is a cross-functional team comprising a small group of representatives from across the different business units in the municipality plus a category manager. These business unit representatives are appointed by the head of their departments, and are only fulfilling a part-time task as their main tasks are related to the core function of their unit (for instance, an IT engineer from the IT department, or a doctor from the hospital). Members have expertise in technological efficiency of an IT hardware or software, or quality of medical supplies, and they are capable to develop sourcing strategies in these categories. Each member contributes unique insight into the development of criteria for supplier selection, according to the Procurement Manager. For the extended team, it is comprised of the different stakeholders in the municipality – the different business units who purchase certain products or services, end-users, city council, suppliers and taxpayers.

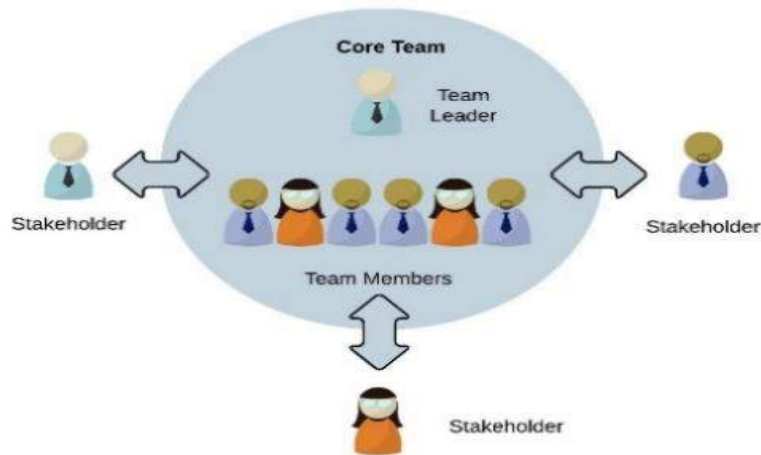


Fig. 2. Category team structure

The category manager has the sole responsibility for managing several categories, while the team members are only there to support the category manager to develop the contract requirements, attend meetings and work as part of the team. The team prepares a forecast of what and how much will be purchased as well as the evaluating criteria for the awarding of contract or framework agreement. Evaluating criteria varies on different categories, which may include (1) price, (2) quality, (3) service, (4) environmental impact, (5) performance metrics, (6) operations/scheduling/technical capability, (7) user-friendliness of the ordering system and (8) certifications and competence of supplier's personnel. Around 300 hours was used for medical supplies category, and 244 hours was used for office and school supplies but only a half of that was used for the photocopier paper. This was because of the large number of products and specifications included in the contract. For the photocopier paper, there are 18 product specifications of A3 and A4 paper, while the office and school supplies category has 179 products and 488 different products and specifications for medical supplies. Other contributing factors are when complaints are received during the tendering process which entails additional time and resources to evaluate the complaints and give feedback, or the tendering process has to be run again because of these complaints. For example, the category team consumed 350 hours for contract labour category because of received complaints when tender was published.

Some of municipality's procurement procedures and guidelines are readily available in the intranet for everyone's easy access. These include the framework of procurement laws, internal policies, archiving procedures, and a procurement handbook which provides the requirements for workflow processes such as ordering, performing receipt, inspection and processing payments. Templates for tenders, protocols, and contract documents are also available in the intranet. Further, information on existing framework agreements such as the terms and conditions, price lists, and contact persons within the organization and the supplier can be found in the intranet. All these are updated and managed on a manual system based on Excel, Outlook and SharePoint. However, there is no documentation with regards to category sourcing process. The central procurement unit believes that because there are only four them, whereby they can discuss things together on a daily basis and have experience with contracts, process documentation is not necessary. There is 'trust' that each of them will make the best decision about how to carry out the process. It also gives them more 'flexibility' to procure goods and services since each category is unique and the approach can be different every time. The interviewed procurement manager also

believes that such documentation only works if an organization has no central procurement unit and if the size of the organization is large.

Conclusion

The studied municipal government applies a hybrid procurement model where the central procurement unit sets the guidelines while the day to day purchasing is set at the business unit level. Purchase ranges from office to medical supplies and from maintenance to health services. For every purchase, the municipal government strives at making sure everything is purchased in adherence to the public procurement principles. In such a hybrid category management structure, the central procurement unit is dependent on its business units to fulfil contract compliance. At the same time, the business units are dependent on the central procurement unit because it is the unit that is responsible for carrying out the strategic purchasing activity of selecting the supplier that can best deliver the right product at the right price. This is an expression of internal interdependency that is reciprocal, meaning uncertainty is tamed through intensive technology, mainly information system supported human interaction. This also implies pooled interdependencies typical of information systems, supporting mutual adjustments typical of reciprocally interdependent coordination activities.

Sequential interdependence is rendered expression of the timeline, the narrative of the purchase as it unfolds. This unfolding, namely viewing procurement as process, can be visualized as a complex system since it is embedded in degrees of uncertainty, much of which is dependent on outcomes of interaction in reciprocal and pooled interdependencies typical of applying category management. To handle this complexity, as it unfolds to the networked purchasing and supplying agents, public procurement is supported by the formal demands for purchasing process transparency. Category management supports these transparency aims. The described purchasing practices use of a hybrid structure is a way to organize purchasing that splits "transparency" into two levels of scrutiny, central and more local. This actually adds to complexity, since it increases the amount of interactions. On the other hand, it brings purchasing decision-making closer to user need, thereby better securing user value.

Further research may provide more detailed, including purchasing spend analytics to the described purchases. Studies may also consider the categorisation of purchase, both as pooling of goods and services purchased as well as how this process is carried out. Finally, studies may also consider how to structure category management in further detail, as a hybrid approach. All the proposed studies are case studies, which at heart open for triangulation, interwoven with quantitative analytics.

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NETWORKED RISK MANAGEMENT IN CHANGE – HOW SME’S ADAPT TO MEGATRENDS

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Abstract

Purpose of this paper:

The constant and increasingly turbulent changes in the business environment have exposed organizations to various risk. Responses to these risks vary between organizations and especially the small organizations may struggle in managing the new threats. In particular, the perception organization have on megatrends can have drastic implications on the risk management processes. The purpose of this paper is to study the risk management perceptions and practises of SME’s in a changing business

Design/methodology/approach:

The research follows a qualitative and explorative research design, where an integrated literature review is utilized to ground the research and empirical data is gathered by means of semi-structured interviews as well as stakeholder analyses to establish an understanding of megatrend perception, risk management practices and the role and importance of different stakeholder groups in the risk management process.

Findings:

The findings reveal the differences between SME’s adaptation to changes and managing the risks related to the different changes. The utilization of networks had significant differences between the studied organizations and the identification of different possibilities enabled by megatrends varies among organizations. In particular, the role of megatrend perception is a significant determinant in the scope of risk management activities.

Value:

The paper reveals the different approaches of SME’s in different fields in utilizing the network potential in different risk management phases and furthermore in gaining competitive advantage from the positive aspects of changes to their value creation. The paper gives insights which can help researchers to better understand the role of risk management in changing business environment and furthermore how networks can be utilized in this.

Research limitations/implications (if applicable):

The research follows a qualitative research approach, which has obvious limitations. The research has been conducted in a small number of companies, which limits the generalizability of the results.

Practical implications (if applicable):

The results reveal how organizations in different fields are experiencing the drastic and increasingly frequent changes in the business environment and further help managers to understand and adapt to these changes with risk management and network collaboration. The results help managers in understanding the network

contribution in SME risk management process and gives insights in selecting proper risk management techniques to apply both within and outside the organization.

INTRODUCTION

Change has become a central issue for businesses. Changes are happening in an increasing pace creating several impacts and challenges for businesses. Large-scale changes are often referred to as *megatrends*, which were originally introduced by John Naisbitt (1982) to describe significant economic, social, political and/or technological movements in global economy. Due to their significant impact, megatrends may provide clues and valuable information of the likely future and can be therefore utilized to assess the business environment (Guemes-Castorena 2009).

However, companies respond to these changes differently depending on how these changes are perceived by the head of the company. Reactions to these changes vary between perceiving these changes as threats or opportunities (Wiengarten et al. 2016). In particular, working with megatrends requires knowledge and skills as megatrends may act as *empty signifiers*, not transporting any information and acting as a bracket for different social changes, and without assessing their impacts, they may be taken for granted as the inevitably emerging future, although their meaning is constantly changing (Goeddeck et al. 2013). In particular, small and medium-sized companies may struggle assessing these changes due to their limited resources and structural features, which may limit the perception ability in the company. In particular, structural features may affect perception as the entrepreneur can be solely in charge of recognizing these changes and in cases, in which changes are not perceived, they cannot be addressed. Moreover, due to limited resources the potential threats created by megatrend-related changes may have drastic impacts on firm performance.

Controlling these uninvited changes in business environment may determine the survival of organizations as they may have devastating impacts on a firm's shareholder value and firm's growth trajectory (Bruckman 2008; Slyvotsky et al. 2005). Therefore, an increasing focus on risk management has emerged in recent years as the complexity and velocity of the business environment has evolved and increased the volume and complexity of challenges, which pose a risk to business operations (Frigo et al. 2011). In fact, perception of changes represent the starting point for risk management process in which potential risks are identified. Besides utilizing resources found within the company, SMEs can utilize their networks for risk identification. However, academic literature is rather limited on which stakeholders SMEs utilize for risk identification besides consultants and whether entrepreneurs and managers in SMEs conduct the risk analysis or is advice sought outside the company as well (Falkner et al. 2015).

Academic literature on megatrends and their perception is limited (Retief et al. 2016) and majority of literature on megatrends has been published by practitioners. This literature states what impacts megatrends have on a general level. As megatrends should not be taken as granted and fixed terms which may limit company's foresight ability, this study aims to instigate scientific discussion on how megatrends are perceived by SME's. More precisely, we illustrate how SME's utilise networked risk management in preparing for megatrend driven changes in their operational environment. In doing this, we propose a framework which illustrates the connectivity of the companies in different phases of the risk management process. This paper identifies and synthesises the relevant perspectives to networked risk management on how stakeholders contribute to risk identification, analysis and management in SMEs.

THEORETICAL BACKGROUND

Increasing pace of changes has contributed to a more complex business environment. These turbulent changes may represent challenges to companies and to manage these changes, risk management offers a systematic process to identify, analyse and manage risks. In particular, risk identification is often considered a crucial part of the risk management process as risks that are not identified, cannot be addressed in the next stages of risk management. In identifying changes, megatrends can offer valuable clues to risk identification. However, academic literature on megatrends is limited (Retief et al. 2016) and mainly focuses on defining the term, not its implications.

Megatrends and SME's

In recent years a body of practitioner literature has emerged providing reports of different megatrends. Although this literature is not peer-reviewed, it can offer insights on what megatrends global consulting and accounting and management firms evaluate to be important in the likely future. Due to limited academic literature on megatrends, our search focused on internet search engines rather than academic databases. By creating a matrix from megatrends listed by following authorities: OECD (2016), Sitra (2017), EY (2017), PWC (2016) and European Environment Agency (2015) consensus was identified among megatrends in which at least three identified the megatrend. Megatrends were further categorized into economic, social, technological and environmental changes. Chosen megatrends are listed in table 1.

Categories	Megatrends
Economic	Shared economy & Resource Scarcity
Social	Urbanization, Aging population & Globalization
Technological	Robotics, Automation, Digital Platforms, 3D printing, Augmented Reality, Cyber and Cloud security, Industrial Internet, Big Data and Analytics, Simulations
Environmental	Climate Change

Table 1 Identified megatrends

Besides having significant impacts in the society and businesses, megatrends are complex, unpredictable and extensive in their impact, they require skill to understand (Mittelstaedt 2014). Indeed, some megatrends can be overloaded with meaning and fail to transport clear information of the phenomena itself resulting megatrends to become meaningless and therefore a deeper understanding of the phenomena is required to assess the impacts of the megatrend (Goeddeck et al. 2013). As megatrends require skill to understand and it is crucial to acknowledge the importance of assessing their impacts, SME's may struggle with these as they have a tendency of having limited resources and structural features, which may limit the process of assessing impacts.

Risk management in SME networks

In theoretical literature risk management is defined as an iterative stage-gate process. Risk management is a process of identifying, analysing and managing risks by control and treatment. (Vilko 2012, Verbano et al. 2013). Firm size is suggested to be an important precondition for risk management and limited resources and structural feature such as lack of time, financial and human, limited risk management skills and inadequate management knowledge and training, may hinder SMEs' risk management process (Wong 2005; Alquier et al. 2006). Furthermore, financial constraints may limit adaptation of formal RM approaches such as econometric models, management accounting techniques, reporting

standards and control systems, as they can be too costly and complicated for SMEs (Gao et al. 2011). Therefore, SME risk management process may differ from the process introduced by theoretical literature and be an informal and unsystematic process.

As identification of change implications is crucial and if changes are not recognized by the entrepreneur, it may be that the issues will not be addressed in risk management. However, networks have potential to aid SMEs in the risk management process as networks have potential to provide firms an access to information, resources, technologies, markets, innovation, performance and other benefits (Gulati et al. 2000). In fact, networking can compensate SMEs' limited resources and structural features through exchanging information, identifying problems and managing conflict (Packalen 2007). In risk identification SMEs may utilize external consultants (Spedding & Rose 2008), however there is a lack of empirical studies how the external stakeholders partake risk identification process in SMEs. In risk evaluation entrepreneurs may acquire information from informal trust-based networks for risk framing (Herbane 2010) and from more formal contract-based networks SMEs may receive aid from insurance companies to analyse risks more systematically (Gao et al. 2013). Similarly to risk identification, in risk analysis it is unclear whether other network members contribute to the risk analysis process (Falkner et al. 2015).

In risk management (control and treatment) stage formal networks may provide a means to obtain valuable information and necessary resources (Kim et al. 2014), for example contracts with insurance companies, although focused on protection of financial losses, may be beneficial by obliging the entrepreneurs to examine risks more systematically (Falkner et al. 2015). Besides formal networks, maintaining an informal network of contacts can be beneficial in ensuring business continuity by nurturing existing customer relations and potentially attracting new customers (Gilmore et al. 2004). Furthermore, informal networks may provide an access to advice, skills and additional resources (Kim et al. 2014). Thus, by tapping into informal networks, entrepreneurs may be able to make more informed decision after receiving knowledge and advice from their informal networks. Information shared in formal and informal differs as formal network communication is concerned with issues such as the quantity and data of a product where as informal network information exchange is rather tacit and holistic (Uzzi et al. 1997).

METHODOLOGY

Qualitative and explorative research design was employed to establish an understanding of megatrend perception, risk management and different stakeholder groups' contribution to risk management process. Case study approach was employed to study a contemporary phenomenon in its operational context and was considered appropriate to serve the explanatory nature of the research (Yin 2008).

Empirical data was collected by means of semi-structured interviews and stakeholder analyses. Interviews were mainly conducted with the entrepreneurs or managerial level personnel who are in charge of daily business as they were evaluated to be suitable informants being experts of their business and having insights on the industry. Identification of different stakeholders begun by utilizing value mapping tool by Bocken et al. (2013) which contributed to establish an understanding of different stakeholders in networks and their proximity to the firm. Next, the same stakeholders were further examined and categorized with stakeholder analysis tool, which was prepared according to the procedure by Eden and Ackermann (1998) by assorting stakeholders on a commitment versus influence grid, a two-by-two matrix. In combination, these tools established an

overall understanding of the stakeholder networks and their roles.

Cases were selected on information-oriented selection in order to maximize the empirical data (Flyvberg 2011). The selected cases reflected a variety of different SMEs operating in different sectors. Detailed respondent information can be found from Table 2.

Company	Company size	Industry	Position of informant	Sales 2016 (€)	Customers
Company A	Micro (1)	Wellbeing services, dietary supplement retailing	Entrepreneur	30 000	B2B & B2C
Company B	Micro (2)	Entertainment and activity services	CEO	-	B2B & B2C
Company C	Micro (5)	Restaurant and catering services	Entrepreneur	650 000	B2B & B2C
Company D	Micro (7)	Machining and metal product design and development	Entrepreneur	720 000	B2B
Company E	Micro (9)	Bakery and cafeteria services	Entrepreneur	850 000	B2B & B2C
Company F	Small (10)	Bakery and cafeteria services	Entrepreneur	700 000	B2B & B2C
Company G	Small (40)	Sports equipment and small machine retailing	Business controller Marketing manager	14 000 000	B2B & B2C
Company H	Small (47)	Transport and logistics services, wood chipping processing	Director of development	4 800 000	B2B
Company I	Medium (50)	Sports entertainment business	CEO	5 200 000	B2B & B2C
Company J	Medium (65)	Vehicle sales and maintenance	Marketing manager	45 000 000	B2B & B2C

Table 2 Respondent information

The interviews were personal face-to-face interviews with open-ended questions. The interviews were conducted during spring 2018 and the average length of the interviews was 75 minutes. Participants were asked to reflect on the impacts of aforementioned megatrends from which most significant impacts were utilized to further questions risk management process to these changes and investigate the network contribution.

Content analysis was employed for data analysis which begun by listening and transcribing the interviews. Then the transcribed data was uploaded to a qualitative data analysis software, which enabled coding the empirical data into nodes and managing the data within the software. Empirical data was coded into nodes from which some were based on the theoretical framework of the research and some nodes arose from the data itself. Next, the nodes were grouped into categories and further into themes.

ANALYSES AND RESULTS

The perception of megatrends varied significantly among companies. In some cases megatrend impacts were not perceived or megatrends were perceived positively, negatively or both. In cases where megatrend-related changes were not perceived they were not considered as risks. Besides the entrepreneur itself, different stakeholders were used to aid in this process and to evaluate what true impacts megatrends can have.

The stakeholder analysis revealed several formal and informal stakeholders in the networks of the firms. Formal network members were considered connected to business activities and being important part of business. These formal network members include stakeholders such as financier, business partner, accountant office, supplier and employees. Other mentioned stakeholders were industry alliance and consultant. Informal network member were regarded as not so closely

related to core business and were trust-based. These stakeholders included other entrepreneurs, personal contacts, competitors, recreational groups, political parties, inner circle and social media.

In risk identification formal network members aided the risk identification process by offering and access to information. Information was gained through conversation with suppliers, observations from colleagues, speculations with suppliers, information exchange with B2B customers offering information on their state of business and political parties. Besides information access, SMEs received also advice from their formal network members by sparring with importers and benchmarking with competitors. Informal network relations also provided an access to information by information exchange with competitors, inner circle, recreational groups and speculations with competitors. In particular, personal contacts were considered an important source of gaining new perspective as well as other entrepreneurs and competitors. Information exchange with competitors was considered in some cases highly important. Besides information access, informal network members also provided advice for SMEs by benchmarking with other entrepreneurs and developing and testing new ideas with personal contacts. Speculations and somewhat rumours were also gained from word of mouth communication. In risk identification the focus of the SMEs was to gather as much information from a wide perspective which was further combined and constructed by the entrepreneur to form conclusions.

For risk analysis information on financial issues was provided by accountant office and advice for financial issues were gained from consultant. For analysing risks also importers provided in some instances information. Informal network members also offer access to information through information exchange with other entrepreneurs, recreational groups and inner circle. Other entrepreneurs also partook on exchanging opinions. Experience-based knowledge was received from competitors as well as benchmarking. Other entrepreneurs, personal contacts and competitors were regarded as valuable network members to help entrepreneurs see new perspectives. Personal contacts were in some cases useful for developing and testing new ideas as well. In risk analysis the focus shifted from the quality of the information on relevance and to assess the true impacts of the risks from which several network ties offered a variety of information.

In risk management stage fewer network members contributed to the process. On a specific issue an expert, such as accountant office or consultant, was regarded useful in cases which the resources found within the company were not adequate. Furthermore, in some cases firms utilize existing formal networks of customers in an attempt to ensure business continuity and in one case importer offered refundable purchase orders to minimise risk of unsold products. Risk management stage was mostly handled with resources found within the company such as joint pondering of actions with persons in charge and brainstorming of actions. In risk management entrepreneurs were very aware of the business risks and their own responsibility and therefore, tended to prefer own resources for risk management. Thus, the focus of risk management is on controlling these risks with resources found within the company.

By analysing the study result a framework (Figure 1) was intuitively built by to illustrate how the network connections contributed in different risk management stages. The framework was a collaborative contribution by researchers from three different disciplines, namely supply chain management, innovation management and risk management. The horizontal axis of the figures indicates the level of the connectivity in the network ranging from organizational actors own connection to wider network involvement. The vertical axis indicates the stages of risk management process from identification, analysis to management. The analysis

revealed that in the studied case the level of business relationship formality decreased along the risk management stages.

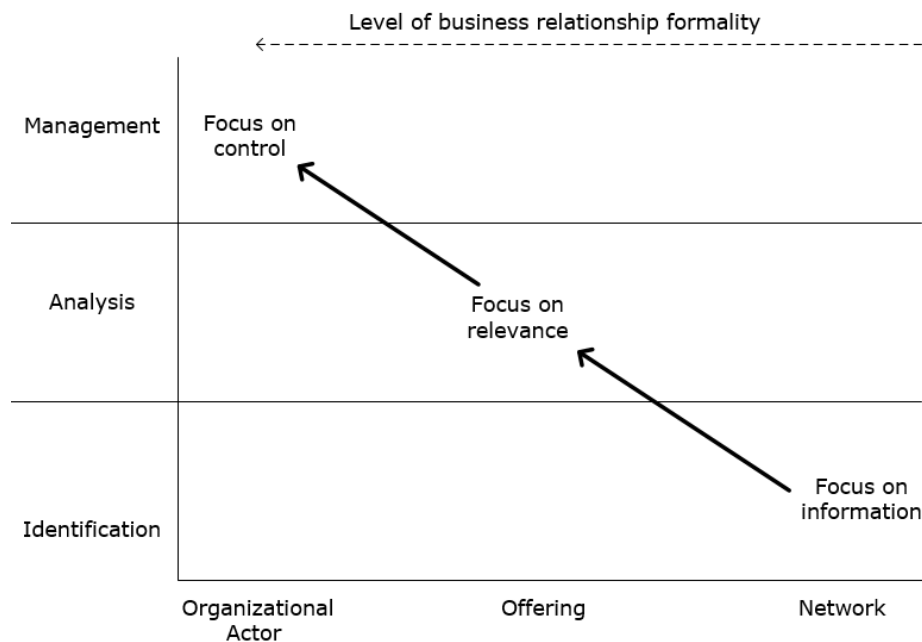


Figure 1 Network contribution to risk management process

CONCLUSIONS

The study reveals the differences of network contribution in different stages of risk management in megatrend driven changes. The risk identification requires focus on information amount and quality and firms utilize networks to gain information and advice from stakeholders. However, the full network potential may not be utilized as networks have potential to provide an access to resources, technologies and markets as well (Gulati et al. 2000). As the risk management progresses to risk analysis, fewer stakeholders are utilized which may imply of entrepreneurs acknowledging their responsibility of managing risks and therefore more formal stakeholders are utilized. Risk management process is handled mostly with organizational actors, which limit the control measures. As the focus of risk management is on control, organizational resources are seen most suitable which may reflect on the responsibility entrepreneurs' sense and tend to favour stakeholders closely proximate to the firm.

The study results help better to understand the SME risk management and how networks are utilized in change-related risk management. For example, instead of controlling risks, some firms seemed to benefit from focusing on solutions and flexibility with their network partners. By utilizing more stakeholders in risk management, entrepreneurs may be able to increase the variety of actions to manage risks, besides knowledge transfer which is regarded as the primary goal of networking. Taken into consideration the versatile networks case companies possess, the full network potential is not been utilized and only knowledge transfer is seen as an important resources the network can provide.

The research follows a qualitative case research approach with a small number of companies in a limited geographical area, which limits the generalizability of the results.

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FOOD SUPPLY CHAIN VULNERABILITY: A REVIEW OF EMERGING CHALLENGES AND RESPONSES

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ABSTRACT

Purpose: Increasing globalisation and pressures to reduce costs and improve efficiencies have increased food supply chain complexity. This has given rise to conditions that increase food firm vulnerability to both food fraud (for economic gain) and attack (for psychological or ideological reasons), (van Ruth, *et al.* 2017; Spink *et al.*, 2017). Thus it is timely to review food defence initiatives across a number of countries to determine the feasibility of incorporating specific food defence measures in supply chain risk management systems.

Design/methodology/approach: Due the emergent nature of the challenges associated with food defence grey as well as academic literature were reviewed. Based on an initial scan of the literature (academic, grey and open) specific search terms and keywords, key authors, key institutions (e.g. European Food Safety Authority (EFSA), FDA, WHO) and key publications were identified. Terminology used was also scanned across social media platforms (in particular Twitter). This informed the key words used in a systematic review of literature using the following databases Google Scholar, Science Direct, Web of Science, EBSCO (business complete) and Scopus and the searches were extended to non-peer-reviewed publications. The "grey" literature included publications by companies involved in food safety training, industry magazines, white papers, publications of standards groups such as GFSI, SSAFE, GMA and the BRC, regulatory authorities and online blogs and websites.

Findings: The development of food supply chain defence initiatives is at an early stage and represents an area of on-going activity and trial. A review of such initiatives identifies key strategies (deterrence; detection; control and countermeasures), increased and ongoing effort to develop rapid tests, and vulnerability assessment tools developed within a regulatory framework. This review points to the need for ongoing development of food supply chain actor capacity to use vulnerability tools and associated databases and to embed fraud/threat defences into their management processes.

Value: A number of factors combine to increase the challenges posed by food fraud and attack in this decade. This study aims to contribute to emerging research by exploring the context, considering key characteristics of food fraud/attack and evaluating responses by companies and regulatory authorities, in the context of resilient supply chains. As such it may be of interest to researchers, policy makers and food supply chain actors.

Research limitations/implications: This paper is limited to the review stage of a larger research project.

Practical implications: In addition to providing an evidence base to underpin the development of a more food resilient food supply chains, this study aims to raise awareness and knowledge about the challenges posed by fraud/attack.

INTRODUCTION

Increasing globalisation and pressures to reduce costs and improve efficiencies have increased food supply chain complexity. This has given rise to conditions that increase food

firms' vulnerability to adulteration of products through both fraud (for economic gain) and threat (for psychological or ideological reasons), (Moyer et al., 2017; van Ruth et al., 2017). Adulteration is the deliberate addition of, or alteration to, an ingredient in a food product for malicious reasons (Moyer et al., 2017). Thus, the concept of adulteration implicitly involves the question of the actor's intention and motivations. By contrast, contamination – which is the focus of Food Safety and Food Quality - is accidental and may not involve deliberate actions by any human or organisational actor in the production network or chain. Researchers, policy makers and supply chain stakeholders have distinguished between two categories of motivations for adulteration (GFSI, 2014); economically-motivated adulteration; and ideologically-motivated adulteration. Responses to prevent, deter, detect, or mitigate the effects of these two categories of motivation have been correspondingly named "Food Fraud" and "Food Defence" (or "Food Threats"). These concepts extend beyond Food Safety and Food Quality, which are concerned with unintentional actions that endanger or contaminate the food supply, because food fraud and food threat are the result of intentional action on the part of malevolent or criminal actors (see Figure 1).

Based on a systematic review of literature in the field, this paper aims to establish conditions contributing to the emergence of these challenges, current responses to these threats and the underlying assumptions, principles and processes. The paper is structured as follows: (i) the next section defines and describes both food fraud and food defence, (ii) this is followed by a methodology section that outlines the systematic literature approach adopted, (iii) the findings of this review are reported in the following section and (iv) the paper concludes with a discussion of these findings and puts forward suggestions for future work.

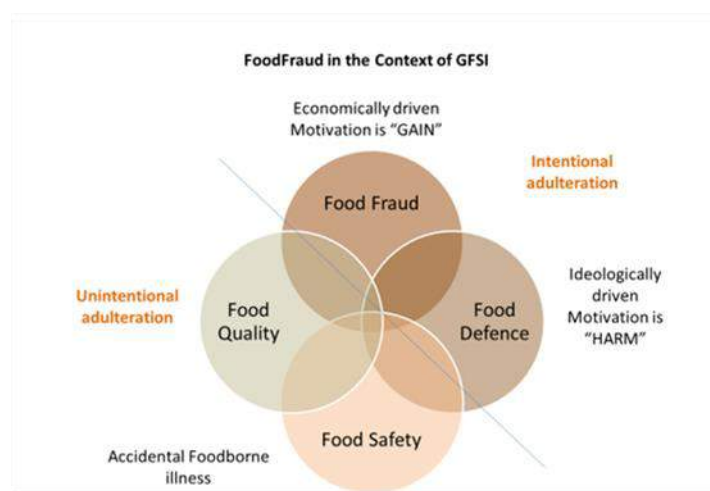


Figure 1 Food Fraud - adapted from GFSI (2014)

DEFINITIONS – Food Fraud and Food Defence

Food Fraud encompasses a wide variety of intentional actions, motivated in one way or another by the potential for economic gain, or – less frequently perhaps - to avoid economic loss. Thus, most cases of food fraud involve the substitution of a relatively expensive ingredient with a less expensive one at some point in the supply chain, and consequent monetary gain for that intermediary supplier. In some other cases an ingredient that was temporarily unavailable or in short stock may be substituted because the processor wished to satisfy a contract or to maintain an established supply relationship. We may also distinguish between two categories of food fraud, which have been termed "intrinsic" and "extrinsic" (Manning, 2016; Manning and Soon, 2016), although not all cases can be clearly categorised as one or the other. Intrinsic frauds involve the material substitution of an ingredient – for example "filling" dried oregano herbs with olive or myrtle leaves (Black et al., 2016). Extrinsic frauds, by contrast, are those that misrepresent "extrinsic" properties of an ingredient, for example whether it is of organically-certified origin (Megget, 2018), has PGI/PDO certification (Marks and Paravicini, 2017); or is produced in conformance with special rules and conditions, such as being halal (McElwee et al., 2017). Many extrinsic frauds are also classified as being cases of mislabelling – this was the most frequently reported classification in the EU Food and Feed Alerts (RASFF) database in 2017. EMA (Economically Motivated Adulteration) has emerged as a term to cover not just deliberate adulteration but also misrepresentation of foods for economic gain and thus covers a range of fraud activities.

Food Threats – and the response to these, termed “Food Defence¹”- are cases of adulteration that are motivated by ideological, political, or personal factors. These range from large-scale adulteration for ideological/political reasons – sometimes termed “bio-terrorism”, or “agro-terrorism” – to those arising from much more local reasons of personal animus or enmity, most typically actions by a disgruntled employee aimed at damaging the economic or reputational position of their employer. While much attention and research, especially in the USA, has focussed on the first type of food threat (Mitenius et al., 2014), documented incidents of that kind have been extremely rare, with the most prominent being the Oregon salad-bar attacks in 1984 which were motivated by political conflicts at the local-government level (Török et al., 1997). By contrast, the second type, arising from personal grievances, have been quite common and widely reported across different industry sectors and geographic regions (Mitenius et al., 2014).

METHODOLOGY – Systematic Literature Review

For this review we followed the general approach of Briner and Denyer (2012). However, we retained the general topics of Food Fraud and Food Threats, rather than refining them to a specific research question, as those authors advocate. The reasoning for that decision was that these topics are currently under-researched and consequently knowledge is too unstructured for specification of questions to be feasible or productive. In addition, we wanted to review a wide range of research questions related to these topics covering descriptive accounts of incidents, theories on motivations and strategies, and practices (both extant and proposed) for managing the risks resulting from food fraud and threats. With that one exception we followed the steps specified in Briner and Denyer’s method as illustrated in Figure 1 **Error! Reference source not found..**

The set of search terms used are listed in **Error! Reference source not found..** These terms were chosen based on initial scanning of the literature, and also because they were “statistically unlikely phrases”. Searches were made in multiple databases: Science Direct, Web of Science, Scopus, EBSCO², and AgEconSearch. The results of these searches are shown also in **Error! Reference source not found..**

Initial selection screened for relevance, e.g. excluding articles on the details or refinement of analytical techniques. Secondary selection involved first merging references and removing duplicates. The next step involved retaining only those articles with non-zero citation counts, based on Google Scholar data. Finally, the uncited articles were reviewed for quality and those which the authors judged to be authoritative (e.g. published by a competent authority or noted author), topical, or otherwise novel were retained.

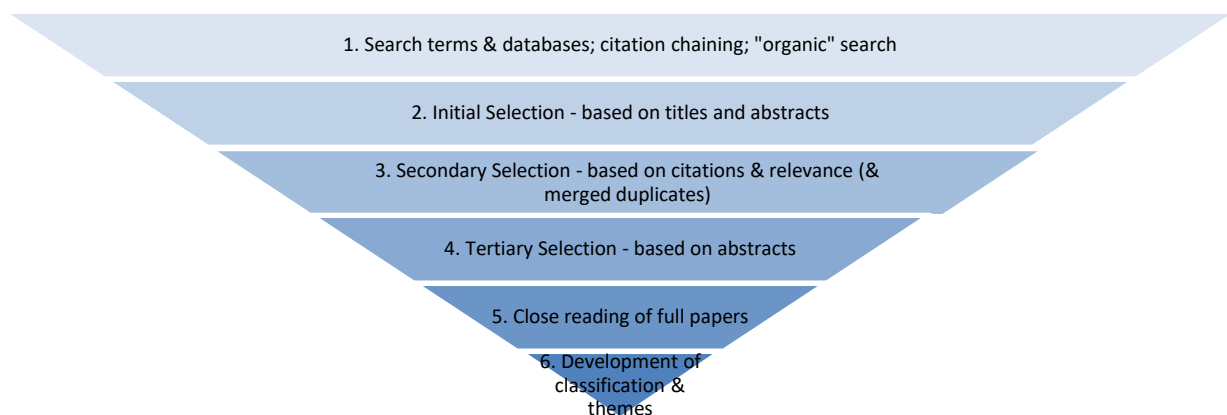


Figure 1 Search & Selection Process

¹ We use the UK spelling, although most of the literature on Food Defence/Defense originates in the USA.

² For EBSCO we choose to search the following sub-collections: Academic Search Complete Business Abstracts, Business Source Complete, eBook Collection, Readers' Guide, Regional Business News, Social Sciences Full Text, SocIndex, UK & Ireland Reference Centre.

Subsequent to selection a number of practices advocated by Briner and Denyer were used to expand the set of resources and to increase its comprehensiveness. These included "citation chaining", working forward from the most cited papers to identify newer citing articles; and working backwards from the references of the most-cited articles. Explicit searches were also made for additional items, e.g. in the forms of presentations and reports by the most-cited authors, and in the archives for those journals with the most articles in the original corpus. Finally, as this is an emerging area of interest, the "grey" literature was deemed important (Adams et al., 2017). Additional articles were collected through what could be termed "organic search", for example ones recommended by experts and colleagues, ones publicised on social media (Twitter) by a list of authorities that had been compiled, and finally by searching the web-sites of organisations known to be actively working on the topic, such as GFSI, BRC and SSAFE. At the end of this stage 509 items were retained, categorised as follows: 304 cited articles; 118 uncited but relevant; 87 'organic' (incl. grey literature).

Table 1 Search terms & statistics

Search Terms	Science Direct	Scopus	Web of Science	EBSCO*	AgEcon Search
food AND fraud	8577	6442	8542	4729	18
"food fraud"	347	594	179	431	0
"food Defence"	173	352	79	140	8
"food defence"	42		15	11	1
"food threat"	19	27	4	22	0
"economically motivated adulteration"	117	377	64	52	0
"supply chain resilience" AND food	45	208	8	8	0
"supply chain vulnerability" AND food	41	177	5	8	0
"vulnerability resolution initiative"	0	0	0	0	0
TOTAL	784	1735	354	672	9

Tertiary selection involved review of the full metadata for the 509 articles and reading of the associated abstracts. In this stage selection was again based on relevance (e.g. excluding consumer studies, and papers on methods for predictive modelling), timeliness (noted but deleted historic/archival articles), appropriateness (e.g. supply chain risk management/resilience), and quality (e.g. short commentaries). In addition, the process of developing themes to summarise this body of research knowledge was begun at this stage. At the end of tertiary selection 180 articles were retained, which were then divided out among the research team for close reading and for analysis using the initially developed set of themes. The output of the final (close-reading) stage was, (i) a set of themes and (ii) thematic assignment of the corpus of articles.

FINDINGS

Motivation – rational behaviour (for a criminal mind)

From a motivational perspective fraud/threat differs fundamentally from food safety and quality. Most authorities on food fraud/threats, e.g. Spink et al. (2013, 2016, 2017) in relation to fraud and the WHO (2002) on defence, have argued that these activities differ markedly from the type of issues that are familiar to producers in relation to Food Safety. They argue that in food safety one seeks to control frequently occurring events, that arise from natural sources such as contamination or processing errors, and therefore the focus of controls is in identifying the most important (or critical) risks, and then initiating responses that reduce the likelihood and consequences of those risks. HACCP (Hazard Analysis and Critical Control Points) is the primary example of such an approach. Risks and likelihoods of this kind are identifiable, enumerable, and quantifiable because, they are internal to the processing unit and, being frequently occurring, are amenable to data collection on their context, causes and overall likelihood. By contrast, in the case of fraud/threat vulnerabilities may have never occurred before, may never occur again, or

may be a potential opportunity that never leads to an actual event. It is such vulnerabilities –“weakness[es] or flaw[s] that create[s] opportunities for undesirable events” (Spink et al., 2017:216)– that matter when developing countermeasures against fraud or threats, and these vulnerabilities can be assessed only qualitatively in terms of likelihood and consequences, i.e. “the susceptibility of the system” (Spink et al., 2017:216). Some aspects of a vulnerability assessment may of course be aided by quantitative data sources (e.g. commodity prices movements) and it is suggested that these are incorporated in response strategies (FSA and NSF, 2015).

Spink et al. (2017:216) further argued that the management of fraud (and, by extension, of threats) “necessitates a shift of the focus of countermeasures and control systems from intervention and response [i.e. mitigation] to prevention”. Here, he defines (from ISO standards) “mitigation” as “countermeasures ... to reduce the consequence of the event”, where those events arise from “risks that cannot be eliminated” (Spink et al., 2017:217). He defines as countermeasures “intended to reduce or eliminate the likelihood of the event occurring”, and thus prevention “focuses on identifying and eliminating or reducing vulnerability”. In summary, therefore, the argument made in the research on Food Fraud and Food Threats is that countermeasures against these risks should be based on prevention of the causes of such events, i.e. by assessing vulnerabilities; whereas countermeasures in the field of Food Safety are based on mitigating the consequences of risks to safety of the product, by assessing risks especially at critical points in the production process (Spink et al., 2017:217).

Response – think like a criminal

Given this motivation, responses focus attention on the conditions that lead to fraud/threats, with assessment tools designed to address motivations and opportunities to commit such offenses and responses are designed to detect and respond to them (Manning and Soon, 2016; van Ruth et al., 2017). Thus, in very broad terms, these responses can be described as strategies based on:

- Deterrence;
- Detection;
- Control and Countermeasures.

These strategies seek to shift the balance from low risk of detection and good opportunity to profit illegally to high risk of detection and strongly negative consequences of such for the perpetrator. The food fraudster’s attention is focused on market signals such as price-spikes or increasing demand for a commodity and the potential opportunity to act which is dependent on issues such as complexity of supply chain or availability of technology and knowledge to adulterate, and thus they seek to identify areas where the chances of detection and/or consequences if detected are low. Thus strategies to combat this seek to enhance horizon scanning to detect candidate products/ingredients and improve visibility and information sharing. Similarly, terrorists are attracted to opportunities to act where they have impact. On the other hand, they may be less concerned with detection after the event, but are concerned about surveillance while planning. Thus, strategies to respond are also informed by horizon scanning, visibility and information flow.

Vulnerability – identifying weak points

Although other states and regions are developing law in relation to fraud and threat (Mol, 2014; Walker, 2017; Zhang and Xue, 2016), almost all of the extant research is concerned with the US or the EU. In the US, the overarching piece of law concerning fraud and threat is the Food Safety Modernization Act (FSMA), signed into law in 2011. This is considered to be the most significant reform of Food law in the US since 1938 (Layton, 2009). In particular, in its provisions on “Preventive Controls”, it addresses “preventing intentional adulteration from acts intended to cause wide-scale harm to public health, including acts of terrorism targeting the food supply”. While the main focus of the law is on food threats, it now incorporates requirements for similar preventive strategies against economically-motivated adulteration (food fraud). Specifically, it requires vulnerability assessments against food fraud: events that could lead to a “hazard that requires a preventive control” from an act that is “economically motivated” (Spink and Moyer, 2017:58).

In the EU the central law is Regulation (EU) 2017/625, which updates the earlier Regulation (EC) 178/2002. The 2002 regulation established the European Food Safety Authority (EFSA) and placed the HACCP process at the centre of food safety practice. The 2017 regulation, developed in the wake of the horse meat fraud (Elliott, 2014) added provisions against what it termed “fraudulent or deceptive practices along the agri-food chain” and required the relevant national authorities to take account of “potential risks and the likelihood” of such events occurring. In addition, it encouraged the development of cross-national information sharing, which have subsequently been implemented through mechanisms such as RASFF and European Food Fraud Network (EFFN).

In response to this a range of industry standards have been developed or adapted (given the limitations of established food quality assurance process (e.g. HACCP) to equip food supply chain actors to respond to these challenges). Such standards specify processes and tests that food business operators and auditors can use in practice to identify and resolve fraud- or threat-related - vulnerabilities in their production systems. Over the past two decades private organisations (e.g. BRC, SQF) have developed internationally accepted quality assurance standards. These standards, which usually seek accreditation from established global bodies (e.g. ISO, GFSI), require certified food supply chain actors to employ various processes and methods which in turn are audited. In recent years the processes required (e.g. HACCP) have been adapted to include measures that respond to food fraud and treats. While these measures in turn differ somewhat they all include a vulnerability assessment tool that assesses level of opportunity and motivation and adequacy of control measures. These tools are largely self-assessment with links to databases (e.g. commodity prices, fraud/threat incidents such as USP and RASFF) to support horizon scanning. Figure 2 illustrates the role and relationship between accreditation and certification within the overall international and national legal context.

In response of the proliferation of schemes at the Certification level in relation to food safety, and the consequent burden of regulation and auditing on businesses (Kleboth et al., 2016), efforts were initiated by industry actors to create more loosely-specified and more encompassing schemes, that would accredit the various “Standards” developed and promoted by the Certification bodies. Most prominent among these are the Global Food Safety Initiative (GFSI), established in 2000, under the auspices of the Consumer Goods Forum (CGF, then CIES), a group comprising of major international food manufacturers and retailers. One of this initiative’s major goals was to reduce redundancy of audits, so that a producer could be “certified once, accepted everywhere” (van der Meulen, 2011:116). A second accreditation body is the International Standard Organisation (ISO), which developed a food safety standard ISO 22000, supported by the multi-national food producers, i.e. the “big brand holders” (van der Meulen, 2011:132). However, the retailers were slow to accept and adopt ISO 22000, and so a new organisation was established, the Foundation for Food Safety Certification (FSSC) and this organisation developed a broader standard, FSSC 22000³, issued first in 2009. FSSC 22000 is among the standards accepted by GFSI. Thus GFSI has emerged as the dominant accreditation body. These standards, classified as ‘private law’ (van der Meulen, 2011), are based on a general “prevention and vulnerability reduction approach” (van Ruth et al., 2017:70) with a vulnerability assessment tool fundamental to their operation.

³ FSSC 22000 integrated ISO 22000, and additional module that was called PAS 220, issued first in 2008.

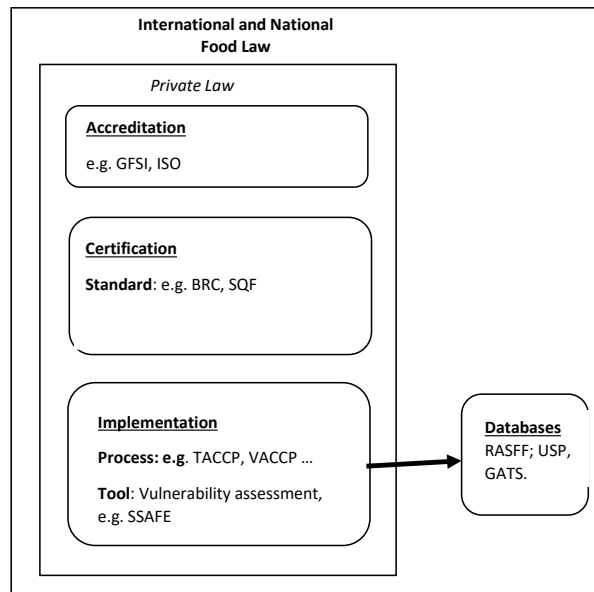


Figure 2 Accreditation and Certification Bodies

DISCUSSION AND CONCLUSIONS

Some key themes arise from this review: susceptibility, role of law and standards, and information flow. Food system susceptibility arises due to weakness/gaps that are identified and exploited by perpetrators intent on fraud/threat rather than vulnerability that we typically consider in the field of supply chain management, i.e. risk level and capability to respond. Hence response to fraud/threat focusses on weakness or gaps within the system, with an emphasis on prevention, rather than mitigation. The role of information flow is crucial to response strategies with a fundamental need for collaboration among food system stakeholders at various levels. Database development has been facilitated by both public agencies (e.g. EFFN in EU) and commercial concerns such as USP, based in the US, and FERA (horizon scanning) in the UK. An increased and ongoing effort to develop rapid testing methods (Ellis et al., 2015) has greatly enhanced surveillance of fraud/threat. This review points to the need for ongoing development of food supply chain actor capacity to use databases and embed fraud/threat defences into their management processes.

As evident from above, quality control and assurance processes fall short when dealing with fraud/threats, as suppliers intentionally set out to act opportunistically in their own self-interest and to the detriment of the buyer. For example, imposition of contractual penalties or reputational loss are not adequate penalties to deter those of a criminal or terrorist mind-set, rather legal frameworks can play a role. Indeed, deterrence as a strategy to control fraud and threat relies primarily on the State, by relying on it for "enforcing policies and regulations" (A. T. Kearney and GMA, 2010:19). Furthermore, the public nature of such prosecutions creates a less attractive environment for perpetrators, as does a visible response by supplier chain actors through use of risk assessment tools usually linked to industry level standards and associated processes. Activity to date also points to a role for 'private law' (i.e. industry imposed standards), since certification is a requirement for doing business in many contracts the non-conformant business is effectively excluded from such business relationships and may be forced to accept lower prices or more disadvantageous conditions. A non-conformant business consequently is positioned outside of, and excluded from doing business with, the whole group of conformant businesses. It is likely that the effectiveness of this will vary with the type of perpetrator, with a negative impact on suppliers seeking to 'cut corners' opportunistically and little impact on 'professional' criminals. While there has been reference to 'organised crime', many perpetrators may well be classified as 'rogue traders' rather than participants in 'organised crime' or, at the other end of the spectrum suppliers seeking to 'cut corners' opportunistically. Thus further research that classifies and measures the impact of different types of perpetrators is warranted. Moreover, large businesses, for example the large

multi-national food processors or retail chains that are the sponsors or members of the GMA (Grocery Manufacturers Association) or GFSI, can, by specifying conformance to their standards (which now include food fraud/threat defences), exert an influence that supports deterrence throughout the food supply chain.

ACKNOWLEDGMENTS

This work was supported by safefood (<http://www.safefood.eu/>) [grant no. 03-2017]

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Session 9: Transport and Distribution

ANALYSIS OF NORTHERN SEA ROUTE AND BALTIC SEA COMBINED SHIPPING COMPETITIVENESS FOR BULK SHIPPING: CASE OF POST 2020 SULPHUR REGULATIONS

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ABSTRACT

Purpose of this paper:

In this paper we aim to analyse various approaches for a small sized product tanker owner to utilize their existing ice class vessel from Baltic Sea in NSR shipping between Europe and Asia. We compare Northern Sea Route (NSR) operations with Baltic Sea operations rather than Suez Canal Route. We also aim to identify necessary freight rates for profitable NSR operations.

Design/methodology/approach:

This research relies on creating and testing a transport cost model which is a commonly used approach when analysing competitiveness of the Northern Sea Route (Theocharis et al., 2018). As recommended by Meng et al. (2017), we test various route combinations, various ports in Asia and high and low market conditions and different sailing speeds to analyse NSR competitiveness thoroughly.

Findings:

Yokohama appears most profitable option under 12 months full NSR scenario due to the greatest distance saving. Any type of NSR operations to Singapore appear not profitable. Utilizing one ice class and one open water vessel on 6/6 months combined shipping appears plausible and could bring savings up to \$200,000 per round trip compared to utilizing two ice class vessels. This holds true under both high and low market conditions.

Value:

This paper takes a new approach on analysing NSR competitiveness by considering existing ice class tonnage operating in the Baltic Sea. Results could encourage the use of existing tonnage for Arctic operations to achieve higher utilization for assets and competitive advantage.

Research limitations:

The results for bigger vessels, such as LR1 Panamax tankers might be more promising. Like so often, our model is a simplification of the reality and does not necessarily consider all variables or oversimplifies them and thus cannot fully reflect the reality of shipping operations (Lasserre, 2015).

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INTRODUCTION

The Northern Sea Route (NSR) has been a hot topic in academia and in business for past ten years. Lots of research has been conducted and especially the viability of the NSR supplementing or even replacing the traditional shipping route of Suez Canal (SCR) between Europe and Asia.

It seems to be confirmed that optimism related to NSR as an alternative to conventional Suez Canal route is exaggerated (Buixadé Farré et al., 2014) and Arctic Passages are not on their way of capturing significant shares of maritime trade from well-established Panama- and Suez Canals (Lasserre and Pelletier, 2011). The main driver for Arctic shipping companies is not merely the shrinking sea ice coverage or the theoretically shorter distances per se, but rather the market opportunities in the Arctic and the relevance of this to shipping companies' current business models (Lasserre et al., 2016). These opportunities seem limited at present.

During last few years things in shipping business have been changing fast: IMO has declared two major regulations for international shipping that could possibly increase the viability of NSR further. First, IMO has set a global limit for Sulphur in fuel oil used on board ships of 0.50% mass by mass from 1 January 2020 (IMO, 2016). Second, IMO's commitment to reducing GHG emissions from international shipping by reducing total annual GHG emissions by at least 50% by 2050 (IMO, 2018). Both of these environmentally conscious acts will have large impacts on global shipping as a whole and most notably the increase price of bunker prices seems inevitable.

In this paper we take a new approach to address the concerns of the increased capital cost of ice class vessels needed in arctic operations (Beveridge et al., 2016). We consider a tanker shipping company already operating in Baltic Sea where ice class vessels are needed during winter season. Thus, by expanding to Arctic during the summer, company can increase the utilization of its ice class vessel(s) rather than merely operating them on warm waters during off season. We also compare NSR profitability against Baltic Sea profitability rather than Suez Canal Route (SCR) which gives this study a new perspective on analysing competitiveness of NSR.

Bulk and tanker operations seem more suitable to NSR than containers for few main reasons: first, the inherent need for Just-In-Time (JIT) that container shipping faces is not that strongly present for bulk/tanker operators. Second, unlike containers, bulk/tanker operations are not run on liner shipping model but rather follow a port-to-port tramp or voyage charter model where contracts are made for single shipments on spot market. To best capture these elements, we focus on petroleum products trade with MR tankers.

LITERATURE REVIEW

Arctic sea ice modelling and ice forecasts

Ice cover in Arctic Ocean has been a subject of lot of research especially since concerns of global warming have risen. Sea ice in the Arctic Ocean is known to be on its minimum level at September and ice-free Arctic is considered to be the state where the ice coverage in arctic is less than one million sq.km. (Smith and Stephenson, 2013, Stroeve et al., 2007, Wang and Overland, 2009).

Stroeve et al. (2007) and Comiso et al. (2008) report that sea ice coverage decline from 1979 onward has been increasingly faster reaching nearly 10%/decade for September ice coverage. Stroeve et al. (2007) conclude that current state of arctic ice is up to 30 years

ahead of forecasts and that GHG load on Arctic sea ice is strong and growing. Authors predict Arctic Ocean reaching seasonal ice free situation somewhere between 2050 and 2100, while Smith and Stephenson (2013) make a daring assumption that vessels without any ice strengthening would be able to navigate NSR already by 2040-2059.

Wang and Overland (2009) documented September 2007 ice coverage in Arctic Ocean being 4,6 million sq.km at its lowest. Authors predict an ice-free Arctic in year 2037 basing their analysis on CMIP3 models under different emission scenarios. Authors also point out ice melting being approximately 10 years early due to global warming. Earliest projections suggested ice free arctic by late 2020's, latest in the end of 21st century, mean value being year 2037. Similar results were acquired in Wang and Overland (2012) arguing that most models run slow compared to recent observations when supplement their previous work with CMIP5 models. These estimates however are in contrary to those made by Vavrus et al. (2012) who argue seasonal ice free Arctic around 2070. Thus, it can be concluded that while researchers generally agree that ice in arctic is melting, speed of the melting is subject to wide range of estimates often very different from each other.

The Northern Sea Route

Container shipping has been deemed not suitable for NSR mainly because containerships operate under a Just-In-Time (JIT) system, which relies on precise schedules for operations from loading to unloading and reliability of operations (Buixadé Farré et al., 2014, Lasserre, 2015, Notteboom, 2006, Zhang et al., 2016a, Zhang et al., 2016b). Also, liner shipping industry is not driven only by the transport cost per TEU but also factors such as transit time, the reliability of delivery schedules and the value of markets along the way all play important role on liner shipping company's offering to its customers (Beveridge et al., 2016, Lasserre and Pelletier, 2011). For NSR navigation, required schedule reliability cannot readily be achieved (Beveridge et al., 2016, Erikstad and Ehlers, 2012). There have been suggestions however to limit the impact of delays, such as slow-steaming along NSR could provide a buffer for maintaining the schedule as if unforeseen delays occur the ship could then speed up and still arrive on time (Erikstad and Ehlers, 2012).

On contrary to the NSR, Suez Canal has many advantages for liner shipping. First, it provides access to multiple markets along highly populated coastal areas, most notably Jeddah, Dubai and Singapore (Buixadé Farré et al., 2014, Furuichi and Otsuka, 2015, Lasserre and Pelletier, 2011, Liu and Kronbak, 2010, Verny and Grigentin, 2009, Zhang et al., 2016a). Also, Suez Canal can accommodate larger vessels with draught up to 20 meters, Suez Canal offers greater predictability due to absence of ice and well-established infrastructure, as well as availability of maintenance and support when needed (Buixadé Farré et al., 2014). Accordingly, hub-and-spoke service via the Suez Canal with large amount of transshipment activities is the prevailing service type between Asia and Europe with growing ship size and cargo volume (Liu and Kronbak, 2010). Furuichi and Otsuka (2015) concluded that because of the economies of scale in container shipping, 4000 TEU container ships in NSR cannot compete with ultra-large (15,000 TEU) ships deployed via Suez Canal unless navigation season lasts for 225 days. Another obstacle of NSR operations often arising is the poor load factor if liner shipping is operated on NSR instead of Suez Canal (Beveridge et al., 2016, Lasserre, 2015, Zhang et al., 2016a). The low level of European exports could result load factor as low as 30% (Verny and Grigentin, 2009). Conducted surveys paint similar picture: it seems that the container industry is not interested in Arctic shipping. The constraints of Just-In-Time planning, schedule creation and risks are perceived as too big when comparing with what are perceived as relatively modest profits (Lasserre and Pelletier, 2011). Similar results were acquired by (Beveridge et al., 2016) who surveyed Asian shipping companies and concluded that especially container companies do not see potential in the Arctic operations.

Then there is the draught limitation. Ships navigating NSR are limited to maximum 13-meter draught due to bathymetry in Sannikov Strait. Avoiding this shallow strait would require sailing further north of the New Siberian Islands, but ships would in turn experience

shorter navigation seasons due to higher risk of unnavigability at higher latitudes (Stephenson et al., 2014). Further problems would occur as containerships require high stability due to high stacks of containers on deck (Zhang et al., 2016a).

Biggest operational obstacle in NSR operations is undoubtedly sea ice in the Arctic Sea as well as growlers (floating ice blocks of extremely hard multiyear ice) which are seen to pose a great threat to ship hulls even during summer season (Buixadé Farré et al., 2014, Lasserre and Pelletier, 2011, Meng et al., 2017, Verny and Grigentin, 2009, Zhang et al., 2016a). While sea ice is the main operational obstacle, the biggest financial obstacle is seen to be the capital cost related to building ice class vessels, and at lesser extent operating expenses (OPEX) related to operating ice class vessels (Beveridge et al., 2016, Lee and Kim, 2015). In addition, to operational and financial obstacles, there are also managerial obstacles such as container shipping that runs on fixed schedules should change the route twice a year and thus causing management and marketing complexity and less predictability for customers (Beveridge et al., 2016, Lasserre, 2015, Lasserre and Pelletier, 2011, Zhang et al., 2016a, Zhang et al., 2016b).

Unlike container ships which commonly have transshipment activities along the way, oil tankers usually carry out port-to-port transportation and thus seem more fit for seasonal NSR operations (Buixadé Farré et al., 2014, Lee and Kim, 2015, Zhang et al., 2016a). According to surveys by Lasserre and Pelletier (2011) and by Beveridge et al. (2016), reaction from bulk shippers is more positive than that of a container sector.

The official NSR fee varies in accordance with the ice class of each vessel, ice condition, sea area and navigation season (Furuichi and Otsuka, 2015), and more importantly, actual payable fee seems to be subject to negotiations between NSR authority and individual shipping companies (Faury and Cariou, 2016, Furuichi and Otsuka, 2015). Accordingly, Lee and Kim (2015) reported that actual fee payed by Hyundai Glovis for Panamax tanker on their pilot journey in 2013 was only slightly higher than that of Suez Canal. Erikstad and Ehlers (2012) accordingly report that the tariffs for the NSR transit have been negotiable down to 5 USD/t, which is a value been used in NSR literature calculations widely. Lasserre (2015) sees it likely that the practice of giving discounts on NSR fees will become permanent pricing method for Russian authorities, while Meng et al. (2017) anticipate the NSR transit fees to be maintained in a reasonable range to be competitive with Suez or Panama tolls.

Overall, an expansion in liner shipping to NSR over traditional Suez Canal route is unlikely in the near future (Schøyen and Bråthen, 2011, Theocharis et al., 2018, Zhang et al., 2016a, Zhang et al., 2016b), but given that bulk commodities are less sensitive to arrival dates and may be transported below deck as well as generally lower relative value of these goods, possible cost savings for fuel could appear as a driver to explore the NSR for commercial bulk transportation (Schøyen and Bråthen, 2011, Stephenson et al., 2014, Zhang et al., 2016b). NSR could be especially viable for small/medium sized tanker operators (Zhang et al., 2016a) and niche shipping companies (Schøyen and Bråthen, 2011). Accordingly, Wang et al. (2018) concluded that while it is very unlikely that large companies would switch their operations to the NSR, medium sized companies are much more likely to do so.

MODEL DESCRIPTION

In our paper we consider a model where shipping company is currently operating in Baltic Sea trade with one newly built 1A ice class MR products tanker. Company is planning to expand its operations and considering opportunities for small/medium sized tanker operators in the NSR as suggested by Zhang et al. (2016a). Similar methodology has been widely used in the NSR literature so far e.g. (Furuichi and Otsuka, 2015, Lasserre, 2015, Liu and Kronbak, 2010, Schøyen and Bråthen, 2011, Theocharis et al., 2018, Verny and Grigentin, 2009, Zhang et al., 2016a). We also follow recommendations made by Meng et al. (2017) who suggested different scenarios/cases to be set when modelling NSR operations, thus we test high and low market earnings scenarios from Baltic Sea operations

and various ports in Asia with various route combinations for vessels to take to cover the one full year of operations as well as different sailing speeds to see what option yields the best profit. For simplicity, we consider shipments were ship returns on ballast with equal speed and fuel consumption on both laden and ballast legs. We also assume unlimited demand and supply of cargoes.

On combined shipping scenarios 6 months/6 months and 4 months/8 months we consider the cases where one vessels in constantly trading on Baltic Sea while other one is trading with one of the Asian ports. In these scenarios, route to Asia is divided between NSR and SCR on yearly basis (see picture 1).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Vessel type
full Baltic	BALTIC	BALTIC	BALTIC	BALTIC	BALTIC	BALTIC	BALTIC	BALTIC	BALTIC	BALTIC	BALTIC	BALTIC	ice
	BALTIC	BALTIC	BALTIC	BALTIC	BALTIC	BALTIC	BALTIC	BALTIC	BALTIC	BALTIC	BALTIC	BALTIC	ice
full NSR	NSR	NSR	NSR	NSR	NSR	NSR	NSR	NSR	NSR	NSR	NSR	NSR	ice
	NSR	NSR	NSR	NSR	NSR	NSR	NSR	NSR	NSR	NSR	NSR	NSR	ice
full SCR	SUEZ	SUEZ	SUEZ	SUEZ	SUEZ	SUEZ	SUEZ	SUEZ	SUEZ	SUEZ	SUEZ	SUEZ	ow
	SUEZ	SUEZ	SUEZ	SUEZ	SUEZ	SUEZ	SUEZ	SUEZ	SUEZ	SUEZ	SUEZ	SUEZ	ow
6/6 combined	BALTIC	BALTIC	BALTIC	BALTIC	NSR	NSR	NSR	NSR	NSR	NSR	BALTIC	BALTIC	ice
	SUEZ	SUEZ	SUEZ	SUEZ	BALTIC	BALTIC	BALTIC	BALTIC	BALTIC	BALTIC	SUEZ	SUEZ	ice
6/6 combined	BALTIC	BALTIC	BALTIC	BALTIC	NSR	NSR	NSR	NSR	NSR	NSR	BALTIC	BALTIC	ice
	SUEZ	SUEZ	SUEZ	SUEZ	BALTIC	BALTIC	BALTIC	BALTIC	BALTIC	BALTIC	SUEZ	SUEZ	ow
4/8 combined	BALTIC	BALTIC	BALTIC	BALTIC	BALTIC	BALTIC	BALTIC	NSR	NSR	NSR	NSR	BALTIC	ice
	SUEZ	SUEZ	SUEZ	SUEZ	SUEZ	SUEZ	SUEZ	BALTIC	BALTIC	BALTIC	BALTIC	SUEZ	ow
nsr 6 + baltic	BALTIC	BALTIC	BALTIC	BALTIC	NSR	NSR	NSR	NSR	NSR	NSR	BALTIC	BALTIC	ice
	BALTIC	BALTIC	BALTIC	BALTIC	BALTIC	BALTIC	BALTIC	BALTIC	BALTIC	BALTIC	BALTIC	BALTIC	ice
nsr 4 + baltic	BALTIC	BALTIC	BALTIC	BALTIC	BALTIC	BALTIC	BALTIC	NSR	NSR	NSR	NSR	BALTIC	ice
	BALTIC	BALTIC	BALTIC	BALTIC	BALTIC	BALTIC	BALTIC	BALTIC	BALTIC	BALTIC	BALTIC	BALTIC	ice

Picture 1: All considered vessel routing combinations

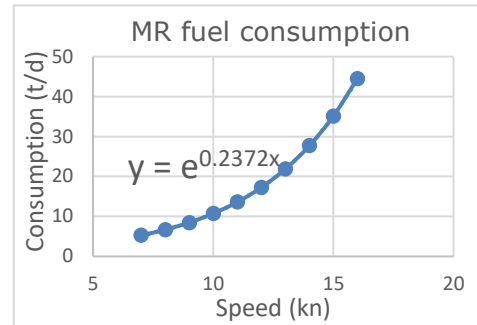
Navigational parameters

According to Eurostat data, Rotterdam handles most liquid bulk cargoes of European ports (216,130 thousand tons in 2016). Also, ports in North-Western Europe account for approximately half of all liquid bulk goods exports from European Union. Thus, Rotterdam with its central location seems the best fit for our modelling purposes and is chosen as departure port for all cases. Four destination ports are considered when analyzing the NSR operations: Yokohama in Japan, Busan in South-Korea, Shanghai in China and Singapore.

Port distances are estimated by authors based on values used in existing literature. Distance between Rotterdam and Yokohama is assumed 7,200nm via NSR and 11,400nm via SCR. Busan is assumed 8,000nm and 11,000nm, Shanghai 8,500nm and 10,500nm respectively while Singapore is assumed 10,600nm via NSR and 8,600nm via SCR thus being only destination where distance via Suez Canal is shorter than via NSR. As different speeds are applied for different parts of voyages on NSR, we consider the length of NSR to be 2,200nm and sailed with speed of 9.37kn as in Zhang et al. (2016a). For parts outside of NSR, two speeds are considered: 15kn and 12kn to examine profitability under high and low market conditions. Port time per voyage is assumed to be four days as used in calculations by Worldscale Association (2018), and Clarksons Research (2018b). However, as we consider shipments were ship returns on ballast, no port days are considered for return voyage. Port fees also occur twice on each voyage: once on loading, once on unloading and are assumed at 30,000 USD per call. For Shipments using Suez Canal, extra day is added to cover canal transit.

Operational expenses and parameters

Fuel consumption is estimated by authors based on estimations by Clarksons Research (2018a), Poten & Partners (2015), and Stopford (2009). For ice class vessel fuel consumption is assumed +5.1% more as suggested by Erikstad and Ehlers (2012) and used by Faury and Cariou (2016) when modeling NSR operations for Panamax tanker. In the case of open water MR products tanker, consumption at 12kn is assumed at 17.2tn/d and for 15kn assumed at 35.1tn/d. Consumption is assumed exponential following ($y = e^{0,2372x}$) curve.



Picture 2: Fuel consumption estimate

As reported by DNV GL (2016) the experiences from the SECA areas show that most operators have decided to switch to low Sulphur MGO, with minimal adoption of scrubbers. We thus assume fuel oil to be compliant low Sulphur fuel oil and price of \$523.31 per ton is derived as a global average from Worldscale Association (2018).

For fee calculation purposes, we use a sample ship to drive the necessary information. German Tanker Shipping GmbH & Co. KG owned 1A ice class MR products tanker MT "Seatrout" was selected for this purpose. SCR fee is calculated based on vessels Suez Canal Net Tonnage using the online calculator (<https://lethagencies.com/egypt/calculator-suez>). MT "Seatrout" has SCNT of 24000, which gives average Suez Canal fee of 168,618 USD. NSR fee is assumed as \$5/gt as suggested by (Erikstad and Ehlers, 2012, Falck, 2012, Furuichi and Otsuka, 2015, Zhang et al., 2016a). Seatrout's gross tonnage 26,500 which then gives NSR fee equal to 132,740 USD per direction. This fee corresponds well to Lee and Kim (2015) who reported that Hyundai Glovis negotiated NSR fees similar to those in Suez Canal Route for Panamax tanker.

OPEX for newly built MR products tanker is estimated by authors from Richard (2017), and Stopford (2009). We use an approach where we consider OPEX as a single cost element with 20% premium as suggested by Faury and Cariou (2016), Schøyen and Bråthen (2011), and Zhang et al. (2016a). OPEX for open water vessel is calculated as \$2,52 million annually and for ice class vessel we assume \$3,03 million. Capital cost of an OW ship is adopted from Clarkson's data where average price for a new MR tanker is \$34,9 million. We then consider 6% interest and 20-year straight line depreciation as suggested by Lasserre (2015) and Stopford (2009). This then yields annual capital cost of \$1,85 million for open water vessel. For ice class vessel we assume +20% more capital cost, as suggested in Lasserre (2015), Liu and Kronbak (2010), Schøyen and Bråthen (2011), and Zhang et al. (2016a). Annual capital cost of an ice class vessel thus rises to \$2,22 million.

ANALYSIS AND MODEL RESULTS

We consider two different sources of revenue: first, on all combined shipping models one ship is assumed operating at Baltic Sea spot trade and income is measured as daily earnings. Daily earnings are assumed under \$10,000 and \$15,000 scenarios to test low and high market scenarios. Second, freight on Asian trade per round trip is considered. On Asian operations we assume return on ballast with equal speed and equal consumption compared to laden voyage and thus freight revenue is considered per round trip basis rather than per voyage basis. No ice premium is considered for any revenue or earnings.

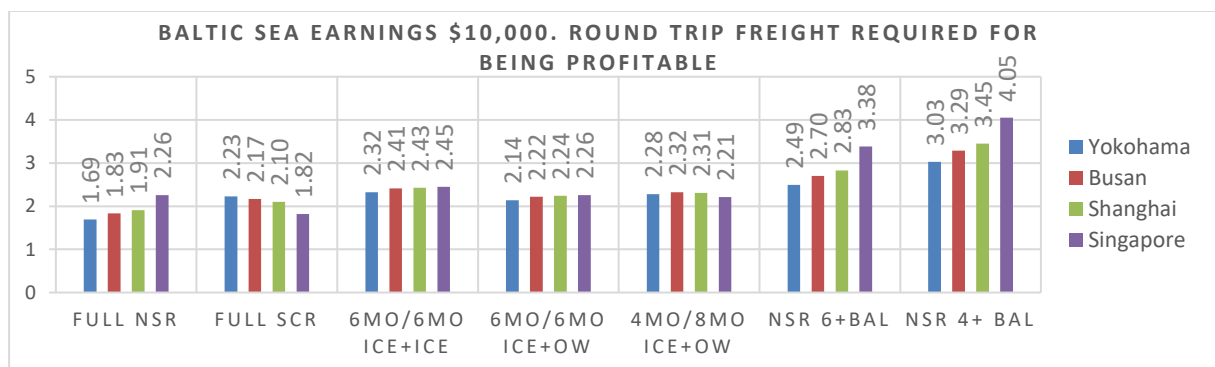
For all cases considered, the base scenario is operating two ice class vessels at Baltic Sea with given daily earnings. On low market scenario \$10,000 daily earnings, Baltic Sea operations with two ice class tanker vessels generate negative result of -\$3,296 million and thus freight rates from Asian trade need to cover the negative result from Baltic Sea. On low market, once annual result reaches positive, operations are deemed profitable. On high market conditions (\$15,000/d) Baltic Sea operations with two vessels generate annual

profit of \$0,304 million and only once Asian trade becomes more profitable than Baltic Sea operations they are considered profitable.

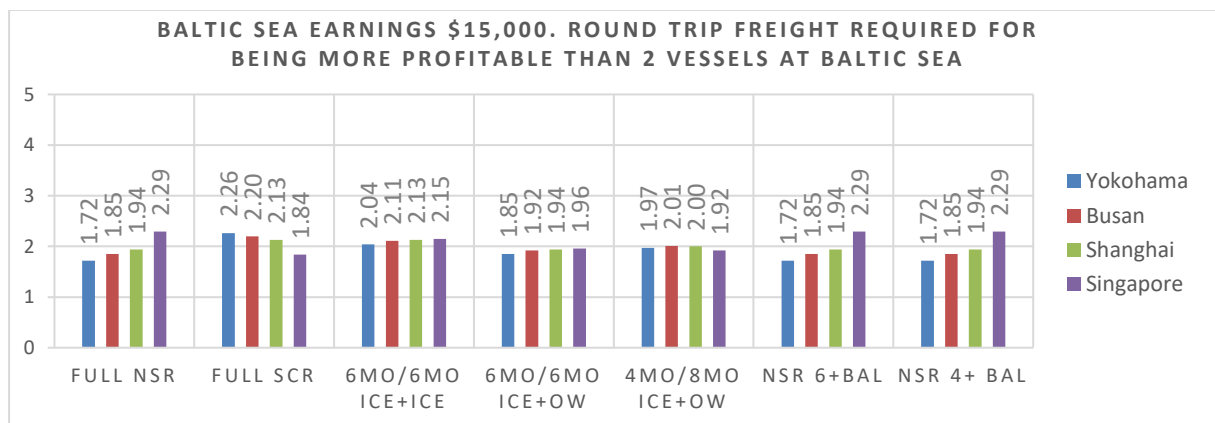
As expected, full NSR scenario to Yokohama appears most profitable option due to the greatest distance saving compared to the Suez Canal Route \$1,69 million freight requirement whereas Singapore is least profitable (\$2,26 million). Busan and Shanghai are in between with freights of \$1,83 and \$1,91 million required respectively. Due to relatively high fuel cost used in our model, scenarios where vessel is sailing with speed of 12kn are more profitable until freight revenue from round trip well exceeds \$3 million.

The freight from year around 6/6 months combined shipping on low market scenario should be between \$2,14 million and \$2,24 million depending on the destination port when utilizing one open water and one ice class vessel. On high market scenario \$1,85 – \$1,96 million freight is required. Based on our analysis, utilizing two ice class vessels on 6/6 months combined shipping would require approximately \$200,000 more freight per round trip than when utilizing one ice class vessel and one open water vessel on both market scenarios. In case of high market conditions, the required freight for full NSR scenario is equal to the point where '4 months NSR rest Baltic Sea' and '6 months NSR rest Baltic Sea' turn more profitable than full Baltic Sea operations implying that even few annual round trips via the NSR negotiated on spot market could be considered (see picture 4).

Under our assumptions, Yokohama would be able to do 6,2 and 5,2 round trips per year on full NSR and 6/6 combined scenarios respectively. For Busan and Shanghai, we get 5,6/5,0 and 5,3/4,9 round trips respectively while Singapore would get only 4,4 round trips on full NSR scenario and 4,9 on 6/6 combined scenario. It is interesting to note that under 6/6 combined shipping, each destination achieves around 5 rotations without much deviation.



Picture 3: Freight required on low market conditions in Baltic Sea



Picture 4: Freight required on high market conditions in Baltic Sea

CONCLUSIONS

This study could be regarded as an attempt to analyse the possibility of utilizing existing ice class fleets from Baltic Sea in NSR operations during off season in Baltic Sea for small/medium sized tanker operators. We adopted a market-oriented approach analysing both revenue and costs rather than merely analysing the total cost of shipping via the NSR.

Purpose of this study was to find out how much freight shipping company would need to charge if it was to offer combined shipping operations to four major Asian ports while simultaneously operating at the Baltic Sea. When considering combined shipping scenarios, it seems plausible to operate one open water vessel and one ice class vessel instead of two ice class vessels for increased operational efficiency and cost saving from such operations would be around \$200,000 USD per round trip. Required freight remains relatively steady regardless the big distance difference between the Asian ports considered, implying that combined shipping could be viable for East Asian ports East from Shanghai and especially so in the case of high market conditions in Baltic Sea. For Singapore, two open water vessels travelling via SCR is always the best option. Due to relatively high fuel cost used in our model, scenarios where vessel is sailing with speed of 12kn are more profitable until freight revenue from round trip well exceeds \$3 million.

Our model, at least partially, confirms the suggestions from Zhang et al. (2016a) that small sized and agile ship owners with existing ice class tonnage could well benefit from NSR operations, especially if owners manage to acquire backhaul cargoes to gather sufficient freight payments. From our model it is also clear that market conditions on Baltic Sea have a profound impact on profitability of NSR operations. If the earnings in Baltic Sea increase it is more profitable to utilize vessels only on Baltic Sea and thus even higher freight from Asian trade would be required to be more profitable than pure Baltic Sea operations.

It is also important to note that as spot rates for considered port pairs are not readily available, freight would be most likely negotiated as a lump sum. There have been some North Europe – Asia MR tanker fixtures in 2017 and lump sum has generally been in between \$1 and \$1,5 million according to Clarksons. Also, results for bigger Panamax vessels might be even more promising due to increased economies of scale.

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IMPACT OF THE EUROPEAN ROAD TRANSPORT MARKET DEREGULATION: THE CASE OF CABOTAGE IN GERMANY

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Abstract

Despite the high managerial relevance and strong political and societal interests, the debate in the European Union (EU) has only resulted in sparse research attention being given to the ongoing liberalization through market deregulation. Hence, we examine the impacts of the EU cabotage liberalization in the case of Germany. Based on the analysis of Eurostat data, expert interviews, and a review of the related literature, we examine four propositions related to the factors affecting cabotage penetration, future cabotage levels, and the effects on modal split and empty runs. We found that cabotage in Germany plays a more important role than officially reported and has increased drastically since 2009. The reasons for this increase are the removal of access restrictions from EU12 to EU15 countries. Given our analysis, a backwards modal shift, that is, a shift from rail to road, and increased national empty runs are the future outcomes of the current regulations. We strongly encourage researchers to address the topic of road market deregulation. Policy-makers in Europe are advised to address the development and the working conditions of Eastern European trucks, as this analysis points to further increase.

INTRODUCTION

Economists generally agree that the deregulation of a market, such as trucking in the transport market, leads to increased efficiency and lower prices for consumers (Vogelsang, 2002, Lafontaine and Malaguzzi, 2009). But market deregulations come with unintended negative effects too. For instance, the ongoing trucking deregulation in Europe has had negative impacts on social sustainability (Hilal, 2008, Sternberg and Lantz, 2018) and the environment (Hendrickx, 2013).

The current "cabotage directive", EC NO 1072/2009 stipulates the "3 in 7" rule: that every European Union (EU) haulier is entitled to perform up to three transports in a foreign market within a seven-day period, starting the day after the unloading of the international transport with which they entered the foreign EU country's market. The focus of the European trucking deregulation has been a debate on the heated question of whether the current limitations on cabotage should be further restricted or relaxed. The European Commission, for example, fosters further liberalization to reduce empty runs and to create a single European transport market where any haulier, regardless of EU member state of origin, can perform transport operations across the EU (European Commission, 2013). A further common argument in favour of liberalization is that it strengthens competition and thus reduces overall transport costs (Visser and Francke, 2010). However, hauliers in the "old" EU countries (EU15) are against further market opening because the significant salary differences between "new" (EU12) and "old" (EU15) countries has led to wage pressure, flagging out and bankruptcy of EU15 countries' hauliers (Kummer et al., 2014). For example, hourly operative costs for construction workers (comparable to truck driver salaries) in Denmark and Germany are 11 respectively 8 times higher than in Bulgaria (39.1/27.1 € vs. 3.6 € per hour) (Eurostat, 2017).

Given the millions of transport workers in Europe, the economic benefits of deregulation, the social and environmental sustainability challenges of the industry, and the importance to shippers, this paper sets out to explore the scarcely researched European trucking deregulation and its role in the European transport market (Baron, 1995). The uncertainty of the future development is a major concern for logistics managers as well as policy-makers (Mangan et al., 2008). Our aim is to aid theory development on road transportation and regulation as well as to provide direction for managers, public authorities and policy-

makers by elaborating on empirically derived propositions. The German road transport deregulation is used as the unit of analysis.

RESEARCH APPROACH

A qualitative and a quantitative approach is applied in this research.

In the qualitative portion, regular Google searches for “cabotage” were used first. Second, a panel was created of experts who were identified from scientific and magazine articles, reports and Eurostat. They were interviewed using an open-ended set of questions in which they were asked primarily about the current state of cabotage and their perceptions of future market developments. Germany was chosen as the focal market (unit of analysis), as it is Europe’s largest economy, is centrally located, and is a country with relatively high wages. The informal interviews were carried out as short conversations over the phone and by email. The following 25 experts contributed:

- Three Eurostat managers and experts
- Two experts from the German National Bureau of Statistics
- Three transport experts and officers in the European Commission
- Six senior transport researchers and professors from universities (Poland, Austria, Italy and France)
- Two journalists
- Three representatives of the German transport authority
- Three representatives of various logistics and transport industry associations
- One consultant
- One senior road transportation manager of a major German logistics service provider
- One chairman of the board of a major German logistics service provider

In the quantitative portion of the research, Eurostat data were used. Germany was chosen for the elaboration of the research propositions and for the same reasons as stated above. In situations where it is useful, Germany is compared with France, for plausibility comparisons. Future potential cabotage penetration rates are calculated by applying regression analysis. To predict future cabotage shares specifically, the existing trendline is extended beyond the actual data (2008 to 2014) in two different scenarios (using linear and S-curve trendlines). The starting year is set at 2008, as 2009 was the first year affected by the current (as of January 2018) cabotage directive (2009). In May 2009, the first EU12 countries (among them Poland) and in 2012 the remaining EU12 countries (e.g. Romania and Bulgaria) entered the cabotage market in road transport. A future scenario based on a logic model is outlined.

ASSUMPTIONS ON THE DATA AND MARKET ADJUSTMENTS

A cabotage host is the country where the cabotage takes place. Germany and France are the primary cabotage hosts in Europe. Since 2009, cabotage shares have been increasing strongly. Despite its importance (McKinnon and Leonardi, 2009), there is still confusion about the “right” figures of cabotage in Europe. Assumptions and adjustments have to be made.

Feasible cabotage rates

In the case of Germany and based on “official statistics” (Eurostat), the penetration rate increased by 15% from 2003 to 2008 and by 19% from 2008 to 2014, implying a compound annual growth rate of 3% and 20%, respectively.

The journeys on *own account* (i.e. by companies carrying their own goods arounda) are deducted from the total national road transport journeys. Therefore, the denominator only includes national *hire or reward* journeys (carried out by professional providers of road haulage services.) In the case of Germany, the journeys on *own account* make up 21% of the total national journeys and 18% in France (Eurostat, 2016a, 2016b). This first adjustment is consistent with the approach by Baybliss (2012).

Several interviewees representing independent research and industry, journalists and trade organizations, stated that the cabotage statistics are underestimated. It is well-established that long-distance trucking represents a “statistical vacuum” because many countries do not even try to collect information about cabotage operations from their national hauliers (McKinnon and Leonardi, 2009). Some interviewees believed cabotage to be 50 to 100% higher than stated by Eurostat. Sternberg et al. (2014) confirmed the underestimation of EU12 haulier activities. According to the Eurostat officials interviewed, some of the new member states also have insufficient routines (both on the authority and haulier levels) to collect adequate data. Hence, a second adjustment of the underlying data consists of adding a modest 25% to the officially reported cabotage journeys to include those by countries that are not part of the EU (e.g. Ukraine or Turkey) and cabotage journeys that are not reported.

Maximum penetration rate of cabotage

Moreover, an important distinction to make is the actual extent in percentage of the domestic freight market that is penetrable by cabotage. Because the current regulation stipulates that a foreign haulier needs to have an international transport coming into the country, transports such as of construction material or forestry products are unsuitable for cabotage. That applies to local distribution, for example, where only cities bordering on a low-cost country are feasible cabotage targets. Hence, this paper applies the selection and reasoning criteria of Sternberg et al. (2014), which makes half of the total German freight market (exactly 53%) the maximum theoretically feasible penetration rate of cabotage.

Diffusion of low-cost freight services

Forecasting the speed of diffusion of low-cost freight services in the European transport market is difficult. However, the market diffusion can be generally modelled as a sigmoid function (S-curve) (Majahan et al., 1991, Rogers, 2003). The flexibility of hauliers in terms of flagging out to achieve cost advantages has been proven by Kummer et al. (2014), for example, and considers the low margins of the industry, which are often a survival measure to maintain competitiveness. The driver shortages of EU12 countries are addressed by generous work immigration policies and several companies employ drivers from Ukraine, Macedonia or the Philippines, for instance.

EUROPEAN ROAD MARKET LIBERALIZATION – REVIEW AND PROPOSITIONS

The EU road transport market liberalization is widely covered in newspapers and magazines, but barely discussed in academic papers, as noted by Lafontaine and Malaguzzi (2009). The few studies that have been published are often influenced or financed by a principal (such as a trade union or industry association) and/or are not peer reviewed, Sternberg et al. (2014). The majority of peer-reviewed papers focus on either air or maritime cabotage (e.g., Giannopoulos and Aifandopoulou-Klimis, 2004) or are outdated.

In Germany, national transport by domestic hauliers accounted for 65%, followed by international bilateral transport with 25%. Goods transported internationally by a third party (cross-trade) accounted for 8%, while the remaining 2% were transported nationally by a foreign haulier (cabotage) (Eurostat, 2016a).

Developments of cabotage penetration rates and East European operators

As was expected, the adjustments – (i) deducting own account, and (ii) adding 25% to the official statistics – result in significantly higher absolute values of cabotage shares. In Germany the gap was 2.1% (6.5% [adjusted] in 2016 vs. 4.4% in 2014) and in France 2.6% (7.5% [adjusted] in 2016 vs. 4.9% in 2014). The fact that the compound annual growth rate from 2008 to 2014 is stable (Germany: 18% [adjusted] vs. 20%; France: 10% [adjusted] vs. 9%) implies that the share of *own account* on national tonne-kilometres (tkm) is relatively constant (Eurostat, 2016a, 2016b). Given this background, the first proposition can be derived:

PP 1: Cabotage penetration will continue to increase in Germany.

Based on the large cabotage market share of Poland, Bulgaria and the Czech Republic (these three countries make up about 70% of all EU12 member states cabotage), we will focus the analysis on these three countries and neglect the other EU12 member states. From 2009 onwards, the generated cabotage tkm has doubled almost every year (CAGR = 67%). Moreover, the absolute values are remarkable. Poland, the Czech Republic and Bulgaria performed over seven billion tkm in Germany in 2014. Furthermore, the numbers indicate Poland's dominance in Germany, but also among other EU12 member states active in Germany (Eurostat, 2016c). This finding is consistent with insights of past studies by Gleave (2013) and the European Commission (2014). Regarding the development of East European operators, we formulate the following second proposition:

PP 2: The cabotage liberalization results in a surge of East European operators in Germany.

Modal split

If PP 2 holds valid, the cabotage liberalization in the EU results in a surge of East European operators in Germany. This shift intensifies the competition in the European road haulage market and forces the old EU member states to reduce their operating costs. Thus, the overall road haulage operating costs will decline. When road transports become cheaper and more flexible than rail haulage, the deregulation in the EU potentially results in a backwards modal shift, as was the case in the US after the Motor Carrier Act of 1980 (Moore, 1986). Following this line of reasoning, we formulate the third proposition:

PP 3: The cabotage liberalization results in a modal shift, that is, a shift from rail to road, in Germany.

Development of empty runs

The surge of East European operators intensifies the competition in the German road haulage market and forces the local hauliers to reduce their operating costs. Thus, the overall road haulage operating costs will decline. As highlighted by Sternberg et al. (2015), empty runs increase linearly with decreasing costs, because the haulier will break even earlier, and thus is able to operate with fewer loaded trucks.

The distinction between cabotage empty runs and overall national empty runs is important. A certain number of empty runs is inevitable due to geographic imbalances and specific characteristics of goods (McKinnon and Ge, 2006). According to Eurostat, 23% of all transports are empty runs on average overall transport operations. While national empty runs are slightly above average with 25%, empty runs of national road freight transport undertaken by a foreign haulier (= cabotage) are almost twice as high (about 50%). Given the previous propositions, we finally state the fourth proposition:

PP 4: The cabotage liberalization results in increased national empty runs in Germany.

PROSPECTIVE IMPACTS OF THE CABOTAGE REGULATION

We now want to elaborate the propositions by using a simple regression analysis with the extension of existing trendlines beyond the actual data. We define two different scenarios to predict future cabotage shares. The "steady-state growth", Scenario 1, extrapolates the future cabotage development with a linear function. In the "strong growth" Scenario 2, we assume an exponential function. We will forecast the cabotage penetration rate for ten years and present the corresponding trendline equations and R-squared values.

Developments of cabotage penetration rates and East European operators

Assuming a sigmoid function for cabotage penetration rates, this shows that the cabotage share would rise from 6.5% in 2014 to 40% in 2030 (Figure 1).

- *Assumption: New regulations totally liberalize the market:* The European Commission is a strong proponent of a Single European Transport Area and has already elaborated detailed options to liberalize the market, making this option a

highly likely one. The scenario assumes a gradual, slow deregulation of the market, in line with the proposal of recent years to change the cabotage rule from "3 in 7" to, for example, 5 days unlimited cabotage.

- *Assumption: Operating cost gap between EU15 and EU12 remains:* Concerning costs, it can be assumed that the gap between EU15 and EU12 member states remains constantly high. The two main costs are fuel and labour. However, fuel prices today are already more or less the same, as they are linked to the global economy (Baybliss, 2012) and are harmonized by Council Directive 2003/96/EC (Community Framework for the Taxation of Energy Products and Electricity, 2003). Labour costs, on the other hand, have not converged in recent years.
- *Assumption: Lack of German drivers and surplus of EU12 drivers:* A continuation of the current driver shortage seems to be reasonable, as the job is unattractive in Germany and the salary is relatively low. A lack of German drivers and a constant in-flow of non-EU drivers to EU12 countries are assumed.
- *Assumption: Maximum penetration:* A maximum cabotage penetration corresponding to the feasible freight categories outlined: 53%.

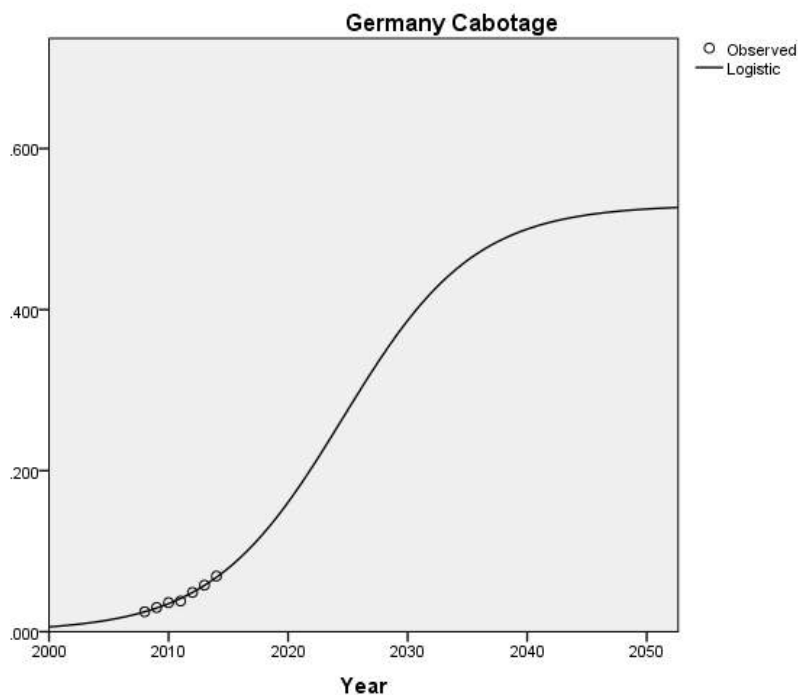


Figure 1: S-curve for cabotage share in Germany (2008-2023), (Eurostat, 2016a)

The current cabotage share of 6.5% is calculated by dividing the national *hire and reward* tkm carried out by German registered vehicles (221 bn), plus cabotage tkm by international vehicles (15.2 bn) divided by cabotage tkm by international vehicles (15.2 bn). Assuming an annual growth rate of 2% for the national *hire and reward* tkm in Germany would add up to 356 bn tkm in 2023. A cabotage rate of 25% would thus assume 91 bn tkm of cabotage. Looking at Poland's total cabotage tkm and its growth rate suggests that Poland alone (without the other EU12 countries, without other East European countries and without the shadow addition) could reach 87 bn tkm in 2023. Poland increased its cabotage tkm in Germany from 0.2 bn in 2008 to 5.8 bn in 2014; this equals a compound annual growth rate of 75%. Assuming that Poland increases its tkm by only 35% per year, this would lead to 87 bn tkm in 2023. The conclusion would be that 91 bn cabotage tkm would lead to a 25% cabotage share in Germany.

Our findings are consistent with the study by the Policy Research Corporation (Hendrickx, 2013). The authors argue that a cabotage share of 25% to 30% is possible in some of the EU15 member states, especially in Germany. For the Netherlands, the main country investigated in the Hendrickx study, the claim is that the cabotage share will reach 15% in the next few years. Moreover, they stress the importance of the two influencing factors: regulation and proximity. They also add that the cabotage penetration rate depends on the amount of international transport between the cabotage host country and other East European countries.

A final reason for the strong increase of cabotage share in Germany is that most of the big German companies support this change by contracting foreign hauliers instead of German hauliers; one interviewed logistics service provider stated they currently use cabotage for 25% of their German domestic hauls. Thus, the procurement of German companies is fostering cabotage in Germany. Available data, previous studies and experts support Proposition PP1: *Cabotage penetration will continue to increase in Germany*, as well as Proposition PP2: *The cabotage liberalization results in a surge of East European operators in Germany*.

Changes of modal splits

We investigated whether the cabotage liberalization has had any effect on modal shift. Based on the current development, not yet (Table 1).

Modal split in Germany	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Road (in %)	68	67	66	66	66	66	67	65	66	65	64
Rail (in %)	18	19	20	21	22	22	21	22	23	23	23
Inland waterways (in %)	14	14	14	13	12	12	12	13	11	12	13
Change of road share (Basis 2008)							2%	-1%	0%	-1%	-2%

Table 1: Modal split in Germany (Eurostat, 2016f)

As long as cabotage penetration is at a relatively low rate and freight demand is increasing, it is not feasible to expect a large modal shift in the available data, as a modal shift typically appears over time following changes in network planning (Simchi-Levi et al., 2007). Hence, we cannot confirm Proposition PP 3: *The cabotage liberalization results in a modal shift, that is, a shift from rail to road, in Germany*.

Recent studies (Visser and Francke, 2010, Hendrickx, 2013) indicate that decreasing road transport prices can trigger a backwards modal shift, that is, a shift from rail to road. In the next few years, however, a backwards modal shift initiated through cabotage is unlikely, because a cabotage share of 6.5% is too little to affect the entire transport market (Bundesamt für Güterverkehr, 2010). If and when cabotage will affect the entire market is still uncertain, but it seems likely that a cabotage share of over 25% in 2023 would have an effect.

Development of empty runs

At the present time, there is no direct link between cabotage empty runs and national empty runs, because cabotage only accounts for a relatively small percentage (about 4%) of the entire market. Therefore, the two segments are first analysed individually and then assessed together (Table 2).

	Cabotage market	National market (without cabotage)	Entire market
Cost	Constant, respectively slightly increasing	Decreasing due to foreign competition	Decreasing

Empty runs	Slightly decreasing	Increasing due to decreasing costs (shipper stronger than haulier)	Increasing since effect of "national" is stronger than "cabotage"
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Table 2: Effects on the cabotage and national market, assuming cabotage reaches a tipping point

Cabotage liberalization has contributed to a decrease of empty runs in the cabotage market. According to Hendrickx (2013), a further liberalization of the cabotage rules will not result in a further decrease in empty runs, as the current "3 in 7" rule already grants an efficient possibility to reduce empty runs. We assume that a slight decrease will take place, because the cabotage empty runs are at a relatively high level compared to national empty runs (about 50% vs. 25%) and therefore offer huge potential to improve average utilization. In regard to the costs, it can be assumed that they will remain constant or marginally increase due to their low level and higher costs in Germany.

Assuming that cabotage reaches a share of 20% to 25%, lower transport costs will increase empty runs in the national market (without cabotage). The reasons behind this are the following: If 25% of all national trips are driven by East European low-wage drivers, then German drivers will have to lower their costs to stay competitive. As a result, overall transport costs in Germany will decrease. Shippers will increase empty runs, because they can afford less efficient trips due to the lower costs. Hauliers have incentives to decrease empty runs as a result of cost pressure, but due to their small size and limited network, they have large difficulties to consolidate freight (Sternberg et al., 2013). Clearly, shippers have the power (Pålsson and Kovács, 2014).

Hence, we can summarize that there are some indications supporting Proposition PP 4: *The cabotage liberalization results in increased national empty runs in Germany.* Transport costs in the entire market will likely decrease and empty runs will increase, since the "domestic" effect is stronger than the "cabotage" effect.

CONCLUDING REMARKS

This paper sets out to explore European trucking deregulation and its role in the European transport market, with the aim of aiding theory development on road transportation and regulation, and providing direction for logistics managers, public authorities and policy-makers. This paper represents a modest contribution to the largely unexplored field of "cabotage" and further research is highly encouraged in order to determine adequate policies for financial, environmental and social sustainability as well as for providing further guidance for practitioners. Though cabotage is not a major issue in some countries, it has been widely debated in Central and Northern Europe (Kummer et al., 2014, Sternberg and Lantz, 2018).

The results show a clear trend towards more EU12 trucking operations and several developments reinforcing that trend. According to Min and Lambert (2002), driver shortage is influenced mainly by the economic climate (recessions tend to erase driver shortage) and poor driver management. Hence driver shortage (resulting in increasing domestic prices) among German hauliers is likely to continue.

Logistics managers looking at future strategy are advised to take these trends into consideration because EU12 hauliers represent significant cost savings – however at an environmental price as modal shift and fill rates suffer (Hendrickx, 2013).

Policy-makers who want to promote a shift towards rail and higher fill-rates face an uphill battle, as the trends are going in the opposite direction. If the trends are not broken, this analysis offers troubling insights and calls for more research into the institutionalization of low-cost transport operations.

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AN EXPLORATION OF THE ADOPTION BARRIERS OF DELIVERY DRONES IN LOGISTICS COMPANIES

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ABSTRACT

The purpose of the study is to explore the factors affecting the adoption of delivery drones as a delivery mechanism in Chinese logistics companies. In particular we assess key factors that affect drone enabled delivery systems and their influence on the intention to adopt such systems. A model of potential barriers to adoption is developed using Technology Acceptance Model involving security, perceived usefulness, perceived ease of use and attitudes as factors that affect the intention to use. We validate the model using empirical data collected through a survey to examine factors currently affecting the intention/non-intention of Chinese logistics providers to adopt delivery drones. We find that solving key security considerations during delivery and receipt of product are crucial for e-commerce suppliers. This is the first study of its kind that contributes to understanding development trajectories of drone usage for increased logistics effectiveness and efficiency.

Keywords: Delivery drones, logistics, adoption, barriers, China, e-commerce

INTRODUCTION

It is reported that there are more than 150 million online shoppers who spend nearly USD 200-250 per year with the value of whole E-retailing market is around USD 305 billion in 2015 (Subramanian et al, 2014). In order to keep pace with the development of online shopping, the logistics industry has also grown quickly. Efficiency and reliability are two key factors that influence improving delivery capability whilst an increasing number of customers require faster, customized and cheaper services (Ling, et al., 2012). Especially B2C e-commerce, compared with traditional entities, is characterized by small order size and increased daily order volumes (Hsiao, 2009). Although human labour is the common method of delivery and proves cost effective in China it is not always effective in the delivery process, especially in the challenging urban and rural environments. Volume and customer service now make it necessary for logistics companies to create new delivery systems. Recently, drone empowered systems have become widely used tools in many areas, such as aerial photograph, news report and environmental monitoring for example and are being assessed as delivery systems for the demands of e commerce (Chase et al. 2015). Some logistics companies have already tried to use drones to deliver parcels. Yet assessment of the potential of drone enabled systems is under researched and especially so in China (Chase et al., 2015).

Traditional pickup and delivery systems present two different classes of problems. The first group, many-to-many problems is characterized by the Swapping Problem involving categorization issues and wrong package pick up. It is with the second group, the one-to-one problem that drone systems can have an impact: that is in the courier operations or during the door-to-door transportation services (Berbeglia et al., 2010).

Although there are potential limitations, drone systems has been tried by, for example, by Amazon for smaller parcels (Edwards and Subramanian, 2014). The potential to deliver small packages to remote rural areas for such categories as medicine has also been explored by companies worldwide.

Delivery by labor force can be prone to late delivery and environmental pollution. In contrast, delivery by drones may offer some affordances. Firstly, the new method is not limited by space, and it can suit many types of terrain especially in some remote rural areas. Secondly, unmanned aerial vehicle has advantages in delivery speed, because it can fly from origin directly to the destination, and is not affected by the traffic jams. Lastly, energy consumption is far less.

Hence this study aims to answer the research question what are the key factors that affect drone enabled delivery systems and their influence on the intention to adopt such systems. We use the Technology Acceptance Model (TAM) proposed by Davis et al., (1989) to explore the development barriers of delivery drones in Chinese logistics companies. The model is widely used to assess attitudes towards adopting new technologies and involves structural equation modeling to assess the range of factors on the intention to use drone-enabled delivery systems.

LITERATURE REVIEW

Same-day delivery is the ideal scenario and also the most challenging. Actually, Amazon is trying to step into same-day logistics, and DHL is practicing this in Cologne (Morganti et al, 2014). In addition, e-retailers can align through third party delivery operators to increase volumes of parcels toward increasing the bargaining power with delivery operators. The paper also pointed out that some new intermediaries could emerge, which provide back-end services, matching an e-commerce order with an express service for quick delivery within 90 minutes.

Verlinde et al, (2014) describe a new concept in urban delivery, the Mobile Depot (MD), which includes a small office, a platform and warehousing facilities, that is supported by the electric tricycle. Every morning the MD is loaded with a number of parcels then heads directly to a central parking location returning to the distribution center in the evening. The concept of MD had been integrated into people's lifestyle in Brussels and complaints from users were significantly reduced. The emission of carbon dioxide was reduced with petrol distances decreased from weekly 1291 van kilometers to around 141 kilometers (Verlinde et al, 2014). In terms of limitations, operational costs are twice as expensive as general delivery.

On December 1st, 2013, Amazon Air made the world headlines as one of the first major initiatives to create a drone enabled delivery system. The concept was using drones to deliver packages from merchants to customers in a promised time of less than thirty minutes (McNeal, 2014). The new project created excitement whilst competitors were highly skeptical. However, it has been more than two years since the scheme was tested and Amazon is still struggling to improve the technique and popularize it. This has brought doubts whether the scheme will be officially put into real use (Keeney, 2015). In addition, one of the biggest Chinese logistics company called SF also announced its intention to use drones for delivery but has yet to start operations.

CONCEPTUAL MODEL

The Technology Acceptance Model (Davis 1985) is a well-established method based on the theory of reasoned action (TRA). In the theory, individual and social concepts are determinant of attitude and values, whilst attitude will contribute to people's behaviors. Davis et al (1989) later developed the technology acceptance model by adding two critical variables, perceived usefulness and ease of use respectively as key factors which determine whether users accept the new technology or not. In addition to the connection

between perceived usefulness, perceived ease of use, attitudes towards use, behavior intentions and technology adoption, the association of relevant external variables are considered.

The structure of TAM has been to study the adoption of various types of new technologies, such as processing software (Shapka and Ferrari, 2003) and the intentions of online shopping (Vijayasarathy, 2004), for example. Sivo et al. (2007) notes that the theory is stable across different types of technology and we therefore conclude that it is appropriate to explore the development barriers of delivery drones in Chinese logistics companies.

Based on the Technology Acceptance Model, a new model is built to explore the development barriers of drone enabled delivery systems. Based on our literature evaluation of relevant factors, Figure 1 shows the structure of our research model with relevant external variables.

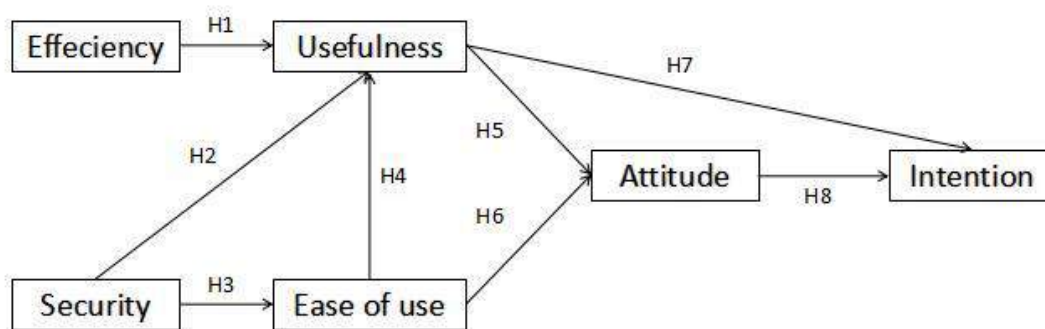


Figure 1: Research Model

Efficiency

Logistics companies will need to consider the efficiency of using new technology. Delivery systems need to outperform existing systems in terms of customer service. Therefore, it is necessary to consider both delivery efficiency and cost efficiency.

Security

The literature suggests that security is a major concern and barrier to the usefulness and efficiency of delivery drones. Data privacy is a customer concern such as information that will be captured during the delivery needs to be secure. Therefore, in order to satisfy their customers, companies should seriously consider how to protect the customer's personal information and the parcels' safety. According to Insinna (2014), drone systems are prone to attack and insecure delivery since they cannot identify the receiver of a package therefore the durability of drones is a major concern. In addition, parcels need to be protected and secure delivery situations created so that customers have confidence in the drone delivery service. Therefore we explore whether using drones for delivery is safe, including personal safety, parcel safety and privacy safety. Insecure delivery situations will seriously diminish the perceived usefulness and efficiency of delivery drones.

Perceived Usefulness

Perceived usefulness here can be understood as the level of people's belief that the new technology would improve performance (Davis, 1989). In other words, we seek to measure whether logistics companies believe delivery drones will bring efficiency, convenience and safety to users. And whether they think it useful both for companies and customers.

Perceived Ease of Use

In a simple way, ease means not difficult to finish a task. It is equal to getting a satisfied result while spending a small effort. Perceived ease of use, it can be defined as the level

of people's beliefs that the new technology would not need them a lot of efforts (Davis, 1989). If a new technology perceived to be effortless to use compared with opposite one, most of people will choose the easy one.

Attitudes towards Use

Attitude can be understood as person's ideas towards a new concept or innovation, it includes the subjective evaluation and will result in behavior tendencies (Doob, 1947). Cognizance and affection are two factors directly determining the attitudes (Fishbein, 1967; Devari et al., 2017). These factors are treated as key components in the Theory of Reasoned Action. Here the attitude towards use is defined as the extent users prefer to use drones for delivery and regard it as a useful method.

Behavioral Intention to Use

After getting the attitudes towards use, people have already had a clear realization of their goals. This makes them to decide to accept or reject the new concepts. If accept, actual behavior will be the next step. On the contrary, they will not put it into action if reject the concept. Therefore, behavioral intention to use is defined as users' intents to use drones for parcels delivery. In exploring the development barriers of delivery drones in logistics companies based on TAM we develop a hypothesis based on the research variables established in the literature review

Whether the new technology is efficient will impact the perceived usefulness. We have noted the operational cost implications of drone delivery systems such as equipment costs, labor and expertise, and legal costs as well as the potential efficiencies. Financial limitations of various kinds create risk and therefore negatively impact on the perception of ease of use of delivery drone systems. Logistics companies should consider both delivery efficiency and cost efficiency in order to satisfy users. Therefore, the relationship between efficiency and perceived usefulness is as followed:

H1: The efficiency of using delivery drones will significantly influence the perceived usefulness of the new technology.

We have described the security and safety problems involved in drone delivery with privacy, recipient authentication and durability significant issues. We hypothesize that these issues will influence perceived usefulness of drone delivery systems. The hypothesis is:

H2: The security of using delivery drones will significantly influence the perceived usefulness of the new technology.

In order to create a safe and secure service companies will have to be expert in the use of drones. This consideration establishes the following hypothesis:

H3: The security of using delivery drones will significantly influence the perceived ease of use of the new technology.

Perceived usefulness is related to how helpful a technology (Davis et al, 1989). Perceived ease of use will directly affect people's sense of how useful a technology is. So the hypothesis is built as follows:

H4: The perceived ease of use of the delivery drones will significantly influence the perceived usefulness of the new technology.

Research (see: Agarwal and Prasad, 1997) supports the intuitive relationship between perceived usefulness and positive attitude towards use. Hence, we establish the hypothesis:

H5: The perceived usefulness of the delivery drones will significantly influence the attitudes towards new technology use.

According to Davis et al (1989), perceived ease of use refers to the effort needed to use a technology. If people use the new method and find that it requires less time to get the same result compared with the previous approach, there is no doubt that they will choose to use it. So the hypothesis is:

H6: The perceived ease of use of the delivery drones will significantly influence the attitudes towards new technology use.

In the Technology Acceptance Model, perceived usefulness not only has a direct influence on behavioral intention but also indirectly moderated through personal attitudes. The direct link between perceived usefulness and intention to use is based on the performance of a new technology and this intention is always decided by the outcome whether the function is positive or negative (Bagozzi, 1982). Therefore, we hypothesis the following:

H7: The perceived usefulness of the delivery drones will significantly influence the behavioral intention of new technology use.

Attitude towards use is located between people's beliefs and the intention. A positive attitude and is reflected in positive behavior intention (Bajaj and Nidumolu, 1998).

H8: The attitudes towards delivery drones use will significantly influence the behavioral intention of new technology use.

METHODOLOGY

The study is conducted using the quantitative research method with data collected through questionnaires. The software tool SOJUMP was used to manage the data gathering process.

The survey questionnaire is divided into two parts. In the first part, questions refer to people's basic information, including gender, age, education level, working experience, logistics Company and so on. The purpose for this is to have a brief knowledge about the participants and their working companies. In the second part, the questions are designed according to Technology Acceptance Model. The purpose of these questions is to test the perception of drone enabled delivery systems. In this section, all the answers use the 7-point LIKERT scale ranging from 1 (strongly disagree) to 7 (strongly agree), while number 4 represents a neutral attitude. The research measures each construct through the following questions derived from the literature evaluation.

Data Collection and analysis

103 copies of questionnaire were completed by different logistics companies' staff from 10 major logistics companies. Questionnaires were administered through the SOJUMP, website. After checking, all the data was assessed as valid. Then the samples will be used for analysis. According to Mansson (2015), reliability analysis is used to test the stability degree and the consistency of the results. Cronbach's Alpha for each construct is more than 0.7, which shows the credibility of scale is acceptable. The values of constructs and items are shown in table 3.

The purpose of survey instrument is to make the measurement and results reach a higher level of validity. A higher validity can reveal a higher fidelity of the measured behavior (Yesil and Korkmaz, 2010). Before the analysis of the exploratory factors, some examinations should be conducted to test whether the sample is suitable for this analysis, one of which is the validity analysis that can examine the correlation between the variables. In order to test the validity in this paper, it was required to put all the sub-scales into the test of Kaiser-Meyer-Oklin (KMO). According to the results of the test, it can be found that the KMO value is 0.838 which means the result is accepted. And in other words, it has a

normal distribution and suitable for factor analysis (Topaloglu et al., 2016). In addition, the significance values was also checked.

The main criteria for assessing the final result is by the value of factor loadings, which can be interpreted as a tool for examining the relationships among factors and variables (Gorsuch, 1983). In the study, all the variables were considered, finally the variables with values of factor loading below 0.5 were deleted. Based on this we arrived at six factors with minimum of three variables. Table 3 below shows the specific information related to reliability and validity analysis, including variables included in the analysis, factor loading for each variable, cronbach's alpha, composite reliability and average variance extracted (AVE) respectively. Average variance extracted (AVE) is used to assess the discriminant validity, which measures the average variance shared between a construct and its measures (Chin, 1998). If the value of AVE is over 0.5, it indicates good convergent validity. Here from the table, although the value of security is less than 0.5, it is extremely close to the requirement which can be treated as accept. Overall, all the factors in this paper pass the reliability and validity test and they can be used for further analysis.

Structural equation models (SEM) were originally used to assess customer satisfaction. First is to use SPSS to do the reliability and validity analysis as described in the previous content, then conduct the exploratory factor analysis (EFA) if the outcome meets the requirements. Second is to use AMOS to do the SEM analysis. The guidance from Gefen et al., (2011) is used in this process.

After the test of SEM, some results are presented below. Table 4 shows the correlation among all the items. Table 5 shows the model scores related to the goodness of fit and also shows the standard value for examining. It is obvious that the chi-square value which is 1.602 less than the prescribed values . Then the next four indexes including comparative fit index (CFI), Tucker-Lewis (TLI), normed fit index (NFI) and incremental fit index (IFI) are all used to assess model fit. The standard value for them is more than 0.9 as shown in table 5 is normally acceptable. In addition, Root mean squared error of approximation (RMSEA) is less than 0.08 signifies outcome in the analysis achieves this goal. Overall the fit indices indicates the model in the paper is overall a good fit.

CONCLUDING REMARKS

Hypothesis testing was conducted using SEM. Table 6 shows the relationships between variables and factors. We find that behavioral intention to use drones is determined by the personal attitude and that this attitude is predominantly shaped by perceived ease of use rather than perceived efficiency. Security is the key factor that influences perceptions of ease of use. Participants are concerned more about whether a serious monitoring system can be developed, which is not only is related to the safety of the drone and package, but also refers to the personal privacy of the recipient. Whether delivery drones can be easily controlled is another key factor in the perceived ease of use field and taking into account the flight limitations of drones at present established pick up points in urban and rural environments would allow a standard flight path, decreasing control limitations as well as potentially solving safety problems.

There are some limitations in the study. Firstly, it is difficult to involve a wide range of senior managers in logistics companies in the study. It is useful to explore the perceptions of participants who are general employees or low-level managers, however they generally do not have the seniority to decide whether adopt the new technology or not. In this way, the final functions will be affected. Secondly, the study would have benefited from more participants than the 103 from 10 logistics companies involved Future research should explore issues of Drone delivery use through a focus on decision makers.

Table 6: Results of the hypothesis using SEM

Relationship	S.E	Path Coefficients	T	P-value	Results
Perceived usefulness ← Efficiency	.04	-0.08	-.82	.410	Unsupported (The efficiency of using delivery drones will significantly influence the perceived usefulness of the new technology)
Perceived usefulness ← Security	.21	0.16	1.17	.241	Unsupported (The security of using delivery drones will significantly influence the perceived usefulness of the new technology)
Perceived ease of use ← Security	.24	0.51	3.53	***	Supported (The security of using delivery drones will significantly influence the perceived ease of use of the new technology)
Perceived usefulness ← Perceived ease of use	.16	0.53	3.22	.001	Supported (The perceived ease of use of the delivery drones will significantly influence the perceived usefulness of the new technology)
Attitude towards use ← Perceived usefulness	.17	0.28	2.38	.017	Supported (The perceived usefulness of the delivery drones will significantly influence the attitudes towards new technology use)
Attitude towards use ← Perceived ease of use	.17	0.67	5.39	***	Supported (The perceived ease of use of the delivery drones will significantly influence the attitudes towards new technology use)
Behavioral intention to use ← Perceived usefulness	.13	-0.10	-.82	.410	Unsupported (The perceived usefulness of the delivery drones will significantly influence the behavioral intention of new technology use)
Behavioral intention to use ← Attitude towards use	.11	0.94	6.18	***	Supported (The attitudes towards delivery drones use will significantly influence the behavioral intention of new technology use)
***	Significant at the .001 level (two-tailed).				

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EVALUATION OF LIQUEFIED NATURAL GAS BUNKERING PORT SELECTION

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Abstract

Purpose of this paper:

Given environment regulations on emissions from ships, shipping companies have sought alternative fuel ships, such as LNG-powered vessels, which may give rise to growth in liquefied natural gas (LNG) bunkering ports. This paper aims to evaluate the factors that lead to the selection of LNG bunkering ports in LNG bunkering industries.

Design/methodology/approach:

This paper employs a second-stage empirical analysis approach that selects criteria for shipping companies' selection of a LNG bunkering port through a literature review and interviews, and then adopts a fuzzy-AHP methodology to reveal the priority of the LNG bunkering port selection criteria.

Findings:

The results indicate that most shipping companies decide on a LNG bunkering port with a greater emphasis on safety/security or port services than port reputation. These results indicate that, among the 20 sub-criteria for LNG bunkering port selection, geographical location ranked first as the most competitive factor in such a selection made by shipping companies, followed by LNG bunkering safety, experienced human resources, and relationship among stakeholders.

Value:

This paper represents the first step in exploring LNG bunkering port selection and offers invaluable policy implications for governments and port authorities that plan to build and operate LNG bunkering ports in the near future. Selecting a LNG bunkering port is important for the following three reasons. (1) Demand for LNG-powered vessels has increased as a result of environmental regulations of international organizations. However, scant research exists on the analysis of LNG bunkering ports. (2) Related LNG bunkering industries are still in an early phase and technologies are new. These industries will most likely develop and offer even more sustainable alternatives for the future.

Practical implications (if applicable):

Three policies such as incentive/discount, communication, and collaborative policy are recommended from a consideration of both the initial more theoretical evaluation and the empirical evidence. The advanced ports (Singapore, Rotterdam) are already preparing for LNG bunkering. The government or port authority preparing the LNG bunkering port will be able to implement policies for more competitive LNG ports by understanding the priorities of shipping companies when selecting LNG bunkering ports.

Introduction

Globally, the environmental crisis caused by global warming has created the serious problem of increasing greenhouse gases, sulfur oxides, nitrogen oxides, and particulate matter. As a result, demand for responses to climate change and environmental protection is increasing (Zhu et al., 2017). This demand has strengthened environmental regulations on air pollutant emissions from ships managed by international organizations, such as Tier

III of the International Maritime Organization (IMO) (Gritsenko, 2017). Liquefied natural gas (LNG) is a potential solution to meeting these stronger regulations. Regarding greenhouse gas emissions from ships, LNG is cleaner burning than heavy diesel oil (HDO) and marine gas oil (MGO) because of its negligible sulfur content (Lloyd's Register, 2012).

Because demand for LPVs is expected to increase, assessing the factors of LNG bunkering port selection in LNG bunkering industries is worthwhile. Furthermore, a dearth of academic research exists in the field of LNG bunkering (Lloyd's Register, 2012; 2014; DNV, 2012), thus presenting a plausible reason for venturing deeper into the relatively uncharted field of LNG bunkering research. This study employs a second-stage approach in empirical analysis and selects criteria for a shipping company's choice of a LNG bunkering port using literature reviews and interviews. The approach then adopts a fuzzy-AHP methodology to reveal the priority of LNG bunkering port selection criteria in LNG bunkering decision making.

Literature review

Port selection

The port selection problem is directly connected to port competitiveness. According to Malchow and Kanafani (2004), because competition among ports has intensified, various intermodal facilities are being improved to minimize the time that shipments are at the port. In addition, port infrastructure and superstructure are being augmented, such as expanding storage space and dredging channel depths to allow shipping companies to operate large vessels. Port selection, which focuses on customer (user) decisions, is part of customer behavior research and includes carriers/shipping companies, shippers, and freight forwarders (Brooks et al., 2011; Tongzon, 2009). Thus, ports should provide sound facilities and services for users.

A considerable body of literature exists from various stakeholders, including shippers, shipping companies, and freight forwarders, on port attractiveness, competitiveness, efficiency, and selection using a number of methodologies. In these studies, factors that affect port selection are identified and categorized using different classification methods. Previous research on port choice models focused on the port choices made by shippers. Other studies identified and described various factors of shippers' port selection using different methodologies (Tongzon, 2009; Hesse and Rodrigue, 2004). Recent research has studied the choice of a port from the perspective of liners and carriers. Lirn et al. (2003) suggested a set of trans-shipment port selection criteria from the viewpoint of the container carrier

LNG bunkering port

Currently, U.S. shipping company TOTE Maritime operates 3,100 TEU-class LNG-powered containerships. Notably, major liners, such as UASC and CMA-CGM, also recently ordered large LNG-powered containerships. Therefore, ports may have to invest in LNG bunkering facilities to accommodate larger LNG-powered containerships. Currently, only a few ports have LNG bunkering facilities (e.g., Incheon, Long Beach, and Antwerp). Therefore, if a port invests in LNG bunkering facilities today, it may have an advantage in attracting LPVs, which will allow it to leverage the competition from other rival ports. As a representative example, the Danish government suggested LNG as an alternative fuel for ships and environmental improvement of state-owned vessels that use new lightweight materials and alternative fuels (Danish Government, 2012). DNV (2012) noted that 4–7 million tons of LNG p.a. are required by 2020, which corresponds to 0.2–0.3% of global LNG production by 2010 because 1,000 more vessels will be fueled by LNG and sailing within regions, primarily in ECAs. They recommended that LNG bunkering be evaluated for validity, such as regarding safety, the environment, regulations, logistics, technology, operations, finance, and the business perspective.

However, the literature on LNG bunkering ports is still in its initial phase. Some existing studies explored the role of the port authority (PA) with respect to the LNG bunkering port

(Wang and Notteboom, 2015), LNG bunkering port development (TRI-ZEN, 2016), and a feasibility evaluation of LNG bunkering (DNV, 2012).

Methodology

Fuzzy-AHP

This research aims to identify the selection factors among various LNG bunkering ports using integrated AHP techniques under a fuzzy environment. Fuzzy-AHP is used to determine the preference weights of the evaluation using triangular fuzzy numbers (TFNs) based on the various characteristics of LNG bunkering ports (Kaya and Kahraman, 2011). This research uses TFNs for the evaluation. The steps in the fuzzy-AHP are presented as follows.

Step 1: Define scale of relative importance used in the pairwise comparison matrix

In this step, TFNs are utilized for pairwise comparisons and to find fuzzy weights because they are intuitively easy for decision makers to use and calculate. Additionally, modeling TFNs has proven to be effective in formulating decision problems for available information that is subjective and imprecise. The computational process for fuzzy-AHP is detailed as follows. A TFN can be defined by a triplet (a_1, a_2, a_3) , and the membership function $\mu_{\tilde{A}}(x)$ is defined by:

$$\mu_{\tilde{A}}(x) = \begin{cases} (x - l)/(m - l), & l \leq x \leq m \\ (u - x)/(u - m), & m \leq x \leq u \\ 0, & \text{otherwise} \end{cases} \quad \text{Eq. (1)}$$

This research uses nine basic linguistic terms, with respect to a fuzzy nine-level scale. Each membership function (scale of a fuzzy number) is defined by three parameters of the symmetric TFN—the left point, the middle point, and the right point—of the range over which the function is defined.

Step 2: Construct the fuzzy comparison matrix

In this step, pairwise comparison matrices among all criteria in the dimensions of the hierarchy system are constructed. Linguistic terms are assigned to the pairwise comparisons by asking which is the more important of each of the two dimensions, as in the following matrix \tilde{A} .

$$\tilde{A} = \begin{bmatrix} 1 & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \tilde{a}_{21} & 1 & \cdots & \tilde{a}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & 1 \end{bmatrix} = \begin{bmatrix} 1 & 1/\tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ 1/\tilde{a}_{21} & 1 & \cdots & \tilde{a}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ 1/\tilde{a}_{n1} & 1/\tilde{a}_{n2} & \cdots & 1 \end{bmatrix} \quad \text{Eq. (2)}$$

where,

$$\tilde{a}_{ij} = \begin{cases} \tilde{9}^{-1}, \tilde{8}^{-1}, \tilde{7}^{-1}, \tilde{6}^{-1}, \tilde{5}^{-1}, \tilde{4}^{-1}, \tilde{3}^{-1}, \tilde{2}^{-1}, \tilde{1}^{-1}, \tilde{1}, \tilde{2}, \tilde{3}, \tilde{4}, \tilde{5}, \tilde{6}, \tilde{7}, \tilde{8}, \tilde{9} & 1, i \neq j \\ 1 & i = j \end{cases}$$

Step 3: Define the fuzzy geometric mean and fuzzy weight

In this step, the geometric mean technique is used to define the fuzzy geometric mean and fuzzy weights of each by Vinodh et al. (2014):

$$r_i = (a_{ij}^1 \times a_{ij}^2 \times \cdots \times a_{ij}^{10})^{1/n} \quad n = 1, 2, \dots, n \quad \text{Eq. (3)}$$

$$w_i = r_i \times (r_1 + r_2 + r_3 + \cdots + r_n)^{-1} \quad \text{Eq. (4)}$$

where a_{ij} is a fuzzy comparison value of dimension i to criterion j . Thus, r_i is a geometric mean of fuzzy comparison value of criterion i to each criterion and w_i is the fuzzy weight of the i th criterion and can be indicated by a TFN.

Step 4: Determine the best non-fuzzy performance (BNP) value

In this step, the BNP value for each weight (l, m, u) is determined and given by Sun (2010).

$$BNP \text{ value} = \frac{[(u-l)+(m-l)]}{3} + l \quad \text{Eq. (5)}$$

Step 5: Rank the criteria

The criteria are ranked using the BNP values. The criterion with a larger BNP value is considered to have a stronger effect when compared with other criteria.

Data collection

Previous research related to the aforementioned studies was circulated among experts to obtain better insights into the problem. In this study, through interviews and the literature review, 20 detailed sub-criteria under five main criteria (cost, geography, port reputation, port service, and safety/security) were identified. The overall objective of the decision process determined for LNG bunkering port selection is on the first level of a hierarchy. The main criteria are on the second level, and the sub-criteria are on the third level of the hierarchy. The questionnaire for the analysis was distributed to each shipping company by referencing the world ports climate initiative (WPCI) website and the list of world LPVs (LNG World Shipping, 2016). From October 13 to November 30, 2017, 134 questionnaires were distributed to the population and 24 were returned, for an approximate response rate of 18%. Depending on the consistency of the answers, 20 questionnaires were finally adopted. Twenty respondents from shipping companies consisting of CEOs, general managers, and operations managers with professional experience answered the questionnaire. The detailed criteria are as follows.

Table 1 The criteria and their descriptions

Main criteria	Sub-criteria	Description	Interview
Cost (M_1)	Incentive/discount (C_1)	Discounts and incentives on eco-friendly vessels from environmental regulations of international organizations	0
	LNG price (C_2)	Low LNG price	0
	Port service charge (C_3)	Low port service charge	0
	Ship turnaround time (C_4)	Short ship turnaround time attributable to saving operating costs	0
Geography (M_2)	Geographical location (G_1)	Proximity to ECAs or main navigation routes	0
	Port accessibility (G_2)	Closeness to shipping companies' service routes	0
	Port traffic (G_3)	Number of calls at port	0
	Port weather conditions (G_4)	Sound weather conditions for LNG bunkering	0
Port reputation (M_3)	Experienced human resources (PR_1)	Education and training requirement for workers of the bunker vessel and experienced workers at the port	0
	Port disputes (PR_2)	Low level of port disputes	0

Port service (M ₄)	Public opinion/word of mouth (PR ₃)	Retain/develop positive public perception of the port	0
	Technical conditions related to LNG bunkering (PR ₄)	Required facilities and technology for LNG bunkering (e.g., TTS: Truck-to-ship, STS: Ship-to-ship, TPS: Terminal-to-ship)	0
	Efficiency of LNG bunkering process (PS ₁)	Short bunkering time attributable to the efficiency of the LNG bunkering process	0
	Infrastructure /superstructure (PS ₂)	Infrastructure and facilities provision for LNG bunkering	0
	Port congestion (PS ₃)	Low port congestion	0
	Relationship among stakeholders (PS ₄)	Sound relationship among LNG ports, LNG suppliers, and port users	0
	LNG bunkering safety (SS ₁)	LNG bunkering safety (e.g., ESD; Emergency Shut-down Systems, Safeguard Systems)	0
Safety /security (M ₅)	Port security (SS ₂)	Number of accident, accidents prevented, and guards	0
	LNG bunkering regulations (SS ₃)	Compliance with regulations and standards for LNG bunkering, such as regulations of SIGTTO (Society of International Gas Tankers and Terminal Operators), OCIMF (Oil Companies International Marine Forum), IMO (International Maritime Organization), ISO (International Organization for Standardization), CEN (European Committee for Standardization), and NFPA (National Fire Protection Association)	0
	LNG supply regulations (SS ₄)	Compliance with regulations and standards for LNG supply, such as ISO.TS 18683:2015 Guidelines for Systems and Installations for Supply of LNG as Fuel to Ships, LNG Bunker Checklists developed by IAPH's (International Association of Ports and Harbors) WPCI (World Ports Climate Initiative)	0

Empirical analysis

In this section, fuzzy-AHP is performed to determine the priority when shipping companies choose a LNG bunkering port. Selecting a LNG bunkering port is important for the following three reasons.

(1) Demand for LPVs has increased as a result of environmental regulations of international organizations. However, scant research exists on the analysis of LNG bunkering ports.

(2) Related LNG bunkering industries are still in an early phase and technologies are new. These industries will most likely develop and offer even more sustainable alternatives for the future.

(3) Advanced ports (Singapore, Rotterdam) are already preparing for LNG bunkering. The government or PA preparing the LNG bunkering port will be able to implement policies for more competitive LNG ports by understanding the priorities of shipping companies when selecting LNG bunkering ports.

Respondents were asked to construct pairwise comparisons of the five major criteria and 20 sub-criteria by employing linguistic variables. Using the arithmetic mean, the pairwise comparison matrices of the criteria and sub-criteria are established. The results from the computations using the pairwise comparison matrices are shown in Tables 9 and

10. The consistency ratio values of all matrices are less than 0.1, indicating that these matrices are sufficiently consistent. Then, linguistic expressions were transformed into FTNs and a fuzzy evaluation matrix was established. The next step is to obtain a fuzzy weighted evaluation matrix. Using the criteria weight calculated, the weighted evaluation matrix is established by Eq. (3) and Eq. (4). The results of the analysis are shown in Tables 2–3.

Table 2 Ranking of main criteria for LNG bunkering selection

Major criterion	Consistency	Major criterion weight	Major criterion BNP	Ranking
Cost (M ₁)		(0.142, 0.157, 0.177)	0.159	4
Geography (M ₂)		(0.257, 0.283, 0.309)	0.283	1
Port reputation (M ₃)	0.091	(0.111, 0.121, 0.133)	0.122	5
Port service (M ₄)		(0.165, 0.185, 0.207)	0.186	3
Safety/security (M ₅)		(0.230, 0.254, 0.280)	0.255	2

Table 3 Ranking of sub-criteria and total ranking for LNG bunkering selection

Sub-criterion	Consistency	Sub-criterion weight	BNP	Ranking	Total ranking
C ₁		(0.257, 0.302, 0.345)	0.301	1	5
C ₂	0.066	(0.191, 0.216, 0.248)	0.218	4	14
C ₃		(0.229, 0.266, 0.310)	0.268	2	8
C ₄		(0.195, 0.216, 0.245)	0.219	3	13
G ₁		(0.351, 0.380, 0.411)	0.381	1	1
G ₂	0.088	(0.201, 0.227, 0.252)	0.226	3	11
G ₃		(0.200, 0.228, 0.253)	0.226	2	10
G ₄		(0.153, 0.169, 0.189)	0.170	4	18
PR ₁		(0.309, 0.346, 0.380)	0.345	1	3
PR ₂	0.094	(0.181, 0.201, 0.221)	0.201	3	17
PR ₃		(0.149, 0.164, 0.181)	0.165	4	19
PR ₄		(0.263, 0.289, 0.327)	0.293	2	6
PS ₁		(0.259, 0.289, 0.323)	0.290	2	7
PS ₂	0.096	(0.203, 0.225, 0.257)	0.228	3	9
PS ₃		(0.149, 0.161, 0.179)	0.163	4	20
PS ₄		(0.294, 0.325, 0.347)	0.322	1	4
SS ₁		(0.319, 0.356, 0.393)	0.356	1	2
SS ₂	0.090	(0.193, 0.221, 0.254)	0.223	4	12
SS ₃		(0.191, 0.213, 0.239)	0.215	3	15
SS ₄		(0.185, 0.210, 0.240)	0.212	2	16

Discussion and concluding remarks

Studies on LNG bunkering port selection that incorporate applications from the perspective of shipping companies are lacking. This paper offers invaluable policy implications for governments and PAs that plan to build and operate LNG bunkering ports in the near future. The results of the analysis enable them to: (1) more clearly understand the needs of shipping companies regarding LNG bunkering ports, (2) determine how to provide efficient LNG bunkering services, and (3) make prompt adjustments to meet their development strategies. The results also enable LNG bunkering port managers to: (1)

grasp the present strengths and weaknesses of their ports and (2) help them establish future strategies to improve the competitiveness of their ports. This paper represents a first step in exploring LNG bunkering port selection.

The final ranking of the criteria is determined according to the BNP values. The results indicate that, among the 20 sub-criteria of LNG bunkering port selection by shipping companies, geographical location (G1) ranked first as the most competitive factor, followed by LNG bunkering safety (SS1), experienced human resources (PR1), and relationship among stakeholders (PR4). In reality, shipping companies normally obtain LNG bunkering services at the North Sea and the Baltic Sea given the ECAs. In addition, in these regions, LPVs are actively being operated and LNG bunkering ports are the most distributed. These examples might indicate that the adoption of an ECA is highly related to the development of LNG bunkering ports. Moreover, for shipping companies to make optimal decisions on the choice of LNG bunkering ports may be helpful. After the analysis, the strategic recommendations may be provided to the government or PA that is preparing the LNG bunkering port. The results indicate that most shipping companies decide on a LNG bunkering port with a stronger emphasis on safety/security or port services rather than port reputation. Therefore, when developing a LNG bunkering port, the government and the PA should improve its safety and security under limited port capacity to enhance its LNG bunker supply efficiency and shorten its waiting time. Meanwhile, the findings indicate that the efficiency of the LNG bunkering process (PS1) was the fifth most important factor. Therefore, port operators should improve the efficiency of port operations and, at the same time, secure sound LNG bunker suppliers in the port. Such partnerships will lead more shipping companies to obtain LNG bunker services at this port by reducing ship turnaround time (Barnes-Dabban et al., 2017).

The following policies are recommended from a consideration of both the initial more theoretical evaluation and the empirical evidence.

- Incentive/discount policy: The incentive and discount policy is a significant problem arising from the introduction of LPVs. The government and the PA should use various forms of financial support to promote LNG bunkering in its port, such as by developing a differential port tariff for LPVs, such as the Green Award at the port of Rotterdam and the Environmental Ship Index (ESI) of WPCI.
- Communication policy: The government and the PA should take a conative coordinating role with respect to sustaining honorable communication within the port community regarding the its LNG bunkering port, such as by (a) improving public opinion to promote the use of LNG bunkering ports and (b) projecting a publicity campaign or by forming conferences, seminars, or workshops (Kuznetsov et al., 2015).
- Collaborative policy: The government or the PA preparing a LNG bunkering port should institute collaboration opportunities with stakeholders of the port (e.g., industrial players such as LNG bunkering ports, LNG suppliers, and port users). Collaboration can focus on the development of the LNG port (e.g., location selection), the safety assessment of the LNG port environment, and the development of bunkering standards and guidelines. Collaboration is believed to improve interactive knowledge and its sharing, which can reduce market uncertainty (Wang and Notteboom, 2015).

The following items highlight the study's limitations: (1) because no major LNG bunkering ports exist, shipping companies have limited selection; (2) for the same reason, this study cannot propose alternative LNG bunkering ports; and (3) shipping companies' decisions may be non-objective and may neglect actual vessel and port conditions. Therefore, important additional studies can follow this paper. Future research directions are as follows: (1) shipping companies that lack LPVs should be added to the analysis; (2) after large LNG bunkering ports are constructed, alternatives should be analyzed; and (3) a two-phase methodology combining fuzzy-AHP-TOPSIS and a sensitivity analysis can be incorporated to confirm the robustness of the analysis. Nevertheless, the authors strongly believe that the study has provided an ideal platform for further research on this increasingly important subject.

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PERFORMANCE ATTRIBUTES OF SMART AND SUSTAINABLE PORTS

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ABSTRACT

Purpose of this paper:

Seaports are key nodes in global supply chains. In the competitive and dynamic business environment, ports are finding ways to be both smart and sustainable. This study aims to identify major design criteria or requirements of smart and sustainable ports. Major performance attributes will be derived through examples from the port of Singapore.

Design/methodology/approach:

First, a literature review is conducted and industry reports/sources are examined to analyse the two main aspects of ports under study, namely smart and sustainable. This provides the foundation in the choice of design requirements. Second, a Quality Function Deployment (QFD) framework is formed to link design requirements with stakeholder requirements.

Findings:

For the smart aspect, design requirements and performance attributes in hardware and software sides of ports are analysed. For the sustainable aspect, criteria in economic, social, and environmental perspectives of ports are analysed. It is found that automation, digital network, data analytics, supply chain collaboration, and energy management are prominent solutions in smart and sustainable ports.

Value:

This paper is the first in the literature to study the topic of smart and sustainable ports. It is an original attempt to develop a QFD framework to link design requirements to stakeholder requirements of smart and sustainable ports. The paper leads to future research to examine their interrelationships. In particular, port development experiences tremendous growth which presents ample opportunities of applying the framework in different ports.

Practical implications:

Port authorities, port planners, and terminal operating companies can take reference from the design criteria of smart and sustainable ports to plan, develop, and upgrade their ports. They can also use the design criteria and Singapore's examples for benchmarking purposes.

1. INTRODUCTION

Seaports are key nodes in global supply chains. The strategic positioning of ports has evolved to become more connected to supply chain performance. At the same time, the escalating demand on supply chain performance translates to higher expectations on port performance. In the competitive and dynamic business environment, ports are finding ways to be both smart and sustainable. A smart port is considered an efficient port ecosystem that is seamlessly integrated with the internet, empowered by Internet of Things (IoT) and automation (BT Infographics, 2017). Technological advancements enable a port to be smarter so that it can better serve its supply chain functions. A sustainable port is one that is able to balance economic, social and environmental values (Xiao and Lam, 2017). It contributes to build a sustainable supply chain, which is largely driven by customers and regulations. The literature focuses more on environmental sustainability, and less on the overall sustainability. While there is a vast amount of

literature on various port research topics, such as port competition, port governance, and port efficiency (Parola et al., 2017), not many studies focus on smart port or sustainable port. It appears that no studies systematically combine smart port and sustainable port.

With the above literature gap as our research motivation, this study aims to identify major design criteria or requirements of smart and sustainable ports. This is done by forming a Quality Function Deployment (QFD) framework to link design requirements with Stakeholder requirements. Thereafter, major performance attributes will be derived through examples from the port of Singapore. The next section discusses the QFD framework. After that, examples from Singapore will be given. The paper concludes with future research directions.

2. QUALITY FUNCTION DEPLOYMENT (QFD) FRAMEWORK

QFD is an established method for translating customer requirements into an organisation's design requirements (DR). Ficalora and Cohen (2010, p. 4) define QFD as "a method for structured product or service planning and development that enables a development team to specify clearly the customer's wants and needs, and then evaluate each proposed product or service capability systematically in terms of its impact on meeting those needs". In the context of our study, it would be insufficient to consider only customer requirements. For instance, a smart and sustainable port should be safe. Safety is beyond the interest of customers alone. Therefore, this study extends the scope to stakeholder requirements (SR).

To form the list of SR and DR, a literature review is conducted. We also include a sample of major ports in the world to investigate industry practices. Their website, annual report, sustainability report, and other available information are analysed. Firstly, the sustainability aspect is considered. Sustainable development is defined by the World Commission on Environment and Development (1987) as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. To be sustainable, the three aspects of economic, social and environmental criteria should be met. Port research has been increasingly addressing environmental issues, however, less covering the three aspects simultaneously can be found. This study includes 1) Cost and price competitive; 2) Health, safety and security; 3) Pollution and waste management as SR which take the three aspects of sustainability into account.

Secondly, the smart or intelligent aspect is considered. A smart port is able to leverage on advanced technologies to create value and enhance competitive advantage. While we do not find any literature directly analyzing/ identifying SR for a smart or intelligent port, there are indications of stakeholder demand or expectation as references. This study identifies 1) Efficiency; 2) Reliability; 3) Connectivity/ Communication; and 4) Proactivity/ Innovation as SR. Hence, the total list consists of 7 SRs. Table 1 summarises the SRs and supporting references.

Table 1. Stakeholder requirements for smart and sustainable ports

Stakeholder requirement (SR)	Reference
Cost and price competitive	Castillo-Manzano et al. (2009), Lam (2015)
Health, safety and security	Chen et al. (2018), Xiao and Lam (2017)
Pollution and waste management	Shiau and Chuang (2015), Sislian et al. (2016)
Efficiency	Cetin and Cerit (2010), Chen and Lam (2018)
Reliability	Hales et al. (2017) Lee et al. (2018)
Connectivity and Communication	Siror et al. (2011), Xisong et al. (2013)
Proactivity and Innovation	Acciaro et al. (2018), De Martino et al. (2013)

Technology is a key enabler of meeting the criteria of being both smart and sustainable. Performance attributes in hardware and software sides of ports are analysed. With reference to Garner (2017) and Forbes (2017), the top three mega technology trends that would substantially influence the future of businesses are Autonomous Vehicles (automation), Internet of Things (IoT), and Big Data Analytics. With the new wave of digitalisation of business processes, it is possible to have closer supply chain collaboration to streamline port operations. Also, energy management which can optimise port energy demand and supply facilitates environmental sustainability. As a whole, this study proposes five main DRs, which are 1) Automation; 2) Digital network; 3) Big data analytics; 4) Supply chain collaboration; 5) Energy management. These are shown in table 2 with supporting references.

Table 2. Design requirements for smart and sustainable ports

Design requirement (DR)	Reference
Automation	Bae et al. (2011), Carlo et al. (2014)
Digital network	Shi et al. (2011), Xisong et al. (2013)
Data analytics	Acciaro et al. (2018), Fernández et al. (2016)
Supply chain collaboration	De Martino et al. (2013), Lam (2015)
Energy management	Acciaro et al. (2014), Lam et al. (2017)

Performance attributes of these DRs should be targeted to meet the identified SRs. This would be enabled by the QFD mechanism as shown in figure 1 when empirical data is collected in future research.

3. EXAMPLES FROM THE PORT OF SINGAPORE

This section provides examples using the case of Singapore’s container terminals. The port of Singapore is the largest transshipment hub in the world. Out of 33.7 million TEU handled in 2017, about 28 million TEU are transshipment containers. The port handles a huge volume of cargoes and interacts with numerous stakeholders 24/7. As compared to gateway ports, transshipment operations have to be even more efficient because ship-to-ship connections have lower tolerance for waiting time. Due to an enormous amount of cargo flows and the associated information flows, the port of Singapore has to be highly smart to ensure smooth operations.

Singapore, in particular terminal operator PSA regarding container business, has embarked on the pathway to achieve a higher level of automation. In the current Pasir Panjang Terminal and the future Tuas mega terminal, automated cargo handling equipment such as Automated Guided Vehicles are deployed. In terms of information technology, cargo handling equipment and facilities in the terminals are installed with image processing devices and sensors. These form a digital network allowing efficiency in communication and monitoring. Furthermore, huge amount of data is obtained every day. The port makes use of data analytics, especially big data handling techniques, for optimisation and intelligent terminal operations.

			Column #	1	2	3	4	5
Row #	Weight	Absolute Importance	Design Requirements (DRs)					
			Stakeholder Requirements (SRs)	Automation	Digital network	Data analytics	Supply chain collaboration	Energy management
1			Cost and price competitive					
2			Health, safety and security					
3			Pollution and waste management					
4			Efficiency					
5			Reliability					
6			Connectivity and Communication					
7			Proactivity and Innovation					
			Absolute Importance					
			Relative Importance					
			Ranking					

Figure 1. QFD mechanism – House of quality

Beyond the physical boundary of container terminals, PORTNET is the flagship electronic port community system of PSA. It handles business-to-business transactions and greatly facilitates supply chain connectivity and collaboration. The platform connects with the port operator community, shipping line community, supply chain community, port service provider community, trade and logistics community, as well as government agencies. To further enhance users' convenience, 'PORTNET Mobile' is a new application for PSA's users to query and receive real-time vessel and container information through mobile phones.

Port activities are energy-intensive so the port of Singapore also uses green technologies to improve energy efficiency and sustainability performance. The port also introduces energy transition plans to use cleaner energy to reduce greenhouse gas emissions and on-site pollution. For instance, the container terminals deploy more electrified cargo handling equipment such as yard cranes and automated guided vehicles to attain higher energy efficiency and mitigate exhaust emissions during terminal operations. Also, the port is committed to use renewable energy, mainly solar energy in Singapore's context, to lower the port's carbon footprint.

4. CONCLUSION

The paper has identified major design requirements of smart and sustainable ports and proposed a QFD framework to link them with stakeholder requirements. Practical examples from the port of Singapore have been discussed.

In terms of this paper's value, first, the research focuses on two important targets, being smart and sustainable, for ports which are crucial trade facilitators and contributors to the world economy. This paper is the first in the literature to study the topic of smart and sustainable ports. Second, port authorities, port planners, and terminal operating companies can take reference from the design criteria of smart and sustainable ports to plan, develop, and upgrade their ports. They can also use the design criteria and Singapore's examples for benchmarking purposes. Third, developing innovative design and technology is an emerging trend in the commercial and scientific communities. This paper leads to future research to examine the relative importance of the identified SRs and DRs as well as their interrelationships. In particular, port development experiences tremendous growth which presents ample opportunities of applying the framework in different ports.

ACKNOWLEDGEMENT

This work was supported by Singapore Maritime Institute under the Maritime Sustainability R&D Programme, project SMI2015-MA09.

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PORT AUTHORITY CHALLENGE: FRAMING EFFECT AND PORT RESIDENTS' PERCEPTIONS OF NIMBY FACILITIES TO INTEGRATE THE LOCAL SUSTAINABLE DEVELOPMENT

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Abstract

Operational management of the port often focuses on economic efficiency, and the issues such as neighborhoods, urban development, and/or the stakeholders' demands are significantly ignored. However, the growing attention to communications and relationships in the communities makes the port a NIMBY (Not In My Back Yard) facility and inflicts the port administration a serious pressure. This study draws upon the regulatory focus theory to explore the framing effect on residents' perception and the relationship between their internal attitudes (conservative or active) and displayed traits (socioeconomic status) for enacting effective managerial policies. In a sample of 211 residents in the Port of Taipei, we found that there are two groups, namely, prevention-oriented group and active-oriented group based on the residents' perceptions of the NIMBY port facilities. The former focuses on 'no bad thing', takes all necessary approaches to avoid losses, and appears conservative. We suggest that port administrators need to inform residents about the potential regrets (or losses) in the near future, or use intimidation to induce residents' inner concerns and strengthen participation. In contrast, active-oriented residents pay attention to 'good thing', strive for benefits, and appear risk-taking. Port administrator could continuously encourage and invite residents to participate in port events to foster the relationships of mutual benefit. This research contributes to examine the framing effect and residents' perceptions on port operations. With our findings, the port executives are able to fully elaborate the impact of each policy to the heterogeneous group of people, which is identified through the linkage from socioeconomic status to attitudes.

Keywords Not in my backyard (NIMBY), port, framing effect, regulatory focus theory

1. Introduction

Since environmental sustainability is a global issue, the stringent environmental regulations currently been reinforced in EU countries will be adopted or adapted in other parts of the world (Yu et al., 2009). Operational management of the port often focuses on economic efficiency, and the issues such as neighborhoods, urban development, and/or the stakeholders' demands are significantly ignored. However, the growing attention to communications and relationships in the communities makes the port a NIMBY (Not In My Back Yard) facility and inflicts the port administration a serious pressure.

This study draws upon the regulatory focus theory to explore the framing effect on residents' perception and the relationship between their internal attitudes (conservative or active) and displayed traits (socioeconomic status) for enacting effective managerial policies. In a sample of 211 residents in the Port of Taipei, we found that there are two groups, namely, prevention-oriented group and active-oriented group based on the residents' perceptions of the NIMBY port facilities. The former focuses on 'no bad thing', takes all necessary approaches to avoid losses, and appears conservative.

2. Literature review

Numerous previous studies on NIMBY compensation policies are related to this study. The majority of these studies relevant to the present study are insufficient in data and difficult to access. Most studies in this field have focused around the issues of NIMBY facilities. Examples of these studies include cognition and attitude of residents toward NIMBY facilities, compensation system analysis, spillover effect of NIMBY facilities

According to Chung and Kim (2009), when the perceived risk of the residents is higher, their level of acceptance is lower. Programs involving advocacy (visiting factories), security guarantees, environmental standards, and environmental monitoring can be adopted to reduce the risk and increase the level of acceptance of residents toward NIMBY facilities. In this study, NIMBY behavior is investigated based on reported factors and then extends to a subtle way of segmentation. The effects of these factors on various types of residents are also examined comprehensively.

In extant literature on clustering segmentation, demographic attributes have been used for segmentation. This approach differs from the method used in the current study. For example, Kunreuther and Easterling (1996) report that the tolerance in pollution is positively correlated with age and socioeconomic. The difference between the present study and previous research is the segmentation strategy used. In this study, we assert that an elaborated strategy can be provided for residents with distinct characteristics to satisfy their needs fairly. In addition to general strategies, such as social, economic, and political strategies, the attitude of residents toward NIMBY facilities is examined. Consequently, the related problems are addressed properly.

3. Methodology

Bian and Moutinho (2011) reports that involvement is the degree of how a person feels one thing is related to him/her because of his/her needs, values, and interests. The degree of involvement can explain the participation of residents. Previous studies have revealed that the influence of various dimensions on the acceptance of NIMBY facilities may be affected by the participation of residents. This premise indicates that the degree of involvement influences the level of acceptance of residents toward NIMBY facilities. For example, high-involvement residents understand their needs more comprehensively and are more aware of the compensation system than low-involvement residents; thus, the former group accepts NIMBY facilities more easily than the latter group does. A questionnaire with four dimensions is used in this study to examine whether residents accept NIMBY facilities. In particular, the questionnaire is combined with other external control variables (degree of involvement) to construct a model for the acceptance level of residents toward NIMBY facilities.

3.2 Questionnaire design

3.2.1. Respondents and range

This study excludes other possible interferences to confirm the relationship between residents and facilities. Therefore, we select a community in the neighborhood of Taipei Port. The community is remote and has exhibited slow economic growth with the continuance of tension between the residents and the port.

The questionnaires were completed during the interviews, and the time during which the questionnaires were distributed influenced the types of residents who completed them. Therefore, the timing of questionnaire administration was crucial. The questionnaires were typically administered in the morning to respondents who were unemployed in the area. Respondents employed by companies in the neighborhood accomplished the questionnaire at noon. The demographic data provided in response to the questionnaires were observed. Thus, most people were determined to be accessible after 2:30 PM. These people may be workers who have rotational leave or are self-employed. Thus, various types of residents were interviewed at different times of the day and in different places.

3.2.2. Research design

A pre-test questionnaires were administered for the first time. Then, the questionnaire was revised to suit the conditions of local residents based on the difficulties and setbacks as well as on the thoughts or suggestions expressed by the residents during the first distribution of questionnaires. The language of the questionnaire was written in a simple and clear manner to enable the respondents to understand the content without explanation. After the pilot questionnaire was distributed and revised, the final version was developed.

This questionnaire consists of four major sections, such as basic information, cognition of information, satisfaction with the good-neighborliness compensation system, and level of acceptance toward facilities. These four categories are generated based on related literature mentioned previously.

3.3 Sample representativeness analysis

The demographic structure of this region was the major background variable examined in this study. The distribution of the valid sample (sex distribution and distribution of residents among neighborhoods) was determined in a manner similar to the matrix after comparing the data. Regarding education, residents who were too young or too old were not included because only those who could answer the questions properly were selected. The distribution of the residents' residence location, gender, and education were compared with the aforementioned matrix. The results demonstrated that the samples were similar to the matrix, implying that the sample used in this study was representative.

In terms of the residency period in the area, 39.6% of the respondents have lived in the area for 21 to 30 years. The residents who had a longer residency period exhibited more affection toward the neighborhood. This condition suggested that the responses given by these residents were highly constructive. Among the respondents, 21% had family members or relatives working in the NIMBY facility, implying that the NIMBY facility provided job opportunities to local residents.

4. Analysis

Factor analysis is conducted on the questionnaire items. Common factors are extracted and the dimension is downscaled to maintain the original data. After rotation, the component matrix is ordered according to the amount of load from the common factors, thereby facilitating the examination of the dimension contained in the common factors. Among the common factors, the fifth factor only contains. Therefore, the dimension is extremely small at this level and is inappropriate to construct a single factor. Thus, this dimension is removed. This deletion changed the entire structure of the factor. A second factor analysis is successfully conducted, and the reliability analysis produces satisfactory results. The Cronbach's α value for all the factors is above 0.7, implying that the questionnaire survey used in this study is reliable.

Degree of involvement is considered to influence the level of acceptance, suggesting that various degrees of involvement are associated with distinct levels of concern regarding the perspectives and feelings toward different dimensions.

In practice, ANOVA and regression analysis are conducted on clustered data. ANOVA is particularly conducted to determine whether the intensity of the reaction of every factor is unique in different clusters. Regression analysis is performed to examine the analysis results and realize the meaning of these results from a practical perspective.

The result shows that the three clusters differed on perceived risk, trust, and compensation. These differences indicate that various groups reacted differently to the intensity of these influential variables. The results of the Scheffe multiple comparison method reveal that the intensity of the reaction of Cluster 1 on perceived risk, trust, and compensation is greater than that of Clusters 2 and 3.

The results reveal that the three dimensions notably affected the level of acceptance of the residents toward the facilities. However, a different explanation is developed after a moderator

variable is incorporated into the study. Such change signifies that various clusters placed importance on different dimensions, thereby affecting the residents' acceptance of NIMBY facilities.

The result also demonstrates that Cluster 1 scored 3.98 for the dimension of perceived risk. The score is the highest among the 3 clusters, indicating that perceived risk is the factor that had the most influence on the level of acceptance dimension of Cluster 1. The highest score in Cluster 2 is 3.26, which corresponded to financial support, signifying that compensation is the factor that had the greatest influence on the level of acceptance dimension of Cluster 2. The highest score for Cluster 3 is 2.11, which corresponded to trust, indicating that the dimension of trust influenced the level of acceptance of Cluster 3.

The aforementioned observations further indicated that Cluster 1 had the highest number of people working in the NIMBY facility, indicating that these people had a positive attitude toward the NIMBY facility. Moreover, education is considered as a factor that influences the degree of concern and understanding of the residents toward the NIMBY facility. This factor also indicates that people working for the NIMBY facility are highly educated. A formal name is therefore generated for the group that exhibited a positive attitude and is highly educated, that is, the high-involvement group. The result shows that this group focuses on the dimension of perceived risk.

5. Conclusions

Latent variable analysis is performed in this study to obtain an accurate analysis of the level of acceptance of a set of people toward NIMBY facilities. Previous studies on NIMBY did not consider the diversity of residents. Thus, the structure of the constitution of the clusters could not be fully understood, resulting in the occurrence of NIMBY-related conflicts.

Through target marketing strategies, this study reveals that the residents affected by NIMBY facilities could be divided into several clusters, with each group displaying distinct latent and corresponding traits. We suggest that port administrators need to inform residents about the potential regrets (or losses) in the near future, or use intimidation to induce residents' inner concerns and strengthen participation. In contrast, active-oriented residents pay attention to 'good things', strive for benefits, and appear risk-taking. Port administrator could continuously encourage and invite residents to participate in port events to foster the relationships of mutual benefit. This research contributes to examine the framing effect and residents' perceptions on port operations. With our findings, the port executives are able to fully elaborate the impact of each policy to the heterogeneous group of people, which is identified through the linkage from socioeconomic status to attitudes

The methods to apply the results of this study are crucial in maintaining a close relationship between the residents and the NIMBY authorities, as well as in reducing the conflicts between the residents and the authorities to increase the acceptance level toward NIMBY facilities. Therefore, the results of this study may be regarded as targets of programs that may determine whether the system is complete. The concepts addressed in this study may also be considered when these systems are practiced to ensure that the total benefits and costs are balanced.

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SOLVING THE VEHICLE ROUTING PROBLEM WITH PRACTICAL CONSIDERATIONS

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Abstract

Purpose of this paper:

This study deals with a generalization of the classical vehicle routing problem with time windows (VRPTWs). The problem aims to determine the optimal routes for a fleet of homogeneous vehicles deployed in a depot of a city logistics service provider (CLSP) that services a set of customers, including general customers and enterprise customers. In addition to the constraints of the VRPTW, three practical considerations for the CLSP, namely, service capacity of sales drivers, delivery time preference of customers, and fairness of drivers' performance bonus are explicitly addressed in this problem.

Design/methodology/approach:

A two-stage optimization model-based approach is developed to deal with the practical generalization of the VRPTW. This solution approach adopts the concept of "cluster-first-route-second". The first stage solves a clustering model that divides the set of customers into a given number of clusters, each of which is serviced by a vehicle (or a sales driver). The objective of the clustering model is to minimize the total distance and the maximal performance bonus of the drivers. The service capacity of SDs and the fairness of their performance bonus are taken into account in the clustering model. In the second stage, a routing model is solved to generate the route for servicing each cluster of customers, determined by the clustering model. The objective of the routing model is to minimize the total cost including the traveling cost and the penalty for violating the preferred delivery times of general customers.

Findings:

To examine the performance of the proposed model, this study generates a number of test instances based on the historical data provided by a large CLSP in Taiwan and solves the test instances using Gurobi. The results show that the proposed approach is able to effectively obtain the vehicle routes which address the aforementioned practical concerns for the CLSP.

Value:

The major contribution of this paper is on proposing an efficient approach to deal with the practical generalization of the VRPTW, which greatly facilitate the CLSP effectively planning vehicle routes to service its customers.

INTRODUCTION

Vehicle routing problems (VRPs) have been extensively studied in the field of operations research. The most basic form of VRP involves identifying a set of vehicle routes that incurs the least total cost, given that the capacity of the vehicles and the demands of all the customers (nodes) are known; such routes enable the vehicles to depart from and return to the depot while reaching all the customers exactly once to pick up or deliver their cargoes. In the past decades, different variants of VRPs have been proposed and studied in the literature (e.g., Golden et al., 2008; Toth and Vigo, 2002; Toth and Vigo, 2014). However, to the authors' best knowledge, previous studies that have investigated the VRPs

of city logistics service providers (CLSPs) have failed to fully explore some critical practical issues such as service capacity of sales drivers (SDs), delivery time preference of customers, and fairness of SDs' performance bonus. To fill in this research gap, this study generalizes the classical vehicle routing problem with time windows (VRPTWs; Anbuudayasankar et al., 2014; Solomon, 1987; Kallehauge et al., 2005) to address these practical issues. The problem of interest aims to determine the optimal routes for a fleet of homogeneous vehicles deployed in a depot of a city logistics service provider (CLSP) that services a set of customers. There are two major types of customers: enterprise customers and general (non-enterprise) customers.

In the classical VRPTW (Solomon, 1987), all delivery services must be provided within given (hard) time windows specified by the customers; the CLSP is not allowed to provide services outside of those time windows. In practice, this type of customers are generally *enterprise* customers who have contracts with the CLSP and require regular (daily) logistics services. On the other hand, *general* customers typically specify their preferred delivery times of cargos or parcels. The CLSP is expected to deliver parcels to a general customer at his or her specified preferred time (τ), but is allowed to have a tolerance time (β) for missing the preferred delivery time. Unlike the hard time window constraint of enterprise customers, for a general customer, the parcel is allowed to be delivered outside of the preferred delivery time interval $[\tau - \beta, \tau + \beta]$, but a certain amount of penalty is charged to the CLSP for violating the preferred delivery time interval. For instance, in Fig. 1, the preferred delivery time of general customer 1 is 9:30am and the tolerance time β is 30 minutes, so the preferred delivery time interval is [9am, 10am]. If a sales driver (SD) of the CLSP arrives at customer 1 (from general customer 2) within this time interval (i.e., Lines B, C and D), then there is no penalty charged on the CLSP; otherwise, a penalty is charged on the CLSP if that SD arrives at customer 1 outside the time interval (i.e., Lines A, E and F). In the literature, this type of preferred delivery time intervals is typically regarded as soft time window constraints. As a result, CLSPs need to take into account both hard time window constraints of enterprise customers and (soft) preferred delivery time intervals of general customers when planning the routes of their fleets.

The aforementioned practical considerations for the CLSP, namely, service capacity of sales drivers, delivery time preference of customers, and fairness of drivers' performance bonus are explicitly addressed in the generalization of the VRPTW. A two-stage optimization model-based approach is developed to deal with the practical generalization of the VRPTW. This solution approach adopts the concept of "cluster-first-route-second". The first stage solves a clustering model that divides the set of customers into a given number of clusters, each of which is serviced by a vehicle (or a sales driver). The objective of the clustering model is to minimize the total distance and the maximal performance bonus of the drivers. The service capacity of SDs and the fairness of their performance bonus are taken into account in the clustering model. In the second stage, a routing model is solved to generate the route for servicing each cluster of customers, determined by the clustering model. The objective of the routing model is to minimize the total cost including the traveling cost and the penalty for violating the preferred delivery times of general customers.

To examine the performance of the proposed model, this study generates a number of test instances based on the historical data provided by a large CLSP in Taiwan and solves the test instances using Gurobi. This study also conducts sensitivity and scenario analyses to discuss the impact of the parameters on the solutions. The results show that the proposed approach is able to effectively obtain the vehicle routes which address the aforementioned practical concerns for the CLSP. The major contribution of this paper is on proposing an efficient approach to deal with the practical generalization of the VRPTW, which greatly facilitate the CLSP effectively planning vehicle routes to service its customers.

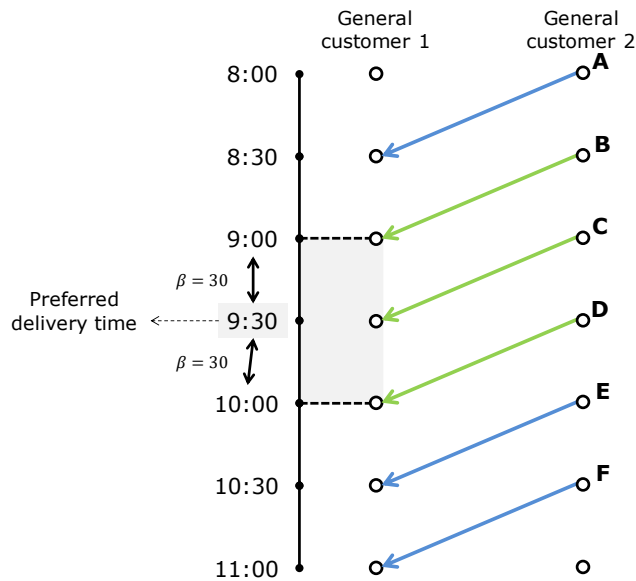


Fig. 1 Illustrative example of preferred delivery time intervals

PROBLEM DESCRIPTION AND ASSUMPTIONS

Given a fleet of identical vehicles (each with capacity Q) and a set of customers with their demand information known, a priori, the classical (single depot) VRPTW aims to find a set of minimum cost vehicle routes, starting from and terminating at a depot, such that (i) each vehicle services one route, (ii) each customer i can be visited only once by exactly one vehicle (i.e., the demand d_i cannot be splitted) within a given time window $[a_i, b_i]$, and (iii) the vehicle capacity Q cannot be exceeded for each route.

The problem addressed in this paper is a practical generalization of the VRPTW that is typically faced by a CLSP. For simplicity, we consider only delivery requests from customers, although the problem with pickup or both pickup and delivery demands can also be handled by slightly modifying the proposed model. The CLSP provides delivery services to both enterprise customers and general customers. In addition to the typical constraints of the VRPTWs, this study takes into account three major practical concerns or needs in generating optimal vehicle routes for CLSPs. These includes (i) the capability of sales drivers (SDs), (ii) the fairness of performance bonus of SDs, and (iii) the delivery time preferences of general customers.

To efficiently provide delivery services in the service area covered by a depot, most of CLSPs would partition the service area into a number of subareas and assign a SD to service the customers in each of the subareas. The daily sequence (or route) for servicing the customers in each subarea is then determined by the SD assigned to that subarea or generated by a computer-aided routing program. This two-stage method belongs to the category of cluster-first-route-second approaches for solving vehicle routing problems (e.g., Fisher and Jaikumar, 1981; Ryan et al., 1993; Taillard, 1993). Fig. 2 depicts an illustrative example of a depot with three subareas, each of which is serviced by a vehicle route departing from and terminating at the depot. In practice, the partition of the service area into subareas is typically performed in the tactical (resource allocation) stage, and the assignment of SDs to the subareas remain the same for a certain period of time (e.g., three to six months), so they will get more familiar with their respective subareas and be able to efficiently plan the service route and provide better customer services. The service route in each subarea is planned daily, as the demand (number of customers and their locations and cargos) changes every day. In most cases, geographic or jurisdictional characteristics are used as the criteria to partition the entire service area of a depot into the subareas. For instance, some CLSPs determine the subareas using the five-digit or three-digit postal codes.

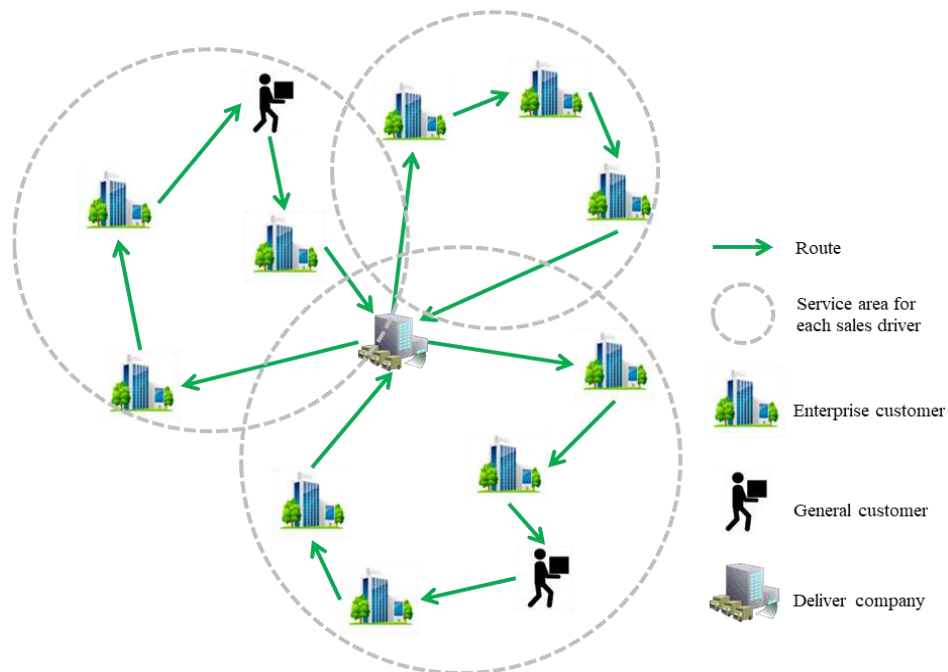


Fig. 2 An illustrative example of a depot with three subareas

The drawback of this partitioning approach is that the amount of demand and the daily variation in demand among the subareas are not considered. When the demand of a subarea (i.e., number of customers) exceeds the service capacity of a SD assigned to that subarea, that SD cannot complete all of the delivery requests in that subarea within a maximum working time per day (e.g., 8-hour), resulting in delivery failure (some of the delivery requests may be delayed to the next day) and customer complaints. Following the practices of most CLSPs, this study defines the service capacity of a SD as the number of customers which can be serviced by that SD within the maximum working time per day (e.g., 8-hour per day). The service capacity of a SD can be determined as a function of age, working attitudes, familiarity with the subarea assigned to that SD, years of service (seniority) in the logistics industry or company, and etc. Different CLSPs use distinct criteria or methods to measure the service capacity of their SDs. The service capacity may differ significantly among SDs and hence, has to be taken into account when CLSPs partitions the service area and assigns a subarea to a SD. Fig. 3 shows an illustrative example of two SDs with different service capacities; the service capacities of SDs A and B are three and four, respectively, within a given maximum working time.

Moreover, significant differences in demand among the subareas will cause unbalanced workloads among SDs, which result in the unfairness of their performance bonuses and the complaint of SDs. The purpose of rewarding performance bonuses to SDs is to maintain their work efficiency. In general, SDs receive their performance bonuses according to the number of customers they have serviced or the freight charge of cargos they have picked up. For example, a large CLSP in Taiwan rewards each of its SDs US\$0.25 for each cargo delivered and 7% of the freight charge for each cargo picked up. To maintain balanced workloads and a fair distribution of performance bonuses, the manager has to carefully assign the subareas and customers to SDs.

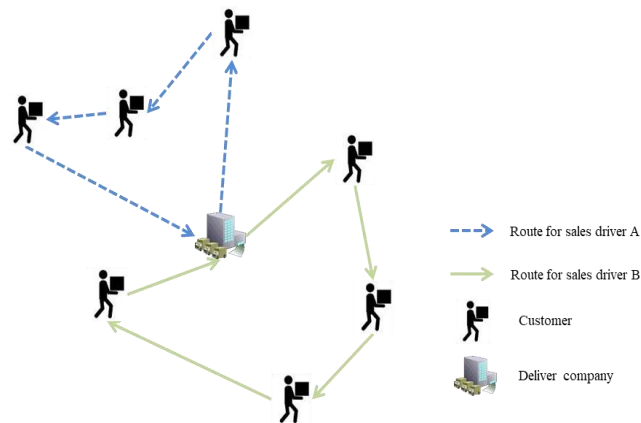


Fig. 3 An illustrative example of two SDs with different service capacities

SOLUTION APPROACH

This study develops a two-stage optimization model-based approach to solve the problem described in the previous section. This solution approach adopts the concept of "cluster-first-route-second", which performs a single clustering of the (customer) vertex set and then determines a vehicle route on each cluster. Fig. 4 shows an illustrative example, where the customers are divided into four clusters and then the optimal route (or delivery sequence) for each cluster is determined.

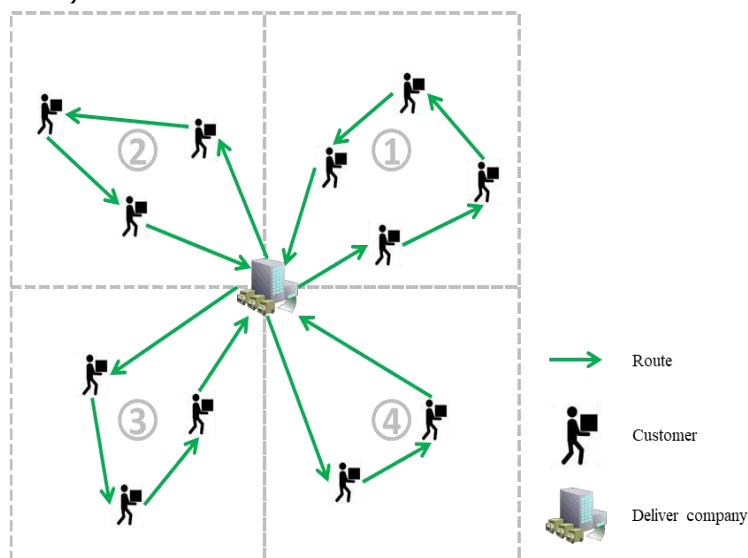


Fig. 4 Illustrative example of the cluster-first-route-second approach

In the first stage (or clustering stage), the set of customers is partitioned into p clusters, where p is the number of SDs, and each customer is assigned (or allocated) to one cluster (or SD). Instead of using heuristics (e.g., Fisher and Jaikumar, 1981; Ryan et al., 1993; Taillard, 1993) to determine the clusters and to assign the customers, this study proposes a p -median-based clustering model and solves the model to obtain the p clusters of customers. The objective of the clustering model is to minimize (i) the total travel distance between the customers and p cluster centers and (ii) the maximal performance bonus of the SDs. The purpose of minimizing the maximal performance bonus of the SDs is to prevent some SDs with large service capacity from collecting much larger bonuses than other SDs (e.g., fresh SDs), hence avoiding an unfair performance bonus distribution (i.e., balancing the performance bonuses of the SDs). The constraints of the clustering model ensure that each customer is assigned to a cluster and take into account the capacity of the vehicles, the service capacity of SDs, and the minimal bonus requirement for the SDs. Coupling the objective which minimizes the maximal performance bonus of the SDs and

the constraint which guarantee the minimal performance bonus for the SDs enable the model to achieve the fairness of the bonuses of the SDs.

As mentioned previously, the partition of the service area into subareas typically is performed in the tactical (resource allocation) stage, and the assignment of SDs to the subareas remain the same for a certain period of time (e.g., three to six months), so they will get more familiar with their respective subareas and be able to efficiently plan the service route and provide better customer services. If we consider that the clustering of customers is equivalent to the partitioning of the service area into subareas, then the CLSP would prefer less changes in the clusters for a short-term planning horizon. For this case, the center of each cluster is fixed (and predetermined) in the proposed p -median-based clustering model, and this model is called the fixed-center clustering model. Actually, since the cluster centers (or the location of the centers) are fixed, *a priori*, this model is reduced to determining only the allocation of the customers to the given cluster centers.

The disadvantage of this fixed center clustering model is that the amount of demand and the daily variation in demand among the clusters are not taken into account. To address this issue, we propose an alternative non-fixed-center clustering model that determines both the location of the cluster centers and the allocation of the customers to the selected centers. The clustering results (i.e., subareas) produced using the non-fixed center model may change from day to day because of changes in the daily customer demands. As a result, the non-fixed-center model is suitable for the CLSP which faces varying daily demands and has the flexibility to adjust its fleet to service frequently changing subareas.

In the second stage (or routing stage), the routing problem for each cluster (or SD) is solved to determine the delivery sequence of the customers assigned to that cluster. Because the constraints such as vehicle capacity and SD capability have already been considered in the first (clustering) stage, the routing problem can be considered as the traveling salesman problem with (hard) time window constraints for enterprise customers and (soft) preferred delivery time intervals for general customers. An optimization model is formulated accordingly. The objective of the model is to minimize (i) the total travel cost of the vehicles and (ii) the (penalty) cost for violating the preferred delivery time intervals of general customers. In practice, if a SD fails to deliver to a general customer within the preferred delivery time interval of that general customer, the CLSP would provide a discount on the delivery charge and the reduced price can be viewed as the penalty to the CLSP for violating the preferred delivery time interval of that general customer. The constraints of the routing model are the typical constraints for the traveling salesman problem with time windows (TSPTW).

In summary, the capability (i.e., service capacity) and the fairness of performance bonus of SDs are addressed in the clustering model (first stage), and the delivery time preferences of general customers is considered in the routing model (second stage).

NUMERICAL ANALYSIS

To examine the performance of the proposed two-stage optimization model-based approach, this study conducted numerical experiments using the test instances generated from the data provided by a large CLSP in Taiwan. The daily operational time of the CLSP is between 8 a.m. and 8 p.m. (a total of 12 hours). We considered a branch of the CLSP that has four SDs (i.e., subareas or clusters). The service area of this branch is approximately a square measuring 40km by 40km. The depot of this branch locates at around the center of the service area. The centers of the four clusters used in the fixed-center clustering model were suggested by the CLSP according to its historical data.

There are 10 test instances generated as follows. There are 100 customers in each test instance, where 20% of them are general customers and 80% of them are enterprise customers. The time windows of the enterprise customers were randomly generated in the three time periods: 8:00 a.m.–12:00 p.m., 12:00 p.m.–5:00 p.m., and 5:00 p.m.–8:00 p.m. The preferred delivery times of the general customers were randomly generated within the range 8:00 a.m.–8:00 p.m. The number of cargoes to be delivered ranged from 5 to 20 for each SD. The parameters values used in the computational experiments are

summarized in Table 1.

Table 1 The parameters used in the computational experiments

Total number of customers	100	θ (%): performance bonus of each delivery computed as the percentage of the cargo value	7%
Number of general customers	20	α (NT\$/minutes): penalty per minute for violating the preferred delivery time interval of general customers	100
Number of enterprise customers	80	β (min): tolerance time for missing the preferred delivery time of general customers	30
Number of clusters	4	vehicle speed (km/hrs)	35
Service capacity of the four SDs	26, 27, 28, 27	service time rate (cargo in Kg /min)	2
Minimum performance bonus (NT\$)	1200	gas price (NT\$/L)	25
the capacity of vehicle	800	gas consumption rate (km/L)	11.5

The test instances of the two-stage optimization models were solved using Gurobi. The computational experiments were conducted on the personal computer with Intel(R) Core(TM) i5-4570 CPU@3.20GHz and 4.0GB RAM and the operating system is Microsoft Windows 10. The computational results of solving the 10 test instances are summarized in Table 2.

In the clustering stage, the average total travel distance is a bit higher in the fixed-center clustering model (742.53) than in the non-fixed-center clustering model (710.46). The fixed-center model also produces a larger range of performance bonus (15.75) than the non-fixed-center model (6.65). Thus, the non-fixed-center model outperforms the fixed-center model for the two objectives in the first stage, although the differences in the two objectives of the two models are not very large. Note that the range of performance bonus in the two models is very small, indicating that the proposed approach is able to attain the fairness of performance bonus for the SDs.

In the routing stage, the average total vehicular travel cost obtained by the fixed-center model (2186.97) is slightly larger than that obtained by the non-fixed-center model (2131.47). The average total penalty for violating preferred delivery time intervals of the fixed-center model (44541.85) is much smaller than that of the non-fixed-center model (49624.73). Since the differences in the two objectives of the two models are insignificant in the clustering stage, it is reasonable that we can use the sum of the two objectives (total vehicular travel cost and total penalty cost) as the measure of effectiveness (MOE) to evaluate the two clustering models. The results show that while both models are able to attain the fairness of performance bonus for the SDs, the non-fixed-center model is more effective than the fixed-center model (because the former generates less-cost solutions). However, the better solution quality obtained by the non-fixed-center model is gained at the expense of significantly larger computational times. The average computational times of the fixed-center model and non-fixed-center model are 317.17 sec and 3152.21 sec, respectively.

Table 2 Computational results

			Fixed-center clustering model	Non-fixed-center clustering model
Clustering stage	Total travel distance (km)	Avg.	742.53	710.46
		Std.	12.72	12.78
		Max.	772.99	732.11
		Min	726.50	686.89
	The range of performance bonus (NT\$)	Avg.	15.75	6.65
		Std.	4.74	3.48
		Max.	21	14
		Min	10.5	3.5
Routing stage	Total travel cost of the vehicles (NT\$)	Avg.	2186.97	2131.47
		Std.	63.46	39.22
		Max.	2273.71	2174.21
		Min	2065.77	2054.09
	Total penalty for violating preferred delivery time intervals (NT\$)	Avg.	44541.85	49624.73
		Std.	3163.00	7284.64
		Max.	51399.71	58775.85
		Min	40545.41	38522.56
Computational time (sec)	Avg.	317.17	3152.21	
	Std.	132.12	1613.33	
	Max.	618.147	6255.113	
	Min	161.293	1413.472	

CONCLUDING REMARKS

With the aim to address the practical concerns of the CLSP (the capability of SDs, the fairness of performance bonus of SDs, and the delivery time preferences of general customers), this study proposes the aforementioned two-stage optimization model-based approach to deal with the practical generation of the VRPTW. This solution approach adopts the concept of "cluster-first-route-second". The first stage solves the (fixed-center or non-fixed-center) clustering model that divides the set of customers into a given number of clusters, each of which is serviced by a vehicle (or a sales driver). The objective of the clustering model is to minimize (i) the total travel distance between the customers and the cluster centers and (ii) the maximal performance bonus of the drivers. The service capacity of the SDs and the fairness of their performance bonus are taken into account in the clustering model. In the second stage, the routing model with TSPTW constraints is solved to generate the route for servicing each cluster of customers, determined by the clustering model. The objective of the routing model is to minimize (i) the total vehicular travel cost and (ii) the penalty for violating the preferred delivery times of general customers.

To examine the performance of the proposed model, this study generates a number of test instances based on the historical data provided by a large CLSP in Taiwan and solves the test instances using Gurobi. This study also conducts sensitivity and scenario analyses to discuss the impact of the parameters on the solutions. The results show that the proposed approach is able to effectively obtain the vehicle routes which address the aforementioned practical concerns for the CLSP.

ACKNOWLEDGMENTS

This research was supported by grants (MOST 105-2410-H-009-062-MY3) from the Ministry of Science and Technology and from the Ministry of Education, Taiwan.

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ABSTRACT

Consumers recognized the benefits of locally produced food, which represents an alternative to the global food model, where food travels long distances before it reaches the consumer. Local food movement is all about the desire to eat in a way that does not have negative impacts on the environment. Reducing energy use in the food system, increasing crop diversity or biodiversity, and improving land use patterns are the main environmental issues addressed by local food system advocates. Consumers choose food from local producers over the one from industrialized food system, because they believe it tastes better and has more nutrition. Although, these are subjective perceptions of quality and should not be over interpreted as objective attributes of local food. Nonetheless, local food is the fastest growing segment of agriculture due to strong consumers' demands for local produced food.

KEY WORDS: Distribution, Locall produced food, Logistics

INTRODUCTION

It is hard to determine what makes a food "local", and there is no single definition of local within the movement. Some will define local foods based on a number of miles, or a county, or a watershed, but local food resists being defined strictly in terms of a number of miles the food has travelled (Werner, 2013). Nonetheless, range up to 60 kilometres between the grower and consumer has been determined by agronomic experts, as acceptable for defining local food. The supply system, which is carried out in these criteria, is also called "short chains system", which means that the food was produced, processed and distributed on local markets. In Slovenia, The Agriculture Act (Zakon o kmetijstvu, Uradni list RS, No. 45/2008) defines the local market as the whole territory of the Republic of Slovenia.

Food miles is a term which refers to the distance food is transported from the time of its production until it reaches the consumer. Food miles are important factor used when assessing the environmental impact of food, including the impact on global warming. The environmental impact caused by transport can be reduced by using alternative energy sources. This study is about possibility of replacing fossil fuels with electrical energy as a source of power in local distribution of strawberries.

METHODS AND RESULTS

The purpose of the research is to determine the convenience of the use of electric vehicles in the delivery of locally grown food. We surveyed 28 different food producers across Slovenia. With the questionnaire, we wanted to define the characteristics of the delivery of local grown foods and to associate them with the parameters that influence the range of electric vehicles.

The biggest deficiency of electric vehicles is their range. Due to limitations in battery technology, the range of the electric vehicle is typically 100-300 km, which is insufficient to meet the requirements of the driver who performs longer distances (Wang & Liu). Given the average distance of delivery, 69% of respondents answered that their average delivery is up to 60 km (Fig. 1), which is sufficient for the use of electric vehicles without charging.

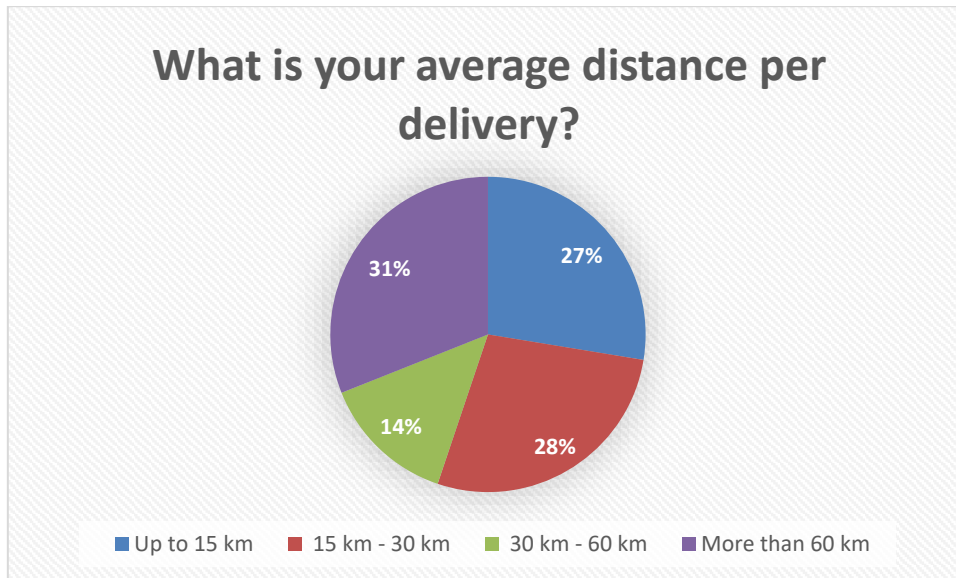


Fig. 1: Average distance per delivery (N=28)

The range of any vehicle depends on various factors that can increase energy consumption. One major factor in this area is heating and air conditioning, for electric vehicles it can also mean a 10% lower range. The most important factor in the consumption of electricity is the speed at which we drive, the wind resistance is proportional to the square of the speed, so the increase in speed for only a few kilometres per hour is caused by a great resistance. For example, Tesla S 85D has a range of 772 kilometres at 72km/h or just 432 kilometres at 120 km/h (Anthony, 2014). According to our survey, 76% of respondents answered that delivery is mostly carried out on regional and express roads, 14 % answered that their delivery is only done on regional roads and 10 % that is mainly done on regional roads.

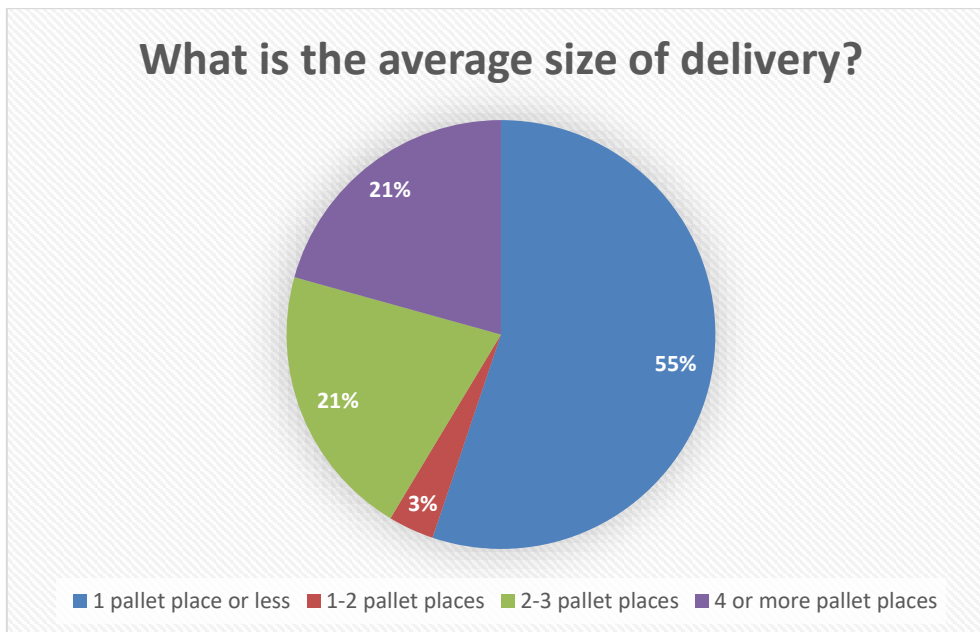


Fig. 2: Average size of delivery (N=28)

Another important factor that affects range of electric vehicles is terrain. Driving an electric car in the hilly terrain consumes more energy than driving on a flat terrain. The vehicle does not use electricity while driving downhill but requires a lot of power to drive uphill. 59 % of respondents answered that they mostly drive both, in the hilly as well as flat terrain. That delivery takes place mainly on flat terrain answered 41 % of respondents.

It is assumed that producers who deliver a shipment in size of two pallets or more per delivery use a van or larger delivery vehicle. As shown on Fig. 2, majority of respondents (55 %) need one pallet place or less per delivery, which can be done with light commercial vehicle class.

CASE STUDY

Case study was made about possibility of replacing fossil fuels vehicles with electrical vehicles in a local distribution of strawberries from Dolenjska region. As the The Agriculture Act (Zakon o kmetijstvu, Uradni list RS, No. 45/2008) defines the local market as the whole territory of the Republic of Slovenia, connections to six biggest towns in Slovenia were selected. For the analysis, a Nissan e-NV200 with electric and Nissan NV200 with diesel engine were chosen. The power consumption of the car was calculated according to the online application (Green race, 2018), which calculates the average electricity consumption according to the selected route. The application detects the inclination and the regenerative braking of the car.

Depending on the locations of the producers, we selected the nearest rapid charge station and defined it as the starting point for distribution. The fastest route to the six largest towns in Slovenia was determined (Fig. 3). Strawberries are defined as perishable goods, that's why we selected only rapid charge stations, the loss of time on other charging stations can significantly affect the quality of the transported goods. The main town markets are marked with numbers, letters represent rapid charging stations which are intended for use on certain routes (Fig. 3).

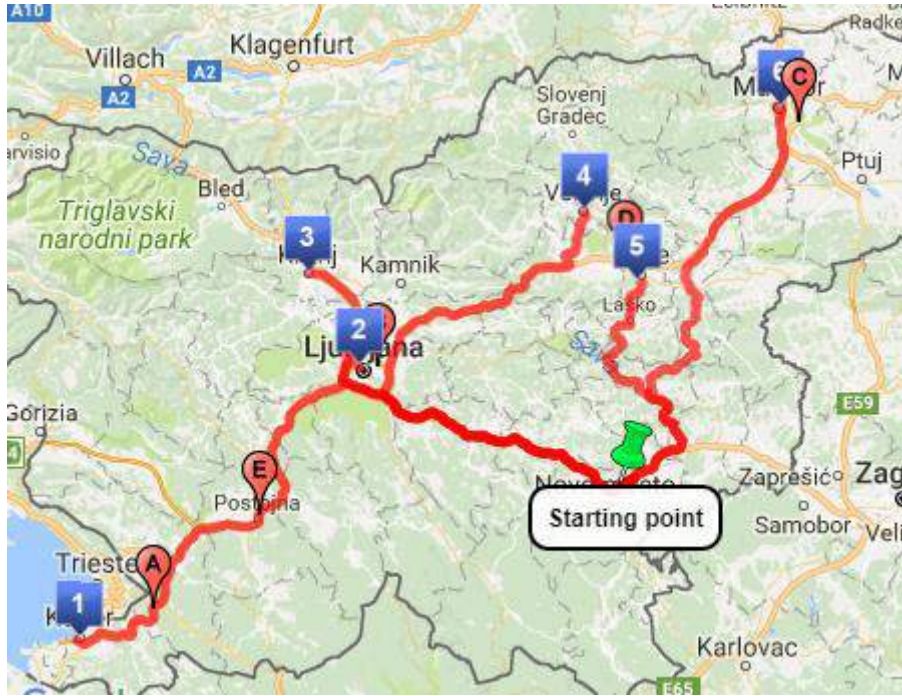


Fig. 3: The fastest route to the six largest cities in Slovenia.

Time efficiency of electric vehicles

According to technical specifications Nissan e-NV200, it takes 30 minutes to charge the battery up to 80%, when using rapid charge. Fast charging takes about 4 hours to fully charge your Nissan e-NV200, and standard charging takes 10 hours. It was assumed that the vehicle left the starting point with a full battery. The given distances in the table also include the return of the vehicle to the starting point.

The biggest loss of time is noticeable on the longest route, from Novo mesto to Koper (Table 1). The reason for this is the need for multiple recharging. Since the whole route to Koper is on the highway, electricity consumption is significantly higher. High consumption can also be attributed to driving without regenerative braking. The average time loss because of charging electric vehicle is 37 minutes. If we do not take into account the route to Koper, the average loss of time is 24 minutes due to charging.

Table 1: Time efficiency comparison

Start: Novo mesto	Distance (km)	Time (h)		Time difference (h)
		Electric vehicle	Diesel vehicle	
[1] Koper	346	05:25	3:44	1:41
[2] Ljubljana	146,1	02:14	1:36	0:38
[3] Kranj	207	02:44	2:14	0:30
[4] Velenje	190	04:00	3:42	0:18
[5] Celje	160,4	03:03	2:49	0:14
[6] Maribor	250	04:17	3:55	0:22

Route cost comparison

Nissan NV200 with diesel engine has a combined consumption of 4.9 litters per 100 kilometres. The diesel fuel price taken into account in the study was 1,217 € per litter. Data on the consumption of electric vehicles was calculated according to the application "Green race" (Green race, 2018). The required charging time was calculated according to

the specifications of the Nissan e-NV200, which means that we need 30 minutes to charge up to 80% of the battery. According to this information, our car requires 0.375 minutes to charge 1% of the battery, which amounts to 0.06 € on a quick charging station. Energy that remained in the car at the end of the route was subtracted from the final value, so that actual cost of driving was calculated.

Table 2: Total price per route per month

Route	Total price of a route (€)	
	Electric vehicle	Diesel vehicle
[1] Koper	50,95	61,90
[2] Ljubljana	11,35	26,14
[3] Kranj	16,93	37,03
[4] Velenje	8,83	33,99
[5] Celje	5,23	28,70
[6] Maribor	15,49	44,72
SUM	123,69	232,48

Table 2 shows the costs of an electric and diesel vehicle for a period of one month. The assumption was made that all routes are done three times a month. Cost for each route was calculated according to the prices of electricity on fast filling stations and the price of a diesel. Price of charging when the car is connected to the domestic power grid was also added. For this study, it was estimated that the electric vehicle is filled with 30 kWh which amounts to 1,74 €.

As can be seen in the table 2, driving with an electric car is more economical, despite the use of quick filling stations while driving. Savings at the monthly level amount to 108,79 €.

Environmental impact comparison

Nissan NV200 releases 131 grams of CO₂ emissions per kilometre, according to the online brochure. The calculated values are based on the sum of kilometres for each route and represent the product of kilometres and grams of CO₂ emissions per kilometre. Nissan e-NV200 electric vehicle does not generate CO₂ emissions during operation. However, it is necessary to take into account the CO₂ emissions that occur in the production of electricity. According to data from the Green Race application (Green race, 2018), the amount of CO₂ emissions produced during the operation of an electric car was calculated. For each route, the energy used (kWh) was multiplied by the average value of CO₂ emissions generated by the production of electrical energy in Slovenia between 2002-2015 (Institut "Jožef Stefan", 2018).

Table 3: Environmental impact comparison

Route	Electric vehicle		Diesel vehicle
	Average energy use (kWh/100km)	CO ₂ Emissions (kg)	CO ₂ Emissions(kg)
[1] Koper	24,83	42,96	45
[2] Ljubljana	21,4	15,63	18,99
[3] Kranj	24,29	25,14	26,91
[4] Velenje	13,42	12,75	24,7
[5] Celje	13,93	11,17	20,85
[6] Maribor	15,6	19,50	32,5
SUM		127,15	168,94

As shown in the table, the emissions of CO₂ depend on the consumption of an electric car. If the average with respect to all the routes is compared, 24.73% less emissions are generated while driving an electric car. Differences are greater when driving on regional roads, routes from Novo mesto to Maribor, Velenje and Celje have an average deviation of produced CO₂ emissions of 55.6% in favour of an electric car.

CONCLUSION

Given the average distance of delivery, 69% of respondents answered that their average delivery is up to 60 km, which is sufficient for the use of electric vehicles without charging. Majority of respondents (55 %) need one pallet place or less per delivery, which can be done with light commercial vehicle class like Nissan NV200.

All the routes that include the highway were poorly assessed compared to a diesel vehicle. It was found out that conventional vehicles are more suitable for driving on the highway while the electric vehicle is more suitable for urban delivery or delivery across the region. When comparing environmental performance, the results are similar. When driving on the motorway CO₂ emissions are similar. But when driving on regional roads, emissions are significantly lower with electric vehicle compared to diesel. We can conclude that the use of electric vehicles for the delivery of locally grown foods is efficient both financially and ecologically, in cases where delivery takes place on local roads to the nearest towns.

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THE STUDY OF GRAIN IMPORTERS' TRANSPORT MODE CHOICE BEHAVIOR

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Organisation(s): National Taiwan Ocean University, Taiwan

Abstract

Purpose of this paper:

The ocean freight and charter hire have dropped rapidly from their peak and this decrease is down-spiraled consistently since 2008. During this period of time, the amount of grain cargo imported to Taiwan by bulk carriers is not able to overtake its historical high level in 2002 yet.

The main focus of this research is to investigate criteria considered by the importers of the grain processing industry in their shipping mode choice behavior and analyze the degree of importance of and the degree of their satisfaction on these criteria. Finally appropriate management strategies for bulk shipping companies, container shipping companies, and their stakeholders are provided.

Design/methodology/approach:

This study is to investigate the criteria influencing grain importers' transportation mode choice behavior and the degree of these grain importers' overall satisfaction on employing dry bulk carriers and container carriers to carry their imported grain cargoes in Taiwan. The authors firstly consulted with executives in the grain silo industry to find appropriate criteria and then use these criteria to develop an analytic hierarchy process (AHP) research model and this research also employ the fuzzy MCDM technique to find out the degree of grain importers' overall satisfaction on using different shipping modes to imported their grain cargoes.

Findings:

Using fuzzy MCDM technique, the author have found the degree of grain importers' overall satisfaction on using dry bulk carrier is better than on using container carriers to carry their imported grain cargoes. Looking into the two shipping modes' performance in various evaluation criteria, the dry bulk shipping mode outperformed the container shipping mode in purchase quantity, handling shortage and flexibility, except for their storage costs. Using dry bulk shipping is perceived to be much excellent than using the container shipping to deliver grain cargoes. But the degree of consignee's and shipper's satisfaction of using container shipping delivery model has the tendency to catch up with the bulk delivery.

Value:

Understanding the criteria influencing grain importers' transportation mode choice behavior, the grain silo operators can then realize the future possible development of grain importers and can negotiate a favorable lease contract with the Port Corporation during their next contract-renew period accordingly. The Taiwan International Port Corporation may also use this research finding to plan their future grain silo facilities development strategy.

1. Introduction

The Eastern Media International Corp. (EMIC), was previously known as the Far Eastern Silo Corp., is the biggest imported bulk grain silo operator in Taiwan. In addition to traditional bulk grain handling business, the EMIC began to handle and stored containerized grain cargoes since 2006. Statistical data reported by the Customs Administration and various grain silo operators is used to calculate the total grain cargoes imported by various grain silo operators and containers between 2006 and 2016 in Taiwan. Table 1.1 illustrates that Taiwan imported around 8 million tones grains annually. To show the relationship between the dry bulk shipping ocean freight and the amount of grains imported by containers, Figure 1.1 is drawn to

indicate Baltic Panamax Index (BPI) and the trend of the amount of bulk grains and containerized grains unloaded in Taiwan. Figure 1.1 indicates there is indeed a moderate correlation between Baltic Panamax Index (BPI) and the amount of grain cargoes imported by containers in Taiwan.

Table 1.1 Total imported grain amount (Corn, soybean, barley, wheat, sorghum and others) between 2006~2016

Year	1. Eastern Media International Corporation + Quayside withdraw (Bulk)		2. Taiwan Sugar Corporation (Bulk)		3. Grain containerized transportation		Customs (Total import amount = 1 + 2 + 3)	
	Amount	%	Amount	%	Amount	%	Amount	%
2006	6,556,616	75.96	356,278	4.13	1,719,039	19.91	8,631,933	100.00
2007	3,898,384	48.29	292,314	3.62	3,881,782	48.09	8,072,480	100.00
2008	2,435,461	32.80	192,003	2.59	4,798,480	64.61	7,425,944	100.00
2009	5,273,249	63.45	241,287	2.90	2,797,334	33.65	8,311,870	100.00
2010	6,337,413	72.18	213,908	2.44	2,228,740	25.38	8,780,061	100.00
2011	4,999,028	62.91	249,723	3.14	2,698,025	33.95	7,946,776	100.00
2012	5,411,053	67.13	245,793	3.05	2,404,796	29.83	8,061,642	100.00
2013	5,087,898	67.46	211,251	2.80	2,243,070	29.74	7,542,219	100.00
2014	5,476,518	70.09	101,835	1.30	2,235,710	28.61	7,814,063	100.00
2015	6,309,135	80.64	203,882	2.61	1,310,227	16.75	7,823,224	100.00
2016 Jan.~Nov.	5,692,458	77.81	133,667	1.83	1,489,609	20.36	7,315,734	100.00

Source: Customs Administration, Ministry of Finance, Eastern Media International Corporation

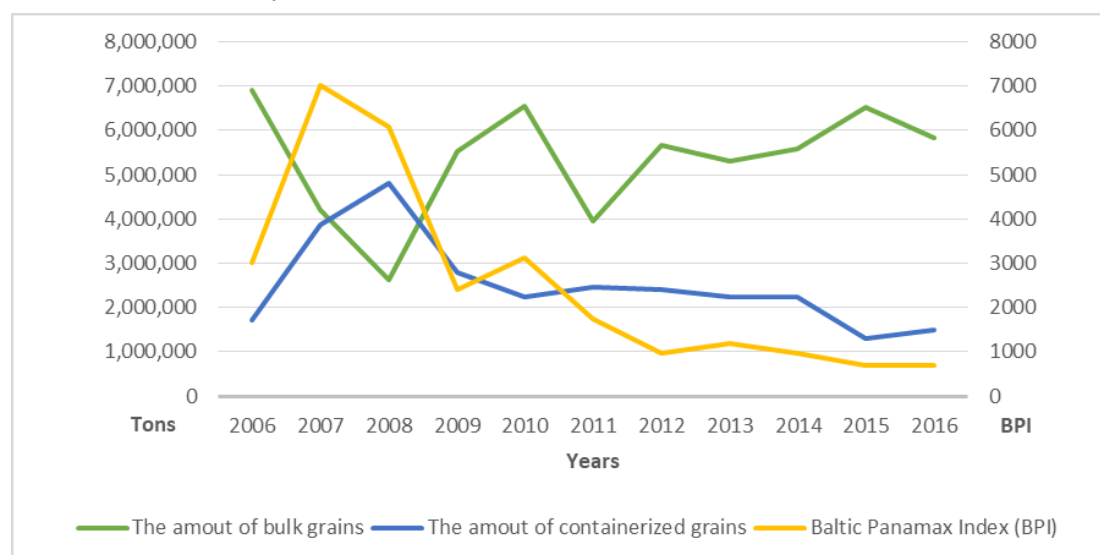


Figure 1.1 Comparison of imported grain transportation modes and Baltic Panamax Index (BPI) between 2006~2011

Source: Compiled by this study

Table 1.1 and Figure 1.1 together have indicated that the downturn of Baltic Panamax Index (BPI) does not make all of the containerized grains shippers to stop use the containers to move their grains. The amount of imported grains previously

moved by containers remained at around 20% even after the decrease of Baltic Panamax Index (BPI). Judging from this, there should be no doubt that containerized grain shipping is and will continue to be as one of the regular transportation modes used by the grain cargo shippers.

This study analyzes the data obtained from an industry-wide questionnaires survey to investigate the degree of importance of various criteria influencing grain importers' transportation mode choice behavior, and also aims to find their degree of satisfaction on these influential criteria in bulk grain shipping and containerized grain shipping. Finally, appropriate management strategies for bulk shipping companies, container shipping companies, and their stakeholders are obtained by using the importance-performance analysis technique.

2. Method

Interview:

Interviews can be defined as a qualitative research technique involved with conducting intensive individual interviews with a small number of respondents to explore their viewpoints on a particular idea, program or situation. (Boyce, C. & Neale, 2006)

Advantages of interviews include possibilities of collecting detailed information about research questions. Moreover, in this type of primary data collection researcher has direct control over the flow of process and also has a chance to clarify certain issues during the process if needed. Disadvantages, on the other hand, include longer time requirements and difficulties associated with arranging an appropriate time with perspective sample group members to conduct interviews (Dudovskiy, 2018)

Analytic hierarchy process (AHP):

The Analytic Hierarchy Process (AHP) is a decision-making procedure originally developed by Thomas Saaty. Its primary use is to offer solutions to decision problems in multivariate environments, in which several alternatives for obtaining given objectives are compared under different criteria. The AHP establishes decision weights for alternatives by organizing objectives, criteria and sub-criteria in a hierarchic structure (Bernasconi, 2010).

The analytic hierarchy process (AHP) provides the objective mathematics to process the inescapably subjective and personal preferences of an individual or a group in making a decision. Fundamentally, the AHP works by developing priorities for alternatives and the criteria used to judge the alternatives. With the AHP, a multidimensional scaling problem is thus transformed to a uni-dimensional scaling problem (Saaty, 2001).

Fuzzy Set Theory:

A fuzzy set is a class of objects with a continuum of grades of membership. Such a set is characterized by a membership (characteristic) function which assigns to each object a grade of membership ranging between zero and one. The notions of inclusion, union, intersection, complement, relation, convexity, etc., are extended to such sets, and various properties of these notions in the context of fuzzy sets are established. In particular, a separation theorem for convex fuzzy sets is proved without requiring that the fuzzy sets be disjoint. (Zadeh, 1965)

Since its inception in 1965, the theory of fuzzy sets has advanced in a variety of ways and in many disciplines. Applications of this theory are found in researches involving with artificial intelligence, computer science, medicine, control engineering, decision theory, expert systems, logic, management science, operations research, pattern recognition, and robotics. Mathematical developments of fuzzy set theory have already advanced to a very high standard (Zimmermann, 2010).

Fuzzy analytic hierarchy process (FAHP):

FAHP is used in determining the weights of the criteria by decision-makers and then rankings of the methods are determined by AHP. The fuzzy logic principle to AHP is firstly proposed by Van Laarhoven and Pedrcyz (1983). The proposed FAHP method is also latter then applied in various scenarios, including the selection of the most appropriate mining methods for Jajarm Bauxite Mine in Iran (Naghadehi, 2009).

3. Result and discussion

The criteria in the questionnaires are based on twelve criteria reported by Determinants of Grain Shippers' and Importers' Freight Transport Choice Behavior (Lirn & Wang, 2013). The structural interviews technique is employed as a method to consult with experts who have actually participated in the decision-making to review the degree of importance of each criteria and to include the other criteria in addition to those reported by Determinants of Grain Shippers' and Importers' Freight Transport Choice Behavior (Lirn & Wang, 2013). After the amendments, it was found there are twelve criteria influencing importers' sea transport mode choice behavior: grains market price, storage cost, transportation cost, procurement price, quality variation, procurement quantity, information transparency, over/short (un) loading, flexibility, delivery time, berthing duration, and transportation time.

Weight Calculation:

In this study, thirty-four questionnaires were retrieved. The Expert Choice software is used to calculate the degree of relative importance of the above-mentioned twelve criteria with the responses replied by the surveyees as shown in the Table 3.1.

Table 3.1 The degree of importance of each dimensions and criteria perceived by experts 1~9 who has replied the survey

Experts Dimension, Criteria	P1	P2	P3	P4	P5	P6	P7	P8	P9
1. Price risk	0.466	0.436	0.649	0.243	0.490	0.143	0.078	0.467	0.454
1.1 Grains market price	0.085	0.198	0.043	0.022	0.064	0.009	0.004	0.077	0.023
1.2 Storage cost	0.039	0.034	0.057	0.022	0.044	0.012	0.005	0.025	0.025
1.3 Transportation cost	0.053	0.029	0.382	0.021	0.036	0.053	0.022	0.076	0.197
1.4 Procurement price	0.289	0.175	0.167	0.178	0.346	0.069	0.047	0.289	0.209
2. Quality control	0.467	0.486	0.072	0.088	0.059	0.429	0.487	0.066	0.455
2.1 Quality variation	0.322	0.201	0.051	0.038	0.027	0.030	0.281	0.028	0.227
2.2 Procurement quantity	0.036	0.175	0.009	0.033	0.004	0.207	0.114	0.027	0.170
2.3 Information transparency	0.046	0.058	0.007	0.006	0.004	0.164	0.057	0.006	0.029
2.4 Over/short (un) loading	0.063	0.052	0.005	0.011	0.024	0.028	0.035	0.005	0.029
3. Time control	0.067	0.078	0.279	0.669	0.451	0.428	0.435	0.467	0.091
3.1 Flexibility	0.038	0.029	0.013	0.038	0.056	0.026	0.091	0.255	0.042
3.2 Delivery time	0.021	0.029	0.136	0.106	0.056	0.035	0.280	0.130	0.036
3.3 Berthing duration	0.004	0.007	0.029	0.137	0.056	0.160	0.042	0.038	0.004
3.4 Transportation time	0.004	0.013	0.101	0.388	0.283	0.207	0.022	0.044	0.009

Source: Compiled by this study

Table 3.2 The degree of importance of each dimensions and criteria perceived by experts 11~22 who has replied the survey

Experts Dimension, Criteria	P11	P12	P13	P14	P15	P16	P18	P19	P22
1. Price risk	0.490	0.637	0.490	0.658	0.104	0.487	0.105	0.200	0.747
1.1 Grains market price	0.347	0.360	0.025	0.270	0.045	0.211	0.029	0.080	0.185
1.2 Storage cost	0.030	0.035	0.026	0.059	0.005	0.021	0.010	0.007	0.032
1.3 Transportation cost	0.027	0.075	0.115	0.059	0.009	0.066	0.009	0.033	0.067
1.4 Procurement price	0.086	0.167	0.324	0.270	0.045	0.189	0.057	0.080	0.463
2. Quality control	0.451	0.258	0.451	0.186	0.637	0.435	0.096	0.600	0.119
2.1 Quality variation	0.316	0.142	0.296	0.013	0.400	0.138	0.008	0.343	0.057
2.2 Procurement quantity	0.045	0.014	0.042	0.121	0.148	0.178	0.055	0.039	0.005
2.3 Information transparency	0.045	0.077	0.021	0.036	0.030	0.017	0.021	0.037	0.012
2.4 Over/short (un) loading	0.045	0.025	0.092	0.016	0.059	0.102	0.012	0.181	0.045
3. Time control	0.059	0.105	0.059	0.156	0.259	0.078	0.799	0.200	0.134
3.1 Flexibility	0.025	0.058	0.034	0.009	0.019	0.017	0.423	0.043	0.030
3.2 Delivery time	0.026	0.008	0.003	0.063	0.120	0.049	0.170	0.129	0.042
3.3 Berthing duration	0.004	0.007	0.009	0.067	0.019	0.006	0.096	0.014	0.005
3.4 Transportation time	0.004	0.032	0.013	0.017	0.101	0.006	0.110	0.014	0.057

Source: Compiled by this study

Table 3.3 The degree of importance of each dimensions and criteria perceived by experts 23~34 who has replied the survey

Experts Dimension, Criteria	P23	P24	P25	P27	P28	P30	P32	P34
1. Price risk	0.798	0.435	0.490	0.799	0.751	0.490	0.672	0.777
1.1 Grains market price	0.059	0.024	0.152	0.145	0.137	0.173	0.211	0.098
1.2 Storage cost	0.074	0.024	0.018	0.049	0.034	0.020	0.062	0.045
1.3 Transportation cost	0.098	0.182	0.120	0.049	0.105	0.059	0.027	0.098
1.4 Procurement price	0.567	0.205	0.200	0.556	0.475	0.238	0.372	0.536
2. Quality control	0.097	0.078	0.059	0.097	0.179	0.060	0.265	0.111
2.1 Quality variation	0.060	0.054	0.040	0.057	0.103	0.026	0.183	0.074
2.2 Procurement quantity	0.007	0.004	0.003	0.005	0.009	0.003	0.040	0.018
2.3 Information transparency	0.008	0.009	0.008	0.008	0.035	0.005	0.030	0.005
2.4 Over/short (un) loading	0.022	0.011	0.008	0.027	0.032	0.026	0.012	0.014
3. Time control	0.105	0.487	0.451	0.104	0.070	0.450	0.063	0.112
3.1 Flexibility	0.013	0.100	0.032	0.014	0.015	0.043	0.026	0.008
3.2 Delivery time	0.060	0.065	0.210	0.072	0.010	0.086	0.005	0.069
3.3 Berthing duration	0.008	0.022	0.032	0.008	0.004	0.053	0.017	0.012
3.4 Transportation time	0.024	0.300	0.177	0.010	0.041	0.268	0.015	0.023

Source: Compiled by this study

Analysis three decision-making dimensions:

(1) Transportation mode choice

This study divides the twelve criteria influencing grain importers' transportation mode choice into three dimensions: price risk, quality control and time control. According to Table 3.4, it is found that price risk is the most important dimension influencing grain importers' sea transport mode choice. The C.I. and C.R.

values are less than 0.1, which conforms to the consistency requirement of the AHP technique.

Table 3.4 The pair-wise comparison matrix and weights of transportation mode choice

Dimension Dimension	Price risk	Quality control	Time control	Weights	Priority
Price risk	1.0000	2.2111	2.2267	0.526	1
Quality control	0.4523	1.0000	1.0604	0.242	2
Time control	0.4491	0.9430	1.0000	0.232	3
$\lambda_{max} = 3, C.I.=0.00, C.R.=0$					

Source: Compiled by this study

(2) Price risk dimension

The four criteria in the price risk dimension that affect grain importers' transportation mode choice are grains market price, storage cost, transportation cost and procurement price. Among them, the weights of the procurement price is 0.564 and it's considered to be the most important criterion in this dimension. The consistency index and the consistency ratio are all conformed to the consistency requirement of the AHP relative weight calculation.

Table 3.5 The pair-wise comparison matrix and criteria weights of price risk dimension

criteria criteria	Grains market price	Storage cost	Transportation cost	Procurement price	Weights	Priority
Grains market price	1.0000	3.0715	1.3060	2.7854	0.208	2
Storage cost	0.3256	1.0000	2.4393	6.7260	0.072	4
Transportation cost	0.7657	0.4100	1.0000	4.1164	0.156	3
Procurement price	0.3590	0.1487	0.2429	1.0000	0.564	1
$\lambda_{max} = 4.03, C.I.=0.01, C.R.=0.0111$						

Source: Compiled by this study

(3) Quality control dimension

The four criteria in the quality control dimension that affect grain importers' transportation mode choice are quality variation, procurement quantity, information transparency and over/short (un) loading. Among them, the weights of quality variation is 0.541 and it's considered to be the most important criterion in the quality control dimension. The C.I. and C.R. values are less than 0.1, which conforms to the consistency requirement of using the AHP technique.

Table 3.6 The pair-wise comparison matrix and criteria weights of quality control dimension

criteria criteria	Quality variation	Procurement quantity	Information transparency	Over/short (un) loading	Weights	Priority
Quality variation	1.0000	2.9161	4.4211	3.5586	0.541	1
Procurement quantity	0.3429	1.0000	1.2724	1.0536	0.167	3
Information transparency	0.2262	0.7859	1.0000	1.4680	0.123	4
Over/short (un) loading	0.2810	0.9491	0.6812	1.0000	0.169	2
$\lambda_{max} = 4, C.I.=0.00, C.R.=0$						

Source: Compiled by this study

(4) Time control dimension

The four criteria in the time control dimension that affect grain importers' transportation mode choice are flexibility, delivery time, berthing duration and transportation time. Among them, the weights of the delivery time is 0.356 and it's

considered to be the most important criterion in the time control dimension. The C.I. and C.R. values are less than 0.1, which conforms to the consistency requirement of the AHP relative weight calculation.

Table 3.7 The pair-wise comparison matrix and criteria weights of time control dimension

criteria criteria	Flexibility	Delivery time	Berthing duration	Transportation time	Weights	Priority
Flexibility	1.0000	1.5566	1.9674	1.0502	0.245	3
Delivery time	0.6424	1.0000	2.9935	1.1611	0.356	1
Berthing duration	0.5083	0.3341	1.0000	2.0661	0.125	4
Transportation time	0.9522	0.8613	0.4840	1.0000	0.274	2
$\lambda_{max} = 4, C.I. = 0.00, C.R. = 0$						

Source: Compiled by this study

Analyzing the weights of dimensions and criteria affecting the importers' sea transportation mode choice:

Using the degree of importance (weights) and satisfaction on these twelve investigated criteria to understand the priority of each criteria influencing grain importers' sea transportation mode choice is analyzed in the Table 3.8. The top five important criteria are procurement price, quality variation, grains market price, delivery time, and transportation cost.

Table 3.8 Overall hierarchical assessment

Dimension	Dimension weights	Criteria	Local weights	Global weights	Priority Ranking
Price risk	0.526	Grains market price	0.208	0.109	3
		Storage cost	0.072	0.038	10
		Transportation cost	0.156	0.082	5
		Procurement price	0.564	0.297	1
Quality control	0.242	Quality variation	0.541	0.131	2
		Procurement quantity	0.167	0.040	9
		Information transparency	0.123	0.030	11
		Over/short (un) loading	0.169	0.041	8
Time control	0.232	Flexibility	0.245	0.056	7
		Delivery time	0.356	0.083	4
		Berthing duration	0.125	0.029	12
		Transportation time	0.274	0.064	6

Source: Compiled by this study

Alternative program satisfaction evaluation:

This study uses Fuzzy Multi-Criteria Decision Making (FMCDM) to assess the degree of satisfaction on bulk shipping and container shipping. With the questions about the degree of satisfaction in the last part of questionnaires, experts was told to fill in their judgments on the possible upper boundary, lower boundary, and most possible value to represent a linguistic variables. The fuzzy concept can be used to calculate the crispy value for each of these linguistic variables.

Table 3.9 Experts' assessments of fuzzy numbers of linguistic variables

linguistic variables Respondents	Very low	Low	Normal	High	Very high
P1	(50, 55, 60)	(60, 65, 70)	(70, 75, 80)	(80, 85, 90)	(90, 95, 100)
P2	(0, 30, 49)	(50, 60, 64)	(65, 70, 74)	(75, 85, 89)	(90, 95, 100)
P3	(30, 40, 49)	(50, 55, 59)	(60, 65, 70)	(71, 80, 90)	(91, 95, 100)
P4	(50, 55, 59)	(60, 65, 69)	(70, 75, 79)	(80, 85, 89)	(90, 95, 100)
P5	(0, 10, 19)	(20, 35, 49)	(50, 60, 69)	(70, 80, 89)	(90, 95, 100)
P6	(0, 10, 24)	(25, 30, 44)	(45, 50, 64)	(65, 70, 84)	(85, 90, 100)
P7	(0, 10, 15)	(20, 25, 30)	(40, 50, 60)	(65, 75, 80)	(85, 90, 100)
P8	(0, 10, 15)	(20, 25, 30)	(40, 50, 60)	(65, 75, 80)	(85, 90, 100)
P9	(0, 20, 39)	(40, 50, 59)	(60, 67, 69)	(70, 80, 89)	(90, 98, 100)
P11	(75, 77, 79)	(80, 82, 84)	(85, 87, 89)	(90, 92, 94)	(95, 98, 100)
P12	(0, 20, 30)	(31, 35, 40)	(41, 50, 60)	(61, 70, 80)	(81, 90, 100)
P13	(0, 30, 44)	(45, 50, 54)	(55, 60, 65)	(66, 75, 80)	(81, 90, 100)
P14	(0, 20, 35)	(36, 50, 69)	(70, 72, 75)	(76, 80, 85)	(86, 92, 100)
P15	(0, 25, 39)	(40, 50, 59)	(60, 70, 79)	(80, 85, 89)	(90, 95, 100)
P16	(0, 25, 39)	(40, 50, 59)	(60, 70, 79)	(80, 85, 89)	(91, 95, 100)
P18	(50, 55, 59)	(60, 65, 69)	(70, 75, 79)	(80, 85, 89)	(90, 95, 100)
P19	(0, 30, 49)	(50, 60, 69)	(70, 75, 79)	(80, 85, 89)	(90, 95, 100)
P22	(0, 10, 20)	(25, 33, 40)	(45, 55, 65)	(65, 73, 80)	(80, 90, 100)
P23	(0, 25, 50)	(50, 60, 70)	(70, 75, 80)	(80, 85, 90)	(90, 95, 100)
P24	(20, 30, 40)	(50, 60, 65)	(65, 70, 80)	(80, 85, 90)	(90, 95, 100)
P25	(0, 10, 20)	(20, 30, 40)	(40, 50, 60)	(60, 70, 80)	(80, 90, 100)
P27	(10, 15, 30)	(30, 35, 45)	(45, 55, 60)	(60, 70, 80)	(80, 90, 95)
P28	(7, 20, 34)	(35, 44, 51)	(53, 60, 68)	(68, 77, 85)	(85, 90, 98)
P30	(0, 10, 19)	(20, 35, 50)	(50, 60, 70)	(70, 80, 90)	(90, 95, 100)
P32	(0, 15, 29)	(30, 35, 49)	(50, 60, 69)	(70, 80, 89)	(90, 98, 100)
P34	(0, 30, 44)	(45, 50, 54)	(55, 60, 65)	(66, 75, 80)	(81, 90, 100)
Average	(11.2, 26.4, 38.0)	(39.7, 47.5, 55.4)	(57.1, 64.1, 71.0)	(72.0, 79.5, 86.2)	(87.2, 93.3, 99.7)

Source: Compiled by this study

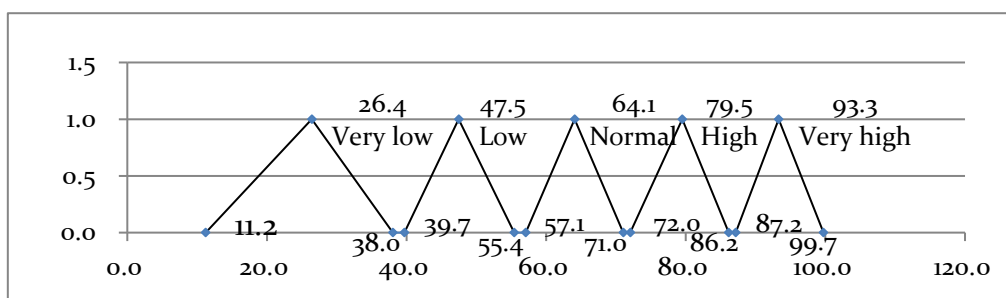


Figure 3.1 Triangular fuzzy linguistic scale

Source: Compiled by this study

Through the calculation, the degree of overall satisfaction on bulk shipping and container shipping can be obtained respectively. It can be clearly seen in Table 3.10, 3.11 that grain importers are more satisfied with bulk shipping. The optimal value of each criteria can be obtained by defuzzing the linguistic variables. Table 3.12 shows the comparison between bulk shipping and container shipping. The degree of satisfaction of container shipping on storage cost, procurement quantity, over/short

(un) loading and flexibility are higher than bulk shipping. However, bulk shipping is better than container shipping in the remaining criteria.

Table 3.10 The degree of satisfaction on bulk shipping

	Average fuzzy number (E_{ij})	Weight (W_{ij})	Mutiple (R_{ij})	BNP_{ij}
Grains market price	(68.9, 75.5, 81.5)	0.109	(7.510, 8.230, 8.884)	8.208
Storage cost	(64.0, 70.8, 76.9)	0.038	(2.432, 2.690, 2.922)	2.682
Transportation cost	(68.8, 76.4, 83.6)	0.082	(5.642, 6.265, 6.855)	6.254
Procurement price	(69.7, 76.8, 83.2)	0.297	(20.701, 22.810, 24.710)	22.740
Quality variation	(64.0, 71.6, 77.6)	0.131	(8.384, 9.380, 10.166)	9.310
Procurement quantity	(52.0, 60.1, 68.3)	0.040	(2.080, 2.404, 2.732)	2.405
Information transparency	(58.2, 66.1, 73.7)	0.030	(1.746, 1.983, 2.211)	1.980
Over/short (un) loading	(54.6, 62.1, 69.3)	0.041	(2.239, 2.546, 2.841)	2.542
Flexibility	(37.0, 45.0, 53.8)	0.056	(2.072, 2.520, 3.013)	2.535
Delivery time	(63.2, 70.2, 76.9)	0.083	(5.246, 5.827, 6.383)	5.818
Berthing duration	(52.2, 59.9, 67.8)	0.029	(1.514, 1.737, 1.966)	1.739
Transportation time	(61.7, 68.7, 75.5)	0.064	(3.949, 4.397, 4.832)	4.393
Fuzzy number of bulk shipping satisfaction (R_i)	(63.513, 70.788, 77.515)			
The optimal value of bulk shipping satisfaction (BNP_i)	70.605			

Source: Compiled by this study

Table 3.11 The degree of satisfaction on container shipping

	Average fuzzy number (E_{ij})	Weight (W_{ij})	Mutiple (R_{ij})	BNP_{ij}
Grains market price	(68.0, 74.2, 80.3)	0.109	(7.412, 8.080, 8.753)	8.084
Storage cost	(64.8, 71.6, 77.8)	0.038	(2.462, 2.721, 2.956)	2.713
Transportation cost	(63.3, 70.5, 77.6)	0.082	(5.191, 5.781, 6.363)	5.778
Procurement price	(68.4, 75.2, 81.5)	0.297	(20.315, 22.334, 24.206)	18.770
Quality variation	(52.7, 60.7, 68.5)	0.131	(6.904, 7.952, 8.974)	7.943
Procurement quantity	(55.8, 63.3, 70.7)	0.040	(2.323, 2.532, 2.828)	2.531
Information transparency	(38.5, 47.4, 55.7)	0.030	(1.155, 1.422, 1.671)	1.416
Over/short (un) loading	(56.0, 63.0, 69.8)	0.041	(2.296, 2.583, 2.862)	2.580
Flexibility	(67.9, 75.0, 81.4)	0.056	(3.802, 4.200, 4.558)	4.187
Delivery time	(45.5, 53.5, 61.0)	0.083	(3.777, 4.441, 5.063)	4.427
Berthing duration	(47.9, 56.1, 63.5)	0.029	(1.389, 1.627, 1.842)	1.619
Transportation time	(55.2, 63.3, 71.2)	0.064	(3.533, 4.051, 4.557)	4.047
Fuzzy number of bulk shipping satisfaction (R_i)	(60.467, 67.731, 74.632)			
The optimal value of bulk shipping satisfaction (BNP_i)	67.610			

Source: Compiled by this study

Table 3.12 The Comparison of the degree of satisfaction on bulk shipping and container shipping

	Bulk shipping <i>BNPIJ</i>	Container shipping <i>BNPIJ</i>	Comparison
Grains market price	8.208	8.084	Bulk shipping > Container shipping
Storage cost	2.682	2.713	Bulk shipping < Container shipping
Transportation cost	6.254	5.778	Bulk shipping > Container shipping
Procurement price	22.740	18.770	Bulk shipping > Container shipping
Quality variation	9.310	7.943	Bulk shipping > Container shipping
Procurement quantity	2.405	2.531	Bulk shipping < Container shipping
Information transparency	1.980	1.416	Bulk shipping > Container shipping
Over/short (un) loading	2.542	2.580	Bulk shipping < Container shipping
Flexibility	2.535	4.187	Bulk shipping < Container shipping
Delivery time	5.818	4.427	Bulk shipping > Container shipping
Berthing duration	1.739	1.619	Bulk shipping > Container shipping
Transportation time	4.393	4.047	Bulk shipping > Container shipping

Source: Compiled by this study

Difference analysis of different grain importers:

In this study, the questionnaires were posted to three groups of grain importers (i.e. corn, soybean and wheat importers). The imported quantity of the other grains is too low to be included in this research survey.

(1) Criteria analysis of corn importers' transportation mode choice and the assessments of the degree of satisfaction

It can be seen that corn importers focus on the price risk dimension in Table 3.13 because in the top five important criteria, three of them are belonged to this dimension.

Table 3.13 Weights of corn importers' transportation mode choice

Dimension	Dimension weight	Criteria	Dimension allocation weight	Criteria allocation weight	Corn priority	Overall priority
Price risk	0.514	Grains market price	0.175	0.090	5	3
		Storage cost	0.067	0.035	8	10
		Transportation cost	0.185	0.095	4	5
		Procurement price	0.573	0.294	1	1
Quality control	0.195	Quality variation	0.537	0.105	3	2
		Procurement quantity	0.154	0.030	11	9
		Information transparency	0.137	0.027	12	11
		Over/short (un) loading	0.172	0.033	9	8
Time control	0.291	Flexibility	0.219	0.064	7	7
		Delivery time	0.374	0.109	2	4
		Berthing duration	0.109	0.031	10	12
		Transportation cost	0.298	0.087	6	6

Source: Compiled by this study

From Table 3.14, it is clear that container shipping outperformed bulk shipping in these four criteria: storage cost, procurement quantity, over/short (un) loading, and flexibility. It can be seen that corn importers' satisfaction on bulk shipping is higher than container shipping in Table 3.15.

Compared Table 3.15 with the data about the degree of satisfaction on bulk shipping and container shipping which are 66.861 and 57.376 in Determinants of Grain Shippers' and Importers' Freight Transport Choice Behavior (Lirn & Wang,

2013), it can be seen that the degree of satisfaction on bulk shipping and container shipping have grown, especially container shipping which increased by 9% and will be a threat to bulk shipping.

Table 3.14 Comparing the degree of satisfaction on the performance of bulk shipping and container shipping from corn importers' viewpoint

	Bulk shipping BNPIJ	Container shipping BNPIJ	Comparison
Grains market price	7.026	6.681	Bulk shipping > Container shipping
Storage cost	2.492	2.556	Bulk shipping < Container shipping
Transportation cost	7.622	6.827	Bulk shipping > Container shipping
Procurement price	23.265	22.001	Bulk shipping > Container shipping
Quality variation	7.280	6.517	Bulk shipping > Container shipping
Procurement quantity	1.730	1.831	Bulk shipping < Container shipping
Information transparency	1.697	1.076	Bulk shipping > Container shipping
Over/short (un) loading	2.074	2.097	Bulk shipping < Container shipping
Flexibility	2.733	4.659	Bulk shipping < Container shipping
Delivery time	7.576	5.435	Bulk shipping > Container shipping
Berthing duration	1.900	1.582	Bulk shipping > Container shipping
Transportation time	6.041	5.374	Bulk shipping > Container shipping

Source: Compiled by this study

Table 3.15 The degree of corn importers' satisfaction on the two sea transportation mode

	Fuzzy number of the degree of satisfaction (R_i)	Optimal value of the degree of satisfaction (BNP_i)
Bulk shipping	(64.324, 71.621, 78.362)	71.436
Container shipping	(59.426, 66.785, 73.697)	66.636

Source: Compiled by this study

(2) Criteria analysis of soybean importers' transportation mode choice and the assessments of the degree of satisfaction

It can be seen in Table 3.16 that procurement price has the highest degree of importance in terms of sea transport mode choice. Quality variation has the second highest degree of importance and grains market price has the third highest degree of importance. It is similar to the overall ranking.

Table 3.16 Weights of soybean importers' transportation mode choice

Dimension	Dimension weight	Criteria	Dimension allocation weight	Criteria allocation weight	Corn priority	Overall priority
Price risk	0.505	Grains market price	0.186	0.094	3	3
		Storage cost	0.086	0.043	9	10
		Transportation cost	0.167	0.084	4	5
		Procurement price	0.561	0.284	1	1
Quality control	0.271	Quality variation	0.555	0.151	2	2
		Procurement quantity	0.208	0.056	7	9
		Information transparency	0.123	0.033	10	11
		Over/short (un) loading	0.114	0.031	12	8
Time control	0.224	Flexibility	0.282	0.063	6	7
		Delivery time	0.327	0.073	5	4
		Berthing duration	0.143	0.032	11	12
		Transportation cost	0.248	0.056	8	6

Source: Compiled by this study

Learn from Table 3.17 that the degree of satisfaction on container shipping is far behind bulk shipping.

Table 3.17 The degree of soybean importers' satisfaction on the two sea transportation mode

	Fuzzy number of the degree of satisfaction (<i>Ri</i>)	Optimal value of the degree of satisfaction (<i>BNPi</i>)
Bulk shipping	(62.591, 69.568, 75.847)	69.335
Container shipping	(56.085, 63.123, 69.666)	62.958

Source: Compiled by this study

It can be known in Table 3.18 that container shipping has better performance than bulk shipping does only in terms of their flexibility.

Table 3.18 Comparing the degree of satisfaction on the performance of bulk shipping and container shipping from soybean importers' viewpoint

	Bulk shipping <i>BNPIJ</i>	Container shipping <i>BNPIJ</i>	Comparison
Grains market price	6.596	6.223	Bulk shipping > Container shipping
Storage cost	2.915	2.809	Bulk shipping > Container shipping
Transportation cost	6.266	5.446	Bulk shipping > Container shipping
Procurement price	20.495	19.161	Bulk shipping > Container shipping
Quality variation	10.797	8.456	Bulk shipping > Container shipping
Procurement quantity	4.082	3.405	Bulk shipping > Container shipping
Information transparency	2.418	1.518	Bulk shipping > Container shipping
Over/short (un) loading	1.883	1.872	Bulk shipping > Container shipping
Flexibility	3.062	4.838	Bulk shipping < Container shipping
Delivery time	4.864	3.852	Bulk shipping > Container shipping
Berthing duration	2.033	1.852	Bulk shipping > Container shipping
Transportation time	3.924	3.526	Bulk shipping > Container shipping

Source: Compiled by this study

(3) Criteria analysis of wheat importers' transportation mode choice and the assessments of the degree of satisfaction

It can be seen in Table 3.19 that procurement price has the highest degree of importance, quality variation has the second highest degree of importance and procurement quantity has the third highest degree of importance. It is similar to the overall ranking.

Table 3.19 Weights of wheat importers' transportation mode choice

Dimension	Dimension Weight	Criteria	Dimension allocation weight	Criteria allocation weight	Corn priority	Overall priority
Price risk	0.397	Grains market price	0.224	0.089	4	3
		Storage cost	0.071	0.028	11	10
		Transportation cost	0.194	0.077	5	5
		Procurement price	0.511	0.203	1	1
Quality control	0.410	Quality variation	0.448	0.184	2	2
		Procurement quantity	0.298	0.122	3	9
		Information transparency	0.129	0.053	8	11
		Over/short (un) loading	0.125	0.051	9	8
Time control	0.193	Flexibility	0.313	0.060	7	7
		Delivery time	0.348	0.067	6	4
		Berthing duration	0.143	0.028	12	12
		Transportation cost	0.196	0.038	10	6

Source: Compiled by this study

Table 3.20 shows that container shipping has better performance than bulk shipping does in the criteria of over/short (un) loading and flexibility.

Table 3.20 Comparing the degree of satisfaction on the performance of bulk shipping and container shipping from wheat importers' viewpoint

	Bulk shipping BNPIJ	Container shipping BNPIJ	Comparison
Grains market price	5.702	5.373	Bulk shipping > Container shipping
Storage cost	1.771	1.722	Bulk shipping > Container shipping
Transportation cost	5.085	3.889	Bulk shipping > Container shipping
Procurement price	13.635	12.485	Bulk shipping > Container shipping
Quality variation	12.156	9.678	Bulk shipping > Container shipping
Procurement quantity	8.601	8.052	Bulk shipping > Container shipping
Information transparency	3.797	2.509	Bulk shipping > Container shipping
Over/short (un) loading	2.691	3.106	Bulk shipping < Container shipping
Flexibility	2.528	4.754	Bulk shipping < Container shipping
Delivery time	4.357	3.408	Bulk shipping > Container shipping
Berthing duration	1.617	1.588	Bulk shipping > Container shipping
Transportation time	2.647	2.208	Bulk shipping > Container shipping

Source: Compiled by this study

Table 3.21 shows that the degree of satisfaction on bulk shipping is higher than container shipping.

Table 3.21 The degree of wheat importers' satisfaction on the two sea transportation mode

	Fuzzy number of the degree of satisfaction (R_i)	Optimal value of the degree of satisfaction (BNP_i)
Bulk shipping	(56.938, 64.679, 72.140)	64.586
Container shipping	(51.243, 58.705, 66.363)	58.770

Source: Compiled by this study

4. Conclusion

Two of the three groups of investigated grain importer's (including corn and soybean importers) transportation mode choice all consider price risk has the highest degree of importance. However, wheat importers consider quality control as the first priority. It can be seen that price risk and quality control are important dimensions for grain importers. The highest important criteria are based on grains market price, procurement price and quality variation.

Due to the advantage of flexibility of container shipping in terms of its batch size, containers are widely adopted by small-scale grains importers. While larger-scale grains manufacturers or large-scale grains dealers tend to use bulk shipping to ensure sufficient grains supply in Taiwan. However, small-scale grains importers gradually have increase their market share in Taiwan recently. In order to facing the challenges due to their decreasing market share, large-scale grains dealers have adjusted their strategy and start to use more containers to move their grains cargoes across the ocean.

When the largest grain silo operator renew their terminal and silo leasing contract with Taiwan International Ports Corporation (TIPC), TIPC should take the decreasing bulk grain imported quantity into its pricing consideration. The grain operators must reduce the handling charges to reward the importers so that the overall import costs can be significantly reduced and attract companies to use bulk shipping to carry their imported grains.

In the current situation of low imported bulk grain amount and large parts of grain siloes in the wharf are not fully utilized, the grain silo operators can also use a long term marketing strategy to attract the other potential customers. The possible future grain silo throughput increase can be generated by the increasing grain silo demand in China and the lack of grain silo facilities in Southeast Asian ports. It will be a possible avenue for the EMIC to transform its grain siloes in Taichung Port and Kaohsiung Port into the transshipment siloes. EMIC also can expand its geographical service coverage to compensate the decreasing bulk grain silo cargo handling quantity due to the increasing demand of importing grain by containers. Finally, the grains siloes capacity in Taiwan can be fully utilized in the very near future.

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Session 10: Last Mile and Urban Logistics

CITY LOGISTICS PRACTICES IN DEVELOPING COUNTRIES

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Abstract

Many reported cases of city logistics in literature have been dominated by developed countries and the numbers of cases have significantly increased over time. On one hand, it is argued that the city characteristics in developed countries differ from those in developing countries. The different characteristics may lead to different problems, and thus different approach to solve the problems. The aim of the present study is to identify important factors, typical city logistics problems, and associated problem-solving methods in developing countries. The paper describes a literature-based research that has sought to understand the practices of city logistics in developing country. The literature research consists of three stages. The first stage determines relevant keywords and search for literature from high-quality and international refereed journal. The second stage is literature classification. The last stage is literature analysis which consists of gap analysis between the city logistics practices by developing countries and those by developed countries. Many of the existing research in network optimization models are still focus on one-dimensional and mono-actor. City Logistic research still needs wider dimensions are spatial, stakeholders and the impact of the system. Spatial dimension in the characteristics of the network still requires a more detailed treatment. This model requires an appropriate method, especially able to translate the model in detail (bottom up) and has a predictive ability in the analysis.

Keyword: city Logistics, developing country, review, simulation

1. Introduction

In the economic globalization, logistics city has a very important role in building the national economy. In Asia, a new term "megalopolis" emerged as an additional dimension to major cities or megacities, such as Tokyo-Nagoya-Osaka and Pearl River Delta (Taniguchi, Fang and Thompson, 2013). Megalopolis produces an economically multiplicative effect by combining various consumer markets from contribute cities, trade development and multi-city coordinated industries. This megalopolis effect serves as a major regional or national economic engine and contributes significantly to the national gross domestic product (GDP) of a country (Taniguchi, Fang and Thompson, 2013). Meanwhile, city logistics features are needed to manage, balance and control the flow of goods and people in the city center, because based on (Taniguchi, Fang and Thompson, 2013), megalopolis refers to the corridors of big cities that are characterized by a complex network of interconnected economic centers connected with efficient urban transport.

Some previous literatures have discussed the application of the concept of city logistics in Europe and Asia. In Europe, logistical barriers have different characteristics. (Lagorio, Pinto and Golini, 2015) stated that some cities are paying particular attention to the role of culture, history and urbanization barriers, so city logistics has been included in the EU guidelines as an important issue for exploitation. The goal is to reduce CO2 levels, improve city liveability by reducing the number of commercial vehicles across urban areas. For example, in Germany, land routes, sea lanes, rail, extensive freight villages and intermodal facilities are challenges in the creation of trade integration (Zuraimi *et al.*, 2012). In contrast, the problems of city logistics emerging in developing countries according to (Zuraimi *et al.*, 2012) are still concentrated on providing infrastructure.

1.1 City Logistics Challenges in Developing Countries

Developing countries have difficulties in handling logistics systems and infrastructure decentralization, where each country has a unique characteristic in its domestic logistics system. Previous studies had shown the recognition of logistics for internationalization, but there are slightly varying value of importance of logistics from region to region. This heterogeneity becomes the most important challenge for international logistics activities. Thus, there are a great variety of domestic logistics systems that join into a global network (Straube, Ma and Bohn, 2008). In Indonesia, the decentralization of infrastructure programs from central to local governments caused the limited experience in urban management. This condition causes limited ability to manage and handle the escalating urban transportation needs (Cervero, 2013). Other problems in developing countries are strategic planning, and logistics and transportation operations that are not yet optimal. Strategic planning in land-use and transportation causes an integrated transport modes is non-existent (Cervero, 2013).

1.2 Research Problems and Questions

We have discussed the relevance of city logistic problems in developing countries. Some literatures state that there are differences in characteristics of logistics systems in each region. This encourages the importance of discussing the activities of city logistics in developing countries. Discussion about city logistics so far is still fragmented, so it takes literature review that can answer the question (Table 1) as follows:

Table 1. Research Questions and Objectives

<i>Research Problem</i>	<i>Research Question(RQ)</i>		<i>Objectives</i>
RP 1 There are constraints and special characteristics in the decentralization of urban infrastructure and logistics that lead to limited knowledge and experience on urban management, budgeting, project supervision and urban planning in developing countries.	RQ 1	What are the subjects related to the problems of city logistics in developing countries?	To identify the subjects of city logistics required in developing countries today.
	RQ 2	How are aspects of these subjects influential in handling city logistic issues?	To identify the aspects that affect the subjects (RQ1) of city logistics in developing countries.
RP 2 Strategic and operational planning in logistics in developing countries is not yet optimal	RQ 3	What important subject has not been identified in depth and important in solving city logistic problems?	To identify important subjects that have not been studied deeply and become urgency today.
	RQ 4	What methods (tools) can be used to complete RQ1, RQ2, and RQ3?	To understand the methods (tools) that match the issues of city logistics, related to RQ1, RQ2 and RQ3.

We use Sistematic Literature Review (SLR) to answer the research question, which focuses on city logistics in developing countries. Description process based on the classification of literature will answer RQ1. Furthermore, we analyze the aspects and potentials in city logistic subjects by reviewing the relevant literatures with RQ2, RQ3. Then, we review and analyze the methods to understand the methods that match the issues of city logistics.

This literature review aims to explore the development of researches in the area of city logistics, including looking at the basic construction, the tools, and the implementation of solutions. First section describes the important issues related to the problems of city logistics, implementation, and research questions. The second section describes a brief systematic literature review and a classification of the literature based on the focus of city logistics problems. The third section examines and discusses the literature based on the category of the problem and the field that involved in the city logistics activities based on the literature. The fourth section synthesizes and describes the insight, knowledge and perception. The fifth section provides conclusions and future research challenges.

2. The Review Methodology

The review was conducted in three main phases, namely the selection; classification; and analysis and results. The process began with the classification stage, and several stages of the process were adopted from (Thakkar, 2008) and (Lagorio, Pinto and Golini, 2015). Majority relevant literature were taken from several research article databases such as Science Direct, JSTOR, IEEE, and Emerald in the last 5 years *Phase 1 (Selection)*

These phase began with determining the keyword "city logistics" and keywords based on the topic of city logistics (Lagorio, Pinto and Golini, 2015, 2016). Then, we selected the literature by reading the title and abstract. The goal was finding the connection between the content of literature with our research scope. We also intend to find previous cases that

were elaborated in these literatures. This process allowed a reduction in the number of articles and simplified the review process by eliminating the out of scope literature. Then, we conduct full-text reading to understand the specific contents of the literature.

Phase 2 (Classification)

The classification process aimed to review the trend of city logistic issues. First classification had objective to classify city logistic issues based on a study area and to know the solving approach. Second classification categorized city logistics schemes that are widely discussed in the developing countries. Then, we examines the tools that were used in solving the city logistics problem.

Phase 3 (Analysis and Results)

In this phase, we conduct an exploration the literatures and identify the gaps that emerged from the classification of city-logistics problems. Then, we seek the potentials of model development and methods improvement in implementing city-logistics concepts.

3. Classification of City Logistics Research and Implementation

In this phase, we processed a descriptive study that focused on the strategic and operational level, the concepts and review of city logistics. Several studies and definitions were adopted from (Taniguchi, Thompson, Tadashi Yamada, et al., 2001; Lagorio, Pinto and Golini, 2015; Yildiz, 2014). In defining the city logistics research, we used (Taniguchi, Thompson, Tadashi Yamada, et al., 2001) and initiated into five schemes, ie; Co-operative Freight Transport Systems, Public Logistic Terminal, Load Control Factor, Advance Information System, Underground freight transport systems. These schemes were implemented in the form of cooperative freight systems, public freight (logistics) terminals, new freight transport systems, e-commerce, and intelligent transport systems (Taniguchi, Thompson and Yamada, 2003). Meanwhile many of city logistics research topics translated in more detail by (Lagorio, Pinto and Golini, 2015) ie; Limited Transfer Zone (LTZ), loading/unloading areas, off-hours delivery, Urban Concolidation Center (UCC) / Urban Distribution Center (UDC), logistics by bike, Information and Communication Technology (ICT) / Intelligent Transport Systems (ITS), Vehicle Routing Problems (VRP), green vehicles and emission.

Table 2. Research Scheme and Application on City Logistics

Research	City Logistics Schemes					
	City Logistics Application	Cooperiative Freight Systems	Public Logistics Terminal	New Freight Transport System	E-Commerce	Intelligent Transport Systems
City Logistics Topics			<ul style="list-style-type: none"> • Network & Location Facility • Loading / Unloading • UCC / UDC / Transfer point 	<ul style="list-style-type: none"> • LTZ • Off-hours • Delivery by bike 		<ul style="list-style-type: none"> • Road Pricing • Vehicle Routing Problems • ICT / ITS
Quantitative		(Taniguchi, Thompson, Tadas Yamada, et al., 2001); (Kohler, 1997); (Nemoto, 1997)	(Eidhammer and Andersen, 2014); (McLeod and Cherrett, 2011); (Cârlan, Roşca and Roşca, 2017); (Oliveira, Oliveira and Correia, 2014); (Battaia et al., 2016); (Ndhaief, Bistorin and Rezg, 2017); (Timperio et al., 2017); (Lee, 2015) (Etemadnia et al., 2015); (Ferreira and Borenstein, 2011); (Kwon, Im and Lee, 2011); (Démare et al., 2015); (Démare et al., 2017) ; (Prasad, Srinivas and Srinivas, 2016);	(Dezi, Dondi and Sangiorgi, 2010);(Holguín-Veras, 2008); (Niță et al., 2018)		(Holguín-Veras, 2008);(Andersson and Ögren, 2013);(Franceschetti et al., 2017);(Gu, Foster and Shang, 2016); (Becker et al., 2016);(Mutlu et al., 2016);(Cinar, Gakis and Pardalos, 2016); (Makarova, Shubenkova and Pashkevich, 2017); (Groß et al., 2015); (Arviato et al., 2016); (Köster, Ulmer and Mattfeld, 2015); (Martin et al., 2016); (Barbucha and Jedzejowicz, 2007); (Barbucha, 2012); (Asri and Simatupang Togar M, 2013); (Sopha, Siagian and Asih, 2016); (Chatterjee, Greulich and Edelkamp, 2016); (Baykasoğlu and Kaplanoğlu, 2015); (Chow et al., 2013); (Zolfpour-Arokhlo, Selamat and Hashim, 2013); (Jabeur et al., 2017); (Melo, Macedo and Baptista, 2017); Felix, Ulmer and Mattfeld, 2017)
Qualitative		(Taniguchi et al., 1995)	(Popiolek and Klopott, 2016); (Blyde and Molina, 2015)	(Holguín-Veras et al., 2014); (Marcucci and Gatta, 2017); (Schliwa et al., 2015)	(Nemoto, Visser and Yoshimoto, 2001)	(Goh and Pinaikul, 1998); (Madlenak, Madlenakova and Kolarovszká, 2016); (Chen, Ardila-Gomez and Frame, 2017); (Chen, Ardila-Gomez and Frame, 2017)
Object (Country)		Japan, Germany	Norwegian city, Poland, Winchester (UK), Brazil, Bucharest (Romania), Germany, US, Indonesia	Bologna (Italy), New York City, Rome, UK	Japan, Netherlands	Indonesia Lisbon, Portugal Rep. of Tatarstan (Russia), Thailand, India, China, New York City

3.1. City Logistics Trend in Developing Countries

Mapping subjects of logistics (Figure 1) is a literatures exploration based on the case that emerged in the researches.

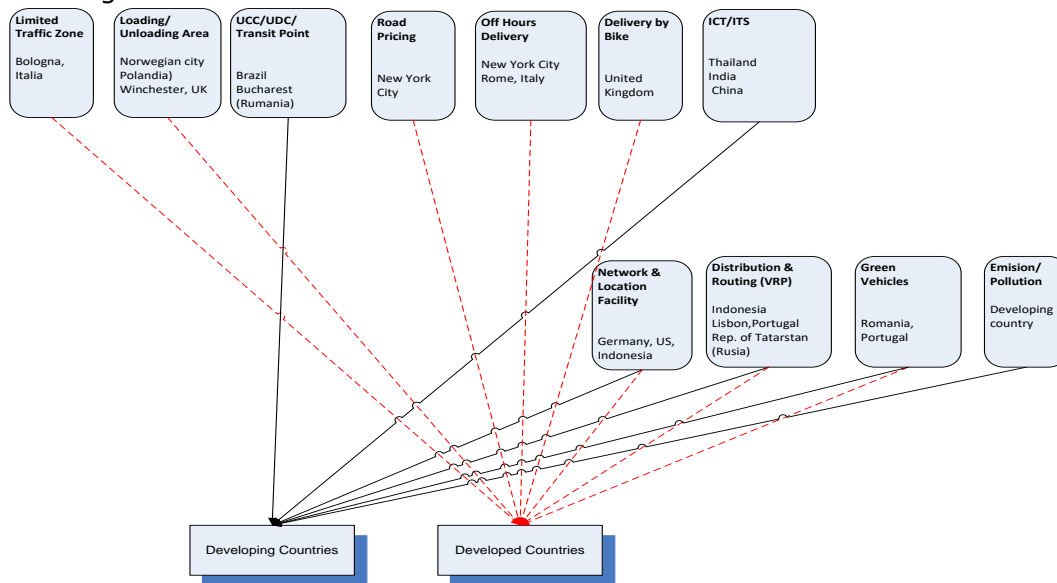


Figure 1. Mapping of Subject in City Logistic

The literature review shows a classification of city logistic subjects based on research papers. The classification used data and case study from the research. Some development models used data derived from previous studies, but in this literature this review included in the theoretical study. The classification process has classified the subjects UCC / UDC, network and facility, ICT / ITS, VRP, green vehicle and emission into developing countries area. Meanwhile the subjects that focus on LTZ, loading / unloading areas, off-hours delivery, bike logistics, network and facility, VRP, and green vehicle are classified in developed countries area. Subjects that were studied in both are network and facility, VRP, and green vehicles. The grouping indicates the issues of infrastructure, technology, transportation and routing, and environment is the focus under study in developing countries. It is interesting to be explored. For example, Population density or overcrowding is one of the important aspects of network and infrastructure planning (Cervero, 2013). The impact of overcrowding is the limited of land use problem in urban areas. Urban freight transport is a derived demand of logistics in general. It is strongly influenced by the distribution pattern of land use and related activities in the city. However, in urban land use planning often ignore consideration of shipping and logistics (Taniguchi, Thompson and Yamada, 2016). Based on the classification of city logistics (Taniguchi, Thompson, Tadas Yamada, et al., 2001), the dominance of research in developing countries set in intelligent transport systems (ICT, VRP and road pricing) and public freight/ logistics terminals (UCC/UDC, Loading/unloading, Network) schemes. Figure 2 describes the distribution of logistics subjects.

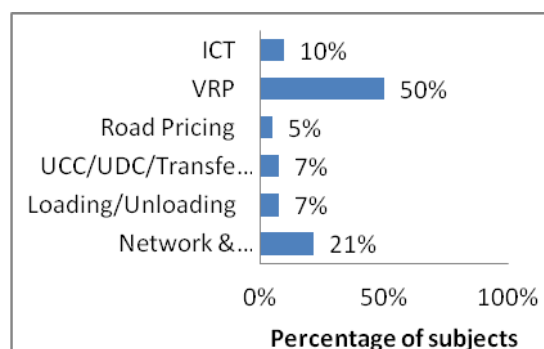


Figure 2. Percentage of Research Subjects

4. Aspects of City Logistics Issues

Daily conditions faced by all stakeholders represent urban activities related to logistical issues. Important and worthy aspects represent the condition. An operational or strategic planning in urban logistics system should consider these aspects to achieve optimal results.

In discussing aspects of logistical issues, it is necessary to identify the range of options in order to produce the right policy variables. Decision-making should take into consideration the current system rules and discuss the scope of the system widely to produce a significant effect. There are three general dimensions that limit or scope of the system in view the problems of city logistics, that is spatial, stakeholders and impact (Taniguchi, Thompson, Tadashi Yamada, et al., 2001).

In this review, aspects are specific to rules or characteristics that are directly related to the flow of goods (road networks, vehicles) and the flow of information (technology). In (Taniguchi, Thompson, Tadashi Yamada, et al., 2001), there are two categories of characteristics, i.e., characteristic of the network; the characteristics of the industry and residents. Meanwhile, other study mentioned other aspects related to logistics city was traffic jam at the pick hours, congestion, limit the use of large vehicles, noise due to traffic congestion, CO2 emissions, road safety and parking systems problems as described in the study (Witkowski and Kiba-Janiak, 2014). These aspects led the government to make new policies to control the city logistics systems. This aspect can increase with the increasing complexity of the problem in urban areas. The discussion of the city logistics aspects directly related to the impact (range of option).

Formulation of the logistics aspect is very important and critical to direct the needs of city logistics systems in developing countries. In the logistics concept, (Taniguchi, Thompson, Tadashi Yamada, et al., 2001) classified spatial dimensions (distance, road usage restriction, parking restriction and capacity) and the dimensions of impact (traffic volume and speed limit) as network characteristics. Industry & Resident characteristics can be represented by spatial dimension (location and type of development intensity). This study discussed the dominant aspects of the literature. The spatial and impact dimensions in each study represented these aspects. The results of a review of some related research can be seen in Table 3.

4.1. Stakeholder Perspectives

For describing the urban logistics problems, we require a more comprehensive perspective of stakeholders. In the city logistics there are four key stakeholders (Taniguchi, Thompson, Tadas Yamada, et al., 2001) namely shippers (manufacturing, wholeseller, retailers), residents (customers), freight carriers (transporters), administrator (government, state, city). Overall, ASEAN had a low competitive level in logistics implementation. This was indicated by a significant difference in perception between logistics companies and government (Tongzon and Cheong, 2014). The concept of city logistics provides more than one scheme implementation and take into account the fact that each stakeholder has a purpose and a different perspective. It is important for these differences to be considered in proposing solutions (Oliveira and Oliveira, 2016). Each stakeholder will have a tendency to the level of perceived dominance of certain subjects. In his research (Oliveira and Oliveira, 2016), the administrator had the dominance of perception on the subject of the UDC / UCC, off hours delivery, and loading / unloading reservation system. Carriers had the dominant perspective on the subject of exclusive lane system and loading / unloading system.

Based on this knowledge (Taniguchi, Thompson, Tadas Yamada, et al., 2001) has made an overview of the analysis and modeling techniques, and classifies the level of complexity; Mono-actor/ multi-factor (level I), a system analyzes the decision-making process-oriented from the perspective of the actors who face a lot of factors; Multi-actor/ multi-factor from the outsider's perspective (level II), the difference is only explained by differences in the interests of the actor, not thinking of other mental constructs of the actors; Multi-actor/ multi-factor from individual stakeholder perspectives (level III), the main objective is to understand the perception of a 'real' from the actors, but in reality the process of interaction between the actors will behave differently; Multi-actor/ multi-

factor with hidden agendas (level IV), each actor will learn from the experience and try to strengthen its current position in the process of interaction. 'Saying this', 'doing that' and 'thinking such' is the key phrase that is characteristic of this level. City logistics schemes are ideally located on this level. The results of this review pursued on several studies of city logistics in Table 3 that taking into account aspects of city logistics and stakeholder perspective.

Table 3. City Logistics Research in Developing Countries

Researcher	Scheme of City Logistics	Research	Tools	Research Dimensional		
				Spatial	Stakeholder Interaction	Impact
(McLeod and Cherrett, 2011)	Public logistics (freight) terminals (Loading / Unloading Area)	Quantitative	simulations	considered	Multi-actor (level II)	not discussed
(Oliveira, Oliveira and Correia, 2014)	Public logistics (freight) terminals (Urban Logistics Space)	Quantitative	Simulation and optimization	not Considered	Mono-actor	not discussed
(Démare et al., 2017)	Public logistics (freight) terminals (Logistic corridor)	Quantitative	ABM	considered	Multi-actor (level III) Shippers, Carriers	not discussed
(Battaia et al., 2016)	Public logistics (freight) terminals (UCC)	Quantitative	Analytical and Simulation	considered	Multi-actor (level II)	not discussed
(Popiolek and Klopott, 2016)	Public logistics (freight) terminals (Container terminals and port city interface)	literature review	-	considered	not discussed	not discussed
(Cârlan, Roşca and Roşca, 2017)	Public logistics (freight) terminals (Hub and spokes network)	Qualitative	analytic	Considered (Network, station)	Mono-actor (Customers / Passangers)	not discussed

4.2. Problem Solving Method City Logistics

The high complexity of city logistics problems will provide a new view in the method of solving the problem. Many previous studies in any subject city logistics used analytic approach, heuristic and simulation. In this review, Figure 3 shows that simulation method (ABM and Discrete Event Simulation) more dominant than the other methods. According to (Taniguchi, Thompson, Tadas Yamada, et al., 2001) mentioned that city logistics consistent to the needs at level IV complexity. Simulations can provide a more comprehensive picture of the actor's understanding, and can also provide the most detailed level of analysis. This review led to the urgency and the opportunity to develop research in more detail, of course, the complexity of the system will increase. A City logistics model requires consideration of stakeholder (resident, shipper, carrier and administrator), spatial dimensions, and its impact to get optimal result comprehensively. Impacts of the implementation for city logistics system, has not been widely discussed in previous studies. City logistics models need predictive capability in the design to measure the impact. Therefore, the studies of city logistics that oriented on the complexity require tools that are able to translate the dynamic interaction among stakeholders.

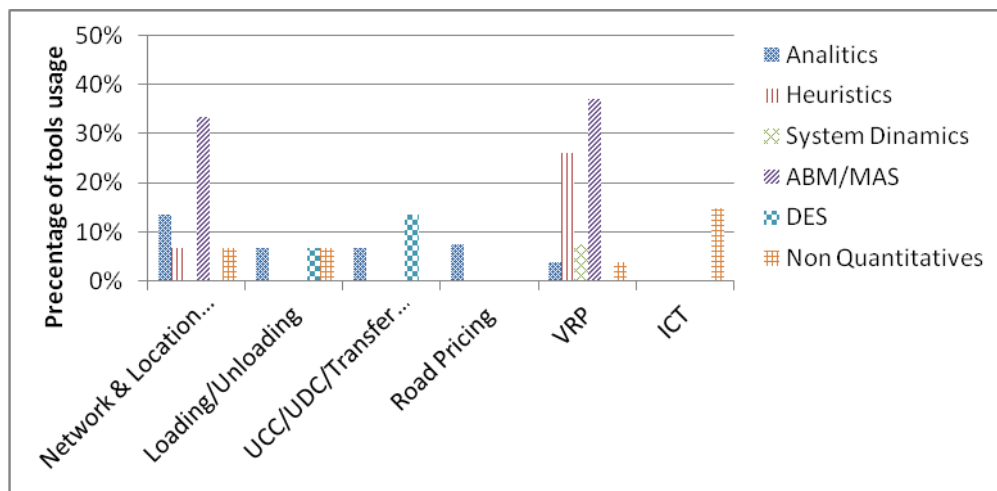


Figure 3. Percentage of Tools Usage

5. Conclusion

This literature review tries to give an overview of the subjects related to city logistics in developing countries. The researches in logistics (freight) terminals schemes are still needed in cities in developing countries. Many of the existing research in network optimization models are still focus on one-dimensional and mono-actor. City Logistic research still needs wider dimensions are spatial, stakeholders and the impact of the system. Spatial dimension in the characteristics of the network still requires a more detailed treatment in the elaboration of the concept. It is still necessary predictive capabilities to analysis the system, so it can describe the impact of logistic models. Other spatial dimension is resident characteristics, which in developing countries. It is a complex problem. This model requires an appropriate method, especially able to translate the model in detail (bottom up) and has a predictive ability in the analysis. These aspects provide a new viewpoint that the problem of city logistics. It means in real conditions, we have opportunity to improve city logistics models to solve the city logistics problem. Another aspect that needs to be developed in this literature review is a grouping of data classification. In particular, the involvement of network characteristics must be evaluated from the literature. It is better if the characteristics have minimal and measurable criteria.

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CHALLENGES WITH TOOLS AND TECHNOLOGIES SUPPORTING COLLABORATION AMONG STAKEHOLDERS IN URBAN LOGISTICS

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Abstract

Purpose of this paper:

This paper explored technology and all technical aspects bring various roles of stakeholders in urban logistics for collaboration.

Design/methodology/approach:

By searching, 188 papers were found for the challenges in urban logistics related to stakeholders. After that, we review papers relate to the technical issues involving collaboration of stakeholders, 25 papers were analysed.

Findings:

It was found that simulation and optimization techniques can support collaboration of different types/groups of stakeholders. Intelligent Transport Systems and Information and Communication Technologies play more important roles to support collaborations among stakeholders in urban logistics activities. Lack of report on education in connection to the support for collaboration among stakeholders in urban logistics was observed.

Value:

This paper shows the current technologies as well as tools for collaboration of stakeholders in urban logistics useful for researchers in this area.

INTRODUCTION

Improving the quality of life, reducing the emissions of greenhouse gases as well as ensuring high service quality to all citizens has been a pre-dominantly aim for much of the research carried out during last decade. This has induced the development of , innovative transport and mobility solutions, both for passengers and goods (de Sousa & Mendes-Moreira, 2015; Maggi & Vallino, 2016; Eidhammer et al., 2016). In-line with this, government and local authorities focus on implementing such concepts like "Mobility as a Service, MaaS" (Tekes, 2016; Ministry of Transport and Communication, 2014), but also on improving existing ones (Arena et al., 2015). The main challenge is however that the success of the implementation and operation of these complex solutions requires a holistic and systematic approach taking all perspectives and stakeholders' needs into account on micro, meso and macro levels (Weber, 2002). This requires not only a good understanding of the different stakeholder's activities and roles in urban logistics at different levels but also that these groups can develop a common understanding that fosters collaboration among them (Lindholm,2012; Gammelgaard, 2015).The main objective of this systematic literature review is therefore to analyze available tools (methods, approaches, supportive technologies) fostering collaboration and common understanding among the different stakeholder groups in order to better understand the underlying mechanics. This will later be used for designing a new training tool.

The literature review focuses on two aspects: the challenges stakeholders face related to the need of collaborative activities and user involvement and the current technical issues covering technology and all technical aspects proposed for supporting understanding among different stakeholders and The paper is organized in the following way: in the next section, we present research methodology used for the systematic literature, before we analyze the relation between stakeholders role and urban logistics' challenges and classify our results in two main areas: Technology for supporting management of mobility data and information for collaboration in urban logistics and smart city solutions , and Simulation and optimization model to support collaboration activities in urban logistics. The last section present conclusion and outline future research activities.

RESEARCH METHODOLOGY

This work is based on the previous systematic literature presented in (Grudpan et al., 2017), using three main databases: Scopus, Web of Science and IEEE- , with the main keywords 'urban logistics' or 'city logistics' and filtering with 1. "challenge", 2."management" and "technical involvement", 3. "management" or "business" and "economic" and "engineering" or "computer" and "environment", and 4. "stakeholder". Whereas the first review analyzed technical and managerial challenges in urban mobility related to stakeholder involvements in general, the focus here is to look at how these challenges are related to the collaboration among the stakeholders.

Only using the main keywords 'urban logistics' or 'city logistics,' resulted in 587, 526, and 312 papers Scopus, Web of Science and IEEE respectively. We further reduced this number by adding 'challenges,' which resulted in 174, 188, and 120 papers. Adding 'collaboration' as filter reduced the number of papers significantly, to less than 20 papers (could be due to different usage of the terms collaboration, co-operation and interaction), so instead, we added 'stakeholder' reducing the overall numbers to 53. Only three papers were duplets, which resulted in 50 papers.

From the 50 papers (Table 1), we extracted the information from the papers for analysis the challenges and the activities that related to each role of stakeholders as well as technical challenges in urban logistics. This is outlined in the next section.

RESULTS

The relation between stakeholders' role and urban logistics' challenges

A more detailed analysis of the 50 articles revealed that 72% (36 of 50) dealt with challenges related to collaboration among different stakeholders, whereas only 14 dealt with collaboration between similar stakeholders, as seen in Table 1.

Table 1 Classification of articles according to the roles in urban logistics

Classification of articles according to the roles in urban logistics	Number of Publications	References
Local authorities / Public service	8	Österle et al., 2015, Eidhammer et al., 2016, Huestis & Snowdo., 2011, Tan et al., 2015, Maggi & Vallino, 2016*, Marinov, Woroniuk & Zunder, 2012*, Rose et al., 2016, Ville et al., 2010, Browne et al., 2014.
Carriers / Logistics operators	6	Cagliano et al., 2014, Ambrosini et al., 2013, Roumboutsos et al., 2014, Chanut & Paché, 2012, Stathopoulos et al., 2012, Crainic, Ricciardi, & Storchi, 2009*, Boschetti & Maniezzo, 2015*.
Collaboration among different stakeholders	36	Lindholm & Behrends., 2012*, Chowdhury, 2016, Dablanc et al., 2011, Harrington et al., 2016, Nuzzolo et al., 2016, Comi et al., 2012, Wang et al., 2015, Nuzzolo & Comi, 2014, Nesterova & Quak, 2016, Jedliński & Kijewska, 2016, Lindholm & Behrends, 2012, Chowdhury, M. S, 2016, Dablanc et al., 2011, Harrington et al., 2016, Nuzzolo et al., 2016, van Heeswijk & Schutten, 2016*, Gruler et al., 2016*, Taniguchi, 2015*, Palacio-León & Adarme-Jaimes, 2014*, Graham & Coles, 2015*, Permala et al., 2015*, Arena et al., 2015*, Ambrosch et al., 2015*, de Sousa & Mendes-Moreira, 2015*, Agrebi et al., 2015*, Morana & Gonzalez-Feliu., 2015*, Kim et al., 2015*, Lu et al., 2011*, Giuli et al., 2013*, Vlacheas et al., 2013*, Quintero-Araújo, 2016*, Lo'ai et al., 2016*, Grzybowska & Kovács., 2014*, Mulay, 2015*.

Following the analysis of the core topics of the papers, we identified three main type of roles a stakeholders by analyze the challenging relate to technologies and tools for supporting collaborative among stakeholders in urban logistics. The role of stakeholders can be analyzed into each of 3 categories.

1. Local authorities / Public service

The main actors are the local authorities and the organization that provide the public service. The actors are governmental bodies dealing with the legislation and also those planning facilities and infrastructure such as urban consolidation center (UCC) in order to improve the logistics in the urban areas. These actors are generally interested in sustainability of urban areas in order to assure good quality of life of the residents as well as fostering the economic activities. The public stakeholders have responsibilities and possibilities to optimize urban logistics activities through policy and planning. The

activities also require the good relationship with the others stakeholders in the urban area in order to have a good response from them to involve in the policy and planning (Lindholm., 2012). The implementation of the mentioned solutions requires collaboration between public stakeholders and private stakeholder's an integration of private stakeholders' requirements into the plans. Furthermore, the implementation of specific policy processes decreasing conflict and misunderstanding among all stakeholders is also important (Österle et al., 2015).

This leads to the development of technology for simulating behaviors of stakeholders (carrier, logistics operators, resident, retailers, and stores) in order to predict cause and effect of policy and planning before implementing it in the real world. The simulation and optimization models are therefore used to explore the cause and effect of the policy and planning (Gruler et al., 2016; Permala et al., 2015;). An example of the mentioned technology for developing the model is Agent-Based Modeling (Quintero-Araújo et al., 2016), which is used for modelling and simulation the interactive between the agent (receivers, shippers, carriers, the UCC operator, and the administrator) in order to measure the impact of the policy and planning.

2. Carriers / Logistics operators

The actor group comprises companies delivering goods and services in an urban areas. Generally, there are the private carriers and producers who provide logistics services. The main activities are to distribution. The interest of private stakeholders is to make a profit and to increase service quality. The actors have to respond to the pressure from the regulation established by public stakeholder (limited delivery time, parking areas, transport emission control) and also to serve customers satisfaction (residence and stores in the community) (Rose et al., 2016). Further, they need to cope with the limitation of urban infrastructure such as narrow streets causing traffic jams. These lead to the attempt to find the solutions minimizing the usage of facilities and optimize their profit. The example of the solutions is the sharing vehicle to distribute the goods in the same area (suboptimal routing). The challenges to include the small vehicle such as bicycle and public transportation into the transport planning also become more interested.

From the literature, we found that there are various technologies supporting data management and sharing such as Information and Communication Technologies (ICT) and Mobility Information Services (MIS) used for helping stakeholder to exchange information and supporting the collaboration (Marinov et al., 2012; Giuli et al., 2013;). Moreover, an optimized solution is applied for establishing efficient location-, routing-, and scheduling plans behavioral factors of individuals and interactions with the stakeholders in this type (Quintero-Araújo et al., 2016).

3. Receiver/Customer

Includes all actors receiving goods and services in a specific urban area. This can be residents, retailers and/or stores. The papers in this area focus at one hand side on legislative and regulatory issues and other hand side on how planning and policy development can take the stakeholders' needs into account and how this affect the quality of life. A main concern in this area is related to the negative environmental and societal impacts of emissions and congestion and how to reduce this by developing new concepts and solutions for an urban area. Examples are increased pedestrian street areas in larger cities (Kim et al., 2015) as well as solutions based on the Smart City concept, implementing and using technologies (based on for supporting goods delivery) (Grzybowska & Kovács., 2014). Furthermore, these articles also covers the area of autonomous vehicles and automatization in urban areas related to sustainability aspects (Vlacheas et al., 2013).

In a second step we analyzed how the literature describes how tools and technologies can support the tasks of the three different types of stakeholders, and again two main areas were identified. These are described in the next chapters.

Technology for supporting management of mobility data and information for collaboration in urban logistics and smart city solutions

Out of the 50, six papers are related to technology for management of mobility data and information in urban logistics. Some of the studies also describe how to apply the technology supporting collaboration among stakeholders by sharing data and information as well as using the data for sustainable mobility. An important

According to (de Sousa, J. F., & Mendes-Moreira, J., 2015), increased sharing of network and transport resources can be achieved by designing and operating the network in the way that each mode's performance increases. In addition, management of passenger and freight transport should be combined in a single logistics. Such solutions can however only be realized if the city becomes smart enough, and for this more and more cities starts to develop solutions based on Internet-of-things concept (Vlacheas et al., 2013) as well as an increased usage of different types of algorithms and automated identification technologies (Grzybowska & Kovács., 2014)

(Marinov et al., 2012), mentioned that information and communication technologies (ICT) have contributed to new developments of freight transport solutions and this has had a positive effect on the efficiency good transportation. Relevant technologies includes global positioning systems (GPS), Electronic Data Interchange (EDI), dedicated short-range communications (DSRC), Radio communication and onboard sensors. Rail freight and rail freight operation still require standalone systems and there is a lack of standardize solutions specifically in terms of semantic interoperability.

(Giuli et al., 2013), stated that Mobility Information Services (MIS) in combination with Intelligent Transport Systems (ITS) can reduce pollution, accidents rates and congestions and therefore improve the sustainability of mobility solutions. Mobility services requires different set of information to support people in pre-, on-, and post-trip situation. Consequently, MIS need to address requirements both from service user (front-end) and providers (back-end)

This type of services involve all the three stakeholder groups identified above. In addition, since different information is required, and that in a complex system and many system-to-system interactions including both physical and digital infrastructures, there is a risk for inefficient resource usage (multiple data collection of same data, no access to the right information etc.). Consequently, in order to ensure the best possible service quality in an efficient way, a strong collaboration between all three groups in both development and maintaining of the service is of utmost importance.

This is in line with the suggestions from (Ambrosch et al., 2015) on personal mobility. Furthermore, when it comes to nature more sustainable mobility solutions (including modal shifts) inducing new transport patterns and change of daily routine, it is also not only a question about the technical solution, but also a matter of behavioral change, which requires much more effort, but smart mobility services based on ITS and MIS as well as by an advanced big data analytics can minimize the required behavioral change and thereby increase the user acceptance.

Simulation and optimization model to support collaboration activities in urban logistics

Simulation of logistics and transport networks for the purpose of optimization has been deployed for decades (Gruler et al., (2016). However, besides in the field of collaborative and participatory design approaches, most optimization models do not mirror the

collaborative interaction between the stakeholders, and thus not relevant for our purpose. Among the 50 identified papers, only four seems relevant containing information on how they can be applied for prediction of urban planning, simulation behaviors of stakeholders in urban logistics as well as finding the solution for pickup and delivery in urban environments. The application of the mentioned models / algorithms is described as below.

Gruler et al., (2016) describe how simulation is used for evaluation of complex city logistics systems and for predicting the effects of measures such as the implementation of Urban Consolidation Centers (UCCs), road pricing, truck bans in city centers, time windows, load factor controls, or operational subsidies. According to Quintero-Araújo et al., (2016) agent-Based Modeling and Simulation (ABMS) allows the consideration of the behavior of different stakeholders. Stakeholder behavior in the opening of a UCC concerning different urban congestion levels, minimum vehicle loads, and time windows in city centers

(Permala et al., 2015), mentioned that Multi-model transportation systems with Electric Vehicles (EVs) are used for interaction among different stakeholders and in connecting to local traffic regulations, whereas simulation-based models are used for evaluating the behaviors of stakeholders regarding city logistics (Anand, et al., 2016). The examples include a simulator to test the impact of driver aggressiveness in the energy consumption of EVs by considering ordinary, economic, and aggressive drivers test the impact of using electric vehicles in UCCs using discrete event simulation. In real life, optimization and simulation model should be applied together. According to (Gruler et al., 2016) Optimization for establishing efficient location-, routing-, and scheduling plans behavioral factors of individuals and their interactions are only scarcely considered due to uncertainty in traditional optimization models, combining simulation and optimization would overcome the drawback.

(Quintero-Araújo et al., 2016) propose simheuristic algorithm for Pick-up and delivery in retail, parcel and courier services, waste transport, transport of equipment for the construction industry, and a broad range of other types of transport engage goods distribution in urban and metropolitan areas. Distribution of goods includes (i) storage of goods inside a logistics facility (warehouse, depot, etc.) and (ii) the corresponding route planning to deliver such goods to retail points (convenience stores). Traditionally, each company serves its own customers from its central depot using its own (or subcontracted) fleet of vehicles. A new strategy is introduced by implemented depot between companies in order to reduce operational costs, among other benefits. Multiple depot vehicle routing problems (MDVRP) is applied to solve the NP-hard problems, which means that it is not possible to find optimal solutions for large-sized instances in reasonable computing times.

CONCLUSION

This article presents challenges and activities of three different stakeholder roles, technologies and tools to support tasks of each stakeholder as well as identified two main areas for describing the technologies and tools. The literature found that each stakeholder has their challenges which lead to the different of technologies and tools for supporting them to solve the solution in the different aspect. For the local authorities and the organization that provide the public service, they require the effective planning and policy to optimize urban logistics and fostering the economic activities. This lead to technology for predict the cause-effect of planning and policy while, for companies delivering goods and services who have the main activities to distribute goods and interest to make the profit under pressure from regular and condition of urban areas, therefore, the solution relates to sharing and optimization of facilities among stakeholder. The last type of actor is actors receiving goods and services in a specific urban area. The technologies and tools which relate to this actors are related to environmental protection by developing new concepts and solutions for an urban area such as autonomous vehicles and automatization in urban areas. Additionally, it is noticeable that so far lack of report on education in

connection with the support for collaboration among stakeholders in urban logistics was observed.

Hence, for the next steps, the finding in this paper which are available tools (methods, approaches, supportive technologies) fostering collaboration and common understanding among the different stakeholder groups to better understand the underlying mechanics. This will be used for designing a new training tool which can be more flexible for the various kind of stakeholders to integrate the game into the teaching process as well as their working environment to increase the stakeholder's involvement in the urban activities.

ACKNOWLEDGMENTS

FUSION (Featured eUrope and South asIa mObility Network) of ERASMUS MUNDUS project granted to SG and partial support by College of Arts, Media and Technology, Chiang Mai University are acknowledged and the Beaconing Project, Grant agreement no. 687676 as a H2020 action.

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GAME THEORETIC ANALYSIS OF COORDINATION AMONG HUMANITARIAN ORGANIZATIONS IN THE LAST MILE

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ABSTRACT

PURPOSE

Coordination among the humanitarian organizations (HOs) in the field of humanitarian operations is often characterized by the large international HOs working with the local HOs that possess the local knowledge and the vital connections essential for the last mile delivery. These two classes of organizations are distinct by size, capability, knowledge, and connections, and complement each other in terms of resources. At the same time, they have self-incentivised for their own purposes, sometimes at the cost of their partners'. This paper builds a game theoretic model to study their interactions throughout the relief operation stages and the optimal strategy that should be applied by the international HOs in securing the local partners' services in the coordination process.

DESIGN/METHODOLOGY/APPROACH

We use a game theoretic model which originally describes the procurement strategies among multiple buyers and suppliers, we extend its gist to the context of coordination between the international and local HOs for emergency relief operations, through which we explore some relevant coordination strategies.

FINDINGS

The model results suggest that international HOs should take an inclusive strategy to engage the local HOs during the stage of preparation. However, when a disaster strikes and the emergency relief operations begins, they would prefer an exclusive approach by working with a single capable local HO partner if possible.

VALUE

This study sheds light on the inter-organizational cooperation by adopting a game theoretic approach, which may enrich our knowledge on the coordination strategies and offer new insights on the coordination mechanism.

RESEARCH LIMITATIONS/IMPLICATIONS (IF APPLICABLE)

The preliminary findings would need empirical validation and field data input to enhance the understanding on the coordination strategies of the HOs.

PRACTICAL IMPLICATIONS (IF APPLICABLE)

The initial findings may give insights to the managers of the HOs in choosing the most pertinent strategy in their coordination in the field, which may improve the operation efficiency and attract more donor supports.

KEYWORDS: Humanitarian logistics, humanitarian organizations, coordination process, game theoretic model, coordination strategy

INTRODUCTION

In recent decades, the world has witnessed an increasing impact from natural and man-made disasters (IFRC, 2016). At the same time, the humanitarian organizations (HOs) across the world are busy rescuing and helping people in disaster-affected areas where humanitarian logistics operations have played a key role (Tomasini and Van Wassenhove, 2009). Typically, many stakeholders are involved such as the commercial enterprises, donor and host governments, the military, HOs (often both international and local ones), as well as the local communities working hand-in-hand to recover from a major disaster. These stakeholders and agencies may often have diverse motivations, mandates, resources, and technical expertise, and must coordinate well both internally and externally to ensure the effectiveness of the disaster relief operations. Therefore, inter-organizational coordination in relief humanitarian logistics has attracted increasing academic and policy attention (e.g., Balcik et al., 2010; Moshtari and Goncalves, 2017). As the HOs are specialized on relief operations, an effective coordination mechanism among the various types of HOs is often a prerequisite for the success of such relief operations. This study is thus initiated to explore the coordination strategy between two classes of HOs, the international and the local HOs.

In general, the international HOs are large in size, scope, and funding with global operations, often equipped with professionals and humanitarianism principles (Tomasini and Van Wassenhove, 2009). In contrast, the local HOs are smaller and less equipped for large scale relief operations, relying more on ad-hoc volunteers. However, these local HOs possess the critical local knowledge and connections, an essential link for the last mile delivery in humanitarian logistics operations (Balcik et al., 2010). Except for some large international HOs like the International Federation of the Red Cross and Red Crescent Societies (IFRC) and World Vision with their affiliated local subsidiaries in most countries, most international HOs are incapable of executing the last mile delivery by themselves, needing the complementary resources of the local HOs (Kovacs et al., 2010). Therefore, we model the coordination interaction between these two types of HOs as a form similar to sourcing in commercial supply chain practices, in which the international HOs procure the services of the local HOs for the effective execution of the last mile delivery in humanitarian relief operations. As these two types of HOs are independent, and with somewhat different motives and interests in relief operations, a game theoretic analysis is thus applied to explore the coordination process and identify the appropriate coordination strategies for these HOs.

While the extant literature has moved towards quantification with various sophisticated models in recent years (Kunz and Reiner, 2012; Van Wassenhove and Pedraza-Martinez, 2012), most of them are simplified optimization models without accounting for the practical conflicts of interest among the diverse humanitarian players (Gupta et al., 2016). This study would thus be of interest by examining the optimal coordination strategies of the two types of HOs in the presence of conflicts. Doing so may stimulate interest in applying game theory as well as other valid quantitative tools to address the numerous humanitarian logistics problems with multiple stakeholders involved in various conflicts of interest. As a theoretical piece on coordination, our model sheds light on the dynamic interactions in cooperation by adopting game theory, and it will enrich our understanding of the coordination strategies practised in the field. Further, we advance the studies on game theory by extending it to the humanitarian logistics domain.

THEORETICAL BACKGROUND

Disaster management is normally divided into two phases of relief and development, and four activities of preparedness, response, rehabilitation, and mitigation (Tomasini and Van Wassenhove, 2009; Goldschmidt and Kumar, 2016). Here, the relief phase includes response and rehabilitation, while the development phase covers preparedness and mitigation. Preparedness, defined as "any activities and measures taken in advance to ensure effective response to the impact of hazards" (UNISDR, 2009), is usually classified under the development phase. However, to respond effectively to a sudden-onset

emergency, the HOs must prepare their resources with a clearly-defined plan well before the start of the emergency. The operation of the HOs during the preparedness stage will determine the effectiveness of their response after the emergency.

A key aspect of preparedness is collaborating with the other players (governments, military, business, and other HOs) that form the humanitarian ecosystem, where environmental, demand, and supply risks have posed great challenges (Moshtari and Goncalves, 2017). The literature divides field coordination into two types: vertical and horizontal (Balcik et al., 2010; Bealt et al., 2016). Vertical coordination is the coordination with upstream or downstream partners such as the logistics service providers, while horizontal coordination is the coordination at the same level of the chain, often with the other HOs. Our focus is on the inter-organizational coordination between the international and local HOs in the field, but it is not purely horizontal as the international HOs need to procure services from the local HOs in this coordination setup.

The most commonly accepted definition of coordination is “the act of managing dependencies between the entities and the joint effort of the entities working together towards mutually defined goals” (Malone and Crowston, 1994: 91). Coordination in humanitarian logistics arises from the task interdependencies, where a single entity is unable to meet the needs of the beneficiaries in a location. We use market bidding to model the coordination mechanism between the international and local HOs. While in practice, neither the international HOs nor local HOs would conduct an opening bidding for services, bidding is a good way to describe the intense meetings and negotiation between them. Given the full autonomy of the HOs in the field, both the international HOs and local HOs expect to work with the most capable partners that provide maximum benefits to themselves. For the international HOs, they hope to find capable and well-connected local HOs for the effective delivery of the relief goods at the lowest possible cost so that they can show the effectiveness and efficiency of their operations to gain reputation and funding support globally. For the local HOs, many of them operate on a voluntary basis without sufficient financial resources and professional training. The connection with the international HOs would provide global connection, much needed funding, and training, which may lend to their survival and growth. A vital research question is then to model the interactions between these two types of HOs appropriately that may induce more effective and efficient coordination in the field. We thus develop a bidding model from game theory to examine how various coordination strategies arise from the perspective of the international HOs, which are eager to serve more people in need with effective and efficient operations in the field and to satisfy their donors as well. The model has largely borrowed from Inderst (2008)’s work which describes the procurement strategies among multiple buyers and suppliers. Here, we view the international HOs as buyers for the last mile delivery services while the local HOs act as the service suppliers.

THE MODEL

The model treats a setting with two symmetric local HOs as potential partners, indexed by $m = I1, I2$. Both HOs are expected to provide local connections for the last mile delivery, providing identical services with a strictly convex and twice continuously differentiable cost function $C(x)$ for a certain size of population x , with $C(0) = 0$. At the upstream level, there are at most two large international HOs, $n = I1, I2$. They have the supplies (humanitarian relief goods) that need to be delivered. In our model, we further specify that each international HO wants to cover a fixed size of population x_n (in reality, it often means a certain region). The total size of the population that requires aid is thus given by $S = \sum_n x_n$, which can be seen as the demand in the model. The coordination between the two HO types is viewed as a game theory problem where either the local HOs (service providers) or the international HOs (as service purchasers) bid for a specified amount of delivery service, measured by the size of population in need.

Suppose the expected population to be covered and the costs of local HOs are common knowledge. Even the simplest framework, namely, the one-shot interaction under complete information, can yield a rich set of predictions. Also, we assume that the international HOs do not compete directly. They may agree to partition the geographical region to avoid any work duplication. We are going to study two types of bidding game. In the first game, the local HOs bid for the service they want to provide. The international HOs possess the resources and the local HOs are competing (often is the case when the local HOs are not well equipped for the delivery task and need training and other resources from the international HOs to finish the task). The international HOs have more resources and power in the game. In the second game, the international HOs bid for the service provided by the local HOs. The local HOs now have more power (often is the case when a major disaster has struck and the international HOs are eager to participate in the relief operation). In such an environment, the local HOs have to be well equipped to partner the international HOs quickly for effective operations.

In the actual humanitarian world, both scenarios exist. The first happens more likely in the stage of preparedness when the international HOs are expanding to cover a new and often large region without time constraints. Therefore, they have more power in selecting the most suitable local partners from a plethora of available local HOs. The second occurs more likely in the response stage when the international HOs are rushing to a small region with tight time constraints. To deliver relief goods quickly to the victims of a sudden-onset disaster, they need to quickly connect with the local HOs for effective last mile delivery. Facing the influx of international HOs after the disaster, a few capable local HOs in the region have the power to select their international partners.

From the perspective of an international HO, it should run the first bidding game often in different locations to build up local partners, and hopefully their good relationship with local HOs would exempt them from the second bidding when the need arises. However, they should still be prepared for the second type of bidding game and participate in it with a best possible strategy if they have to.

1. *First game: Local HOs are bidding*

In our coordination game, first each local HO m submits to each international HO n , a menu (payment request) $t_{m,n}(x)$ specifying the total transfer (expected cost for an international HO) that the international HO has to make for the last mile delivery effort in a certain region with population x . We analyse both the case where the international HOs do not restrict their coordination strategies (i.e., single local partner or multiple local partners) and the case where at least one international HO chooses a single local partner.

First case: One international HO

Suppose there is only one international HO i.e. $x_{11} = S$ and, consequently, $x_{12} = 0$. The analysis is similar to Anton and Yao (1989) where a single buyer should choose a single sourcing policy with a fixed amount of demand. In our context, there exists a set of (Nash) equilibria in which the single international HO ends up dividing different parts of S for services from the two local HOs. It is straightforward to see how different equilibria can be found. For this purpose, assume that each HO submits a "quantity-forcing" contract, namely, first to provide service to some fixed population x_m for some total payment $T = t_m(x_m)$, and second to make the asking cost for the service of any population size other than x_m prohibitively expensive by demanding a sufficiently high payment $t_m(x) \gg T$ for all $x \neq x_m$. If HO m follows this strategy, then this makes it optimal for the other HO $m' \neq m$ to follow a similar strategy with $x'_m = S - x_m$.

For our analysis, we want to divert away from this multiplicity, which is also unrealistic in practice. We do so by applying a common refinement to the set of Nash equilibria, as proposed by Bernheim and Whinston (1986). The key notion of a refinement in the present context is to pin down the parts of the payment schedules t_m that are only of

importance *off equilibrium*. Bernheim and Whinston (1986) did so by essentially fixing the slope of the payment schedules, requiring that they *truthfully* reflect the respective HO's marginal costs. It means each schedule of payments must then satisfy

$$t_m(x') - t_m(x) = C(x') - C(x)$$

With the truthfulness constraint, it is clear that the equilibrium outcome must be efficient given that the schedule of payments offered to the international HO by either local HO reflects the respective HO's marginal cost at all of the quantity levels. By symmetry and strict convexity of the cost, the efficiency dictum requires that each local HO serves $S/2$ of the population. Another implication of the truthfulness requirement is that if the international HO rejects one of the two bids and thus ends up procuring the service of entire population S from a single local HO, then the *incremental* cost equals the respective local HO's incremental costs, namely $C(S) - C(S/2)$. In equilibrium, it holds from optimality that each local HO chooses $t_m(S/2)$ such that the international HO is indifferent between acceptance and rejection. Taken together, this implies that $t_m(S/2)$ is equal to the incremental cost of engaging only from a single local HO, $C(S) - C(S/2)$. Hence, the international HO ends up paying $2t_m(S/2)$, which is equal to $2[C(S) - C(S/2)]$.

If the international HO commits to a single local HO (single sourcing), then by symmetry, the local HOs compete themselves down to zero profit. Consequently, the international HO has to compensate the winning local HO just for the respective cost of serving, $C(S)$. Single sourcing is thus optimal if the respective total payment $C(S)$ is strictly smaller than the respective payment under multiple sourcing, $2[C(S) - C(S/2)]$. Rearranging the expressions, we get $C(S) > 2C(S/2)$, which holds from strict convexity of C .

While the intuitive solution in this case is for double sourcing as the cost $2C(S/2)$ is smaller than cost $C(S)$ in the case of single sourcing. However, due to the award splitting of the local HOs (Anton and Yao, 1989), the optimal bidding price of the local HOs is actually $C(S) - C(S/2)$, and makes the cost of double sourcing higher than that of single sourcing. In short, competition removes the implicit collision in the case of two local HOs serving together.

Second case: Two symmetric international HOs

In the second case, there are two symmetric international HOs as service procurers such that $x_{I1} = x_{I2} = S/2$. With the truthfulness requirement holding, we can prove (see Appendix I) that at equilibrium, each local HO is just covering one half of the total population $S/2$, and any allocation of the population between the two international HOs and local HOs is efficient as long as $x_{L1} = x_{L2} = S/2$. At one extreme of the characterized continuum of equilibrium allocations, is the case where each international HO procures services exclusively from one local HO, and the other extreme is the case where each international HO evenly spreads its procurement over both local HOs, and thus procures the service of $S/4$ from either local HO. However, in either case, each local HO serves exactly $S/2$. Moreover, the procuring costs of the two international HOs would vary with their shares of serving population between the two local HOs. Specifically, the cost is minimized if the shares are spread evenly, and highest if the international HO engages a single local HO. Here the result is different from the single sourcing with one international HO as both local HOs would serve same size of people ($S/2$) regardless the choice of the international HOs, while the case of one international HO would stiffen the competition as one local HO would have no people to serve. Such a competition would squeeze the payoff for the service providers. So for two international HOs without collaboration, the local HOs are better off, and the optimum strategy for the international HOs is to smooth their demands evenly among the two local HOs with their cost at $2C(S/4)$. These findings are summarized in Proposition 1.

Proposition 1. *A single international HO who conducts an auction for a fixed size of population strictly prefers to engage a single local HO for service. In contrast, if there are two symmetric international HOs, then either international HO strictly prefers to spread its service procuring evenly over both local HOs. Generally, in the latter case, an*

international HO's cost of procurement increases when his procurement of the last mile services is concentrated on a single local HO, making single sourcing the worst outcome.

2. *Second game: International HOs are bidding*

Now, it is the international HOs who bid for the service of the local HOs. Hence, we now stipulate that international HOs submit bid payments $t_{m,n}(x)$ to the local HOs. Clearly, if there is only a single large international HO, then the analysis is trivial. The equilibrium outcome is efficient and the single international HO extracts all of the profit.

With two symmetric international HOs, to ensure that the local HOs who reject the bid of an international HO have always profitable alternative options, namely to serve more to the other international HO, we still specify that each of the two international HOs can realize the payoff $r(x)$ when serving the population size x ($r(x)$ is assumed to be continuously differentiable and strictly concave with $r'(0) > C'(0)$). We invoke now again the truthfulness requirement. Now, the respective bid $t_{m,n}(x)$ must now truthfully reflect its marginal revenue $r'(x)$. The set of supported allocations would again be equal to that of all efficient allocations with each local and international HO serving $S/2$ in total, and the model results are summarized in Proposition 2.

Proposition 2. *Suppose the international HOs bid in auctions organized by the local HOs and that the truthfulness requirement still applies. Then the ranking of the equilibrium allocations is reversed compared to Proposition 1. Both international HOs are strictly better off the more an international HO's purchases are concentrated on one local HO. Conversely, a single international HO who can post bids to the local HOs will always strictly prefer multiple sourcing.*

Proof. See Appendix II.

If the international HOs bid, then there are now two reasons for why the average purchase prices are the lowest under single sourcing. The first reason is analogous to that underlying Proposition 1, though now it applies symmetrically to the local HOs instead of the international HOs. Thus, while concentrating the purchases more on one local HO reduces the total value of *an international HO's alternative options* across the two local HOs if the local HOs make bids. If the international HOs make bids then it will also reduce the total value of the *local HO's alternative options*, namely to serve more for another international HO. This is now profitable for the international HO if it has all "contracting power" as it makes the bid in the respective auction.

If the international HOs bids, there is also a second reason for why the average outsourcing costs are now lower the more a competing international HO purchases from one local HO. If we ignore a local HO's option to serve more for another international HO, then an international HO's bid would just need to cover a local HO's incremental cost. If an international HO procures all from one local HO, then the international HO has to compensate the local HO for the respective cost $C(S/2)$. Instead, if the international HO procures $S/4$ from either local HO, then the former must compensate each local HO for the incremental cost $(C(S/2) - C(S/4))$, given that the respective local HO then also serves $S/4$ of the affected population to the other international HO. With strictly convex cost, the respective incremental costs in the latter case, namely two times $C(S/2) - C(S/4)$, are strictly higher than $C(S/2)$.

DISCUSSION AND CONCLUSION

Comparing the outcome of the first bidding game with the second (Proposition 1 versus Proposition 2), when we have multiple international HOs working together in the field (often true for most relief operations), multiple sourcing is the best strategy for the international HOs while the local HOs are bidding for their services. On the contrary, single sourcing is better when the international HOs are bidding for the service of the local HOs.

As the first game is more relevant for the international HOs in the preparedness stage when they need to cover a broad region with many local HOs competing for their partnership, the international HOs should adopt an inclusive strategy to build relationships with the local HOs as long as they meet the basic requirements, and provide resources and training. Conversely, in the context of the second game, often in the response stage for sudden onset emergency operations, the local HOs now have more power and control. The international HOs should apply single sourcing to build exclusive relationships with capable local HOs for effective operations. Further, an international HO can also choose a permanent exclusive strategy if it has no intention to engage the local HOs in the preparation stage but just to work with them for the emergency. Thus, the relationship stays dormant until activated in times of emergency. In such an arrangement, it has to be exclusive as the local HO is the more powerful side in the coordination.

In summary, this study has taken a novel game theoretic approach to explore the coordination strategy of the international HOs in engaging local HOs for the last mile delivery. It takes into account the resource and motivation differences in response to the call in the literature to consider diverging interests of multiple stakeholders in humanitarian relief operations (e.g., Gutjahr and Nolz, 2016; Gupta et al., 2016). This study sheds light on the inter-organizational cooperation by adopting a game theoretic approach, which may enrich our knowledge of the cooperation strategies and offer new insights. Moreover, we advance the studies on game theory by extending it to the context of humanitarian logistics. Our findings may give insights to the managers of the HOs when choosing the most pertinent strategies in their coordination in the field which may improve the operation efficiency and attract more donor supports.

The findings need empirical validation for better understanding of the coordination strategies of the HOs. This model is static without considering the dynamic changes in capacity and relationships between the two game players. The local HOs may build their capacities through the first game and become capable to call for bidding in the second game. The international HOs may also build good relationships with the local HOs through the first game and can continue the work with them without the second game at the start of an emergency. Further studies can relax some of the model assumptions such as perfect information about cost and symmetry of the international or local HOs.

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APPENDIX I: Local HO's bid with two symmetric international HO's

The truthfulness requirement in this setting needs to be extended first. We denote the resulting allocation for a given equilibrium, i.e., the distribution of people served by local HO's and international HO's, by $x_{m,n}$. That is, $x_{m,n}$ denotes the population that local HO m will serve for international HO n in the respective equilibrium. The respective payment transfers are denoted by $t_{m,n} = t_{m,n}(x_{m,n})$. Note also that the total population coverage by local HO m is then $X_m = \sum_n x_{m,n}$. If a payment menu $t_{m,n}$ truthfully reflects the *incremental* costs of local HO m , then given the total population coverage x_m by local HO m , we must have for all y that

$$t_{m,n}(x_{m,n} + y) - t_{m,n}(x_{m,n}) = C(X_m + y) - C(X_m) \quad (1)$$

In short, international HO n can procure from local HO m an addition population size y above $x_{m,n}$ at m 's incremental costs, where the incremental costs are found on the basis of the local HO's rationally anticipated serving population X_m under the respective equilibrium.

Eq. (1) is again intuitive in that without further restrictions on the allocation of the local and international HO's, an equilibrium must again be efficient. Again, this requires that each local HO serves just half of the total population $S/2$. If the services provided by the local HO's are identical, it does not matter for efficiency how each international HO mixes and matches between the services from the two local HO's. Consequently, all the allocations are efficient as long as $X_{L1} = X_{L2} = S/2$. Intuitively, we can also see all of these efficient allocations as equilibrium outcomes.

We then turn to the equilibrium transfers. In optimality, the required payment $t_{m,n}$ makes buyer international HO n is just indifferent between asking for serving population $x_{m,n}$ from local HO m or, instead, seeking the alternative local HO m' to serve population $x_{m,n}$. Note that from the truthfulness requirement of Eq. (1), the incremental price that international HO n would have to pay to the other local HO m' equals the local HO's respective incremental cost $C(S/2 + x_{m,n}) - C(S/2)$, with $X_m = S/2$ in Eq. (1). Hence, $t_{m,n} = C(S/2 + x_{m,n}) - C(S/2)$.

Summing over the payments made to the two local HO's, the international HO n will pay the total price of

$$\sum_m [C(S/2 + x_{m,n}) - C(S/2)] \quad (2)$$

We analyse how Eq. (2) changes as we move between different (efficient) allocations. We are interested in how Eq. (2) changes as an international HO's purchases become more or less concentrated on one local HO. For this purpose, we specify without loss of

generality that a given international HO n procure more service from one local HO m such that $x_{m,n} \geq x_{m',n}$. That is, we can refer to local HO m as the larger service provider to international HO n . Differentiating Eq. (2) with respect to $x_{m,n}$, while using that the international HO's total purchases remain constant at $S/2$, thus shifting more of the international HO's procurement to a larger service provider local HO m increases the total buy cost if

$$C'(S/2 + x_{m,n}) > C'(S/2 + x_{m',n}) \quad (3)$$

From the strict convexity of $C(\cdot)$, Eq. (3) holds whenever $x_{m,n} > x_{m',n}$ holds strictly.

In short, with two symmetric international HOs as service purchasers, a purchaser's total purchasing costs, as given by Eq. (2), are *minimized* if the international HO spreads its purchases evenly over the local HOs. Conversely, the purchasing costs are highest if the international HO's purchases are concentrated on only a single local HO.

APPENDIX II: Two symmetric international HOs bid

The truthfulness requirement means that the respective payment menu $t_{m,n}(x)$ must now truthfully reflect a purchaser (international HO)'s marginal revenue $r'(x)$. To formalize this, we choose a particular equilibrium allocation with respective value of $x_{m,n}$. Given the respective (rationally anticipated) quantity $X_n = \sum_m x_{m,n}$ that international HO n will serve, the truthfulness for the menu $t_{m,n}(x)$ thus requires for all y that

$$t_{m,n}(x_{m,n} + y) - t_{m,n}(x_{m,n}) = r(X_n + y) - r(X_n) \quad (4)$$

From Eq. (4), the set of supported allocations is again equal to that of all efficient allocations. Moreover, for any given allocation, both international HOs now pay strictly less than the amount if local HOs make bids. In other words, the right to make offers is clearly valuable. What is at first somewhat surprising, however, is that the ranking of the different outcomes from the perspective of both international HOs is now exactly the opposite to that in the previous case, where the local HOs made bids.

To prove this, suppose local HO m rejects the bid of international HO n . In this case, the local HO's payoff is $\max_y \{t_{m,n'} + [r(S/2 + y) - r(S/2)] - C(x_{m,n'} + y)\}$. As the local HO's payoff at equilibrium is just $t_{m,n} + t_{m,n'} - C(S/2)$, we have

$$t_{m,n} = \max_y \{[r(S/2 + y) - r(S/2)] - [C(x_{m,n'} + y) - C(S/2)]\}.$$

Consequently, a given international HO n 's payoff, which is $r(S/2) - t_{m,n} - t_{m',n}$, becomes

$$r(S/2) - \sum_m \max_y \{[r(S/2 + y) - r(S/2)] - [C(x_{m,n'} + y) - C(S/2)]\}. \quad (5)$$

Define

$$\Omega(x) = \max_y [r(S/2 + y) - C(x + y)] \quad (6)$$

Then for the respective optimal choice of y , denote $p(x) = x_{m,n'} + y$, which is the population served optimally by local HO m after it rejected the offer of international HO n . As we increase $x_{m,n}$ marginally, we thereby reduce $x_{m',n} = S/2 - x_{m,n}$, the payoff of international HO n in (5) now *decreases* if $\Omega'(x_{m,n}) > \Omega'(S/2 - x_{m,n})$, which for $x_{m,n} \geq S/4$ is again the case if $\Omega(x)$ is strictly concave. The argument for Ω being strictly concave is as follows:

By the envelope theorem $\Omega'(x) = -C'(p(x))$, then $\Omega''(x) = -C''(p(x)) dp(x)/dx < 0$ holds whenever $dp(x)/dx > 0$. This clear when we implicitly differentiate the respective first-order condition $d\Omega/dy = 0$ for Eq. (6), we have $dp(x)/dx = r'(S/2 + y)/C'(p(x)) > 0$.

Finally, the argument also holds if international HOs always purchase $S/2$. In this case, $y = 0$ in all the preceding expressions such that $\Omega(x) = r(S/2) - C(x)$, which is again strictly concave in x by the strict convexity of C .

MODELLING THE DELIVERY SLOTS FOR THE LAST MILE DELIVERY: COSTS AND EMISSIONS

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Abstract

Purpose of this paper:

The last mile delivery is a broad term for the movement of goods from a transportation hub to a final delivery destination. For B2C sector, for example, the delivery of items purchased over the Internet can be considered as an example. The last mile delivery includes next day (or designated day), same day and instant delivery options. These options were used to constitute a premium service for a single item on request, but nowadays are widely becoming a standard for different types of product groups due to the growth of e-commerce. However, this is a big challenge for logistics companies to be able to deliver products in very short time windows while considering environmental impacts of their transportation activities (Demir et al., 2014). The purpose of this paper is to investigate the economic and environmental feasibility of the last mile delivery by modelling the delivery costs and emissions for a set of customised delivery slots.

Design/methodology/approach:

In this paper, we aim to develop simulation-based optimisation framework to support the customer decision for the last mile delivery problem using a combination of a heuristic algorithm and simulation. The simulation-optimization approach brings the advantages of both methods for shorter solution times (Fu 2015). The last mile delivery problem requires a different transport planning approach than classical solutions (Boyer et al., 2009). The assumptions of this new transport problem are challenging and interesting for both the academia and the industry.

Findings:

Our preliminary results show that the proposed approach can be an alternative method with a reasonable amount of time. It provides economic and environmentally friendly delivery options for both the logistics company and the customer.

Value:

The results show that the paper is of value to both academics and practitioners. The proposed quantitative approach is relevant and has a great potential to be implemented by practitioners.

Research limitations/implications:

This study is conceptual in nature and needs to be supported by empirical evidence. The proposed conceptual framework will be implemented with real life data obtained from various sources.

INTRODUCTION

The increase in urban transportation activities creates problems for people, environment and logistics service providers (LSPs) (Ferne & Sparks, 2014). LSPs companies need to respond effectively and promptly to the increase in transport demand due to e-commerce and customers' evolving expectations. Especially, in the last mile transportation, LSPs have to improve their planning systems in order to deal with increasing shipment costs and emissions in a highly competitive market. One of the main challenges is to provide each customer with a dedicated delivery slot, ranging from very early morning to late evening (Agatz, et al., 2011). This is a big challenge for the companies since their transportation plans will entirely depend on individual circumstances, which might not be the most environmentally friendly and cost-efficient solution. Besides that, these companies are under pressure to improve their load factors, the number of drops per routes, distance travelled per vehicle and the maximum driving time while reducing emissions and other negative externalities of their last mile activities in urban areas (Demir, et al., 2015).

The last mile delivery is a transportation term that defines the phase of a supply chain that moves products from a transportation hub to the final destination (i.e., the consumer) (Punakivi, et al., 2001). There is clear evidence that logistics and transportation activities contribute to the growth of economies and a trend projected to continue considering current and future technological developments (e.g., digital connectivity, automotive technology) and business models (e.g., omni-channel logistics, integrated networks) (Savelsbergh & Van Woensel, 2016).

The two main aspects of last mile delivery that LSPs use in promoting new delivery solutions are next day delivery and same day delivery. From the customers' perspective the two important decision factors are delivery price and delivery slot availability on a preferred day. Customers ask for convenience and free delivery at their preferred location (i.e., home). Heretofore, LSPs management of last mile logistics have been to balance decision factors in order to meet customers' needs and preferences while minimising costs of last mile delivery. These companies face an increased demand for their services and operate in highly competitive environments, so they continue to be challenged and the concept of green logistics could be a remedy for new delivery services.

LSPs have started to incorporate environmental concerns into transportation decision-making to increase responsiveness to customers' environmental expectations. In this regard, considering green logistics approach for modelling customised delivery slots could be the deciding factor for customers between different LSPs. This is already being done by online grocery retailers. For example, Sainsbury's, one of largest UK supermarket companies, has started an initiative to provide greener time slots for their customers' deliveries (Sainsbury's, 2018). These green slots highlight that Sainsbury's are already delivering in customer area in that specific time slot. This eventually creates a win-win situation for both the company and the customer. We believe that having another delivery nearby is one of the factors and there are other alternative green logistics solutions that can be used for the measurement and the design of customised delivery slots. This will even help more customers so that they can minimise the negative environmental impacts of their decisions.

The green last mile delivery requires a more comprehensive decision-making process approach than classical solutions (Demir, 2018) . The assumptions of this new problem are challenging and also interesting for both the academia and the industry. The basic problem can be formulated as the transportation of goods between locations within a very tight time window(s) and subject to several side constraints. This problem is known as Vehicle Routing Problem in the literature (Golden, et al., 2008). The VRP is NP-hard problem, meaning that the computational effort required to solve this problem increases exponentially with the problem size. Having more delivery slots options (i.e., time

windows) will make this problem more complicated and it will require even more computational effort which will not be possible in practice. Therefore, in our research, we aim to develop a simple but effective simulation-optimisation based solution algorithm to model the customised delivery slots in the domain of last mile logistics. This approach will be useful for same day, next day and designated day delivery defined in the last-mile delivery concept.

The remainder of this paper is organised as follows. We first provide a brief literature on related vehicle routing problems and problem definition. We then present the mathematical model and proposed heuristic algorithm in the subsequent section. Conclusions and future research directions are presented in the last section.

LITERATURE REVIEW

This section provides a brief literature review on related vehicle routing problems.

Last mile logistics is defined as the final step of the delivery process from a distribution centre (or facility) to the end customer. It is also known as final mile delivery. The destination is typically a preferred location, such as home or office. Customer expectations are making last mile logistics increasingly important as they have direct contact with the logistics companies. The main objective of last mile logistics is to deliver products to the customer as fast as possible since it is the last step of the supply chain. This requirement has been evolved from several days to next hour shipment. Between these two services, LSPs also offer designated day, next day, and same day services (Savelsbergh & Van Woensel, 2016).

Transportation planning at the operational level is known as the Vehicle Routing Problem (VRP). The VRP consists of designing optimal collection or delivery routes for a set of vehicles from a depot to a set of geographically scattered customers, subject to various constraints, such as vehicle capacity, route length, time windows, precedence relations between customers, and etc (Irnich, et al., 2014). Practically all variants of the problem are NP-hard and require advanced solution techniques. This makes the VRP topic more popular for the research community.

From the e-commerce perspective, the most relevant problem is the attended home delivery problem (Agatz, et al., 2011). In this problem, a customer chooses a delivery time slot and upon the delivery signs a receipt to confirm the receiving order. If signature is not needed from the customer, the order can be delivered to the mailbox or a safe place outside the door. This type of problem is considered as unattended home delivery and there is a high flexibility in terms of designing the vehicle routes. There is a rich literature on attended home delivery problem. Interested readers are referred to (Campbell & Savelsbergh, 2006); (Agatz, et al., 2008) and (Klein, et al., 2017).

PROBLEM DEFINITION

This section introduces the proposed attended home delivery problem and then provides a small example for the design of customised time slots.

For each order, a customised delivery plan considering the transportation costs and emissions should be created and presented to the customer. The new plan should provide several options on the preferred day. Besides the costs, the amount of emissions to be generated for each available time slot can be shown to the customer who can then decide the delivery slot. This will not just increase the efficiency of deliveries, but also help

creating environmentally friendly vehicle routes with the help of the customer. The methodology can be used for the designated day, next day, same day and instant attended home delivery.

For each time slot, the problem can be modelled as a variant of the VRP and all costs and emissions can be calculated for each time slot (i.e., time windows). In the VRP literature, time window refers to the time period when the delivery is expected to arrive. Companies would prefer to serve more requests when time windows are spread evenly throughout the planning period.

The constraints of this problem include: *(i)* each customer must have at least one delivery option on the planning period; *(ii)* each customer must be served by a single vehicle; *(iii)* each vehicle will leave and come back to the same depot; *(iv)* the maximum load capacity of a vehicle must be respected; *(v)* total travel time of each vehicle must be limited (e.g., driving regulations); and *(vi)* the total number of vehicles must not be violated.

We now provide a small example to highlight the important factors in the design of customised delivery slots in Table 1. The customised plan can be generated solving the VRP formulation for a different set of time windows. The plan has two set of information and only the first part will be shown to the customer. The second half of the plan will be used by the customer to decide the costs and emissions in the left part of the table. Customer will see the costs and potential increase in CO_{2e} emissions based on all received orders. As can be seen from Table 1, emissions are presented with different signs to highlight the potential increase in emissions. Even though costs are the same for some of time slots, the amount of emissions will be different due to the number of vehicles used, distance, the number of drops and average load factor.

Table 1: An example of customised delivery slots from customer's and company's perspective

Time Period	Delivery Time Slot (hour)		What customer see			What company see					
			Availability	Price (£)	CO ₂ emissions (%)	Cost (£)	Additional cost (£)	Number of available vehicles	Average number of drops	Average load factor (%)	Average distance from the depot (km)
MORNING	06:00	07:00	*	—	—	0	—	—	—	—	—
	07:00	08:00	*	—	—	0	—	—	—	—	—
	08:00	09:00	✓	£		£	£	1	10	80	50
	09:00	10:00	✓	££		£	££	1	1	20	100
	10:00	11:00	✓	£		£	££	2	3	30	80
	11:00	12:00	✓	£		£	£	2	4	70	30
AFTERNOON	12:00	13:00	✓	£		£	£	2	5	70	40
	13:00	14:00	✓	£		£	£	2	12	90	30
	14:00	15:00	✓	£		£	£	2	14	80	20
	15:00	16:00	✓	£		£	£	2	15	90	20
	16:00	17:00	✓	£		£	£	1	5	70	40
	17:00	18:00	✓	£		£	£	1	4	60	40
EVENING	18:00	19:00	✓	££		£	££	1	3	50	60
	19:00	20:00	✓	££		£	££	1	2	40	80
	20:00	21:00	✓	££		£	££	1	2	40	90
	21:00	22:00	✓	£		£	£	1	4	60	50
	22:00	23:00	✓	£		£	£	1	4	60	50
	23:00	00:00	✓	£		£	£	1	4	60	60
Possible increase in CO ₂ e emissions for the new order: :0-2%, : 2-5%, :5-10%, :10%+											

In the next section, we provide the mixed-integer linear programming formulation for the investigated routing problem.

MATHEMATICAL MODEL AND PROPOSED ALGORITHM

The vehicle routing problem can be defined on a complete directed graph $G = (N, A)$ with $N = \{0, 1, 2, \dots, n\}$ as the set of nodes that node 0 considered as depot. $A = \{(i, j): i, j \in N, i \neq j\}$ is the set of arcs and the variable costs from node i to node j is shown by d_{ij} . The set $N_0 = N \setminus \{0\}$ is a customer set. A set of vehicles is represented by $l = \{1, 2, \dots, L\}$. The capacity of each vehicle is equal to Q . Each customer can have a non-negative demand q_i . Time interval of each customer is defined as $[a_i, b_i]$ for the preferred delivery. Each time period is divided to six 1-hour time slots. Early arrivals are permitted but the vehicle must wait until the service can start. To model the problem, we define the following decision variables. Binary variables x_{ij}^l are equal to 1 if and only if arc (i, j) is travelled by vehicle l . Continuous variables f_{ij} show the total amount of flow on arc (i, j) . Continuous variables y_j represent the time at which service starts at node j . Continuous variables s_j represent the total time spent on a route that has a node j as last visited before returning to the depot. Continuous variables w_j define the departure time at node j . Finally, continuous variable m represents the number of vehicles used. In order to calculate the costs of each time slot, the following objective function can be used:

$$\text{Minimise } \sum_{l=1}^L \sum_{j=0}^n \sum_{i=0}^n x_{ij}^l * c_{ij} + m * f_v + \sum_{j=1}^n (s_j - w_j) * f_d$$

subject to

$$\sum_{l=1}^L \sum_{j=1}^n x_{0j}^l = m \quad (1)$$

$$\sum_{j=1}^n x_{0j}^l \leq 1 \quad \forall l \in L \quad (2)$$

$$\sum_{j=0}^n \sum_{l=1}^L x_{ij}^l = 1 \quad \forall i \in N_0 \quad (3)$$

$$\sum_{l=1}^L \sum_{j=0}^n x_{ij}^l = \sum_{l=1}^L \sum_{j=0}^n x_{ji}^l \quad \forall i \in N_0 \quad (4)$$

$$\sum_{\substack{j=0 \\ j \neq i}}^n f_{ji} - \sum_{\substack{j=0 \\ j \neq i}}^n f_{ij} = q_i \quad \forall i \in N_0 \quad (5)$$

$$q_j \sum_{l=1}^L x_{ij}^l \leq f_{ij} \leq (Q - q_i) \sum_{l=1}^L x_{ij}^l \quad (i, j) \in A \quad (6)$$

$$y_j - s_j + t_i + t_{j0} \leq L(1 - \sum_{l=1}^L x_{j0}^l) \quad \forall j \in N_0 \quad (7)$$

$$y_i - y_j + t_i + t_{ij} \leq K(1 - \sum_{l=1}^L x_{ij}^l) \quad (i, j) \in A, i \neq j \quad (8)$$

$$a_j \leq y_j \leq b_j \quad \forall j \in N_0 \quad (9)$$

$$w_j - b_j x_{0j}^l \leq 0 \quad \forall j \in N_0, \forall l \in L \quad (10)$$

$$w_j - y_j - t_{0j} \leq 0 \quad \forall j \in N_0 \quad (11)$$

$$s_j - w_j \leq T \quad \forall j \in N_0 \quad (12)$$

$$x_{ij}^l \in \{0, 1\} \quad \forall l \in L, (i, j) \in A \quad (13)$$

$$y_i \geq 360 \quad \forall i \in N_0 \quad (14)$$

$$s_j \geq 0 \quad \forall j \in N_0 \quad (15)$$

$$f_{ij} \geq 0 \quad (i, j) \in A. \quad (16)$$

The objective function calculates the total costs, including fixed vehicles costs (f_v), distance-based variable costs (c_{ij}), and driver costs (f_d). Constraint (1) state that number of vehicles leaving the depot is equal to m . Constraints (2) ensure that each customer is visited by a single vehicle. Constraints (3) and (4) state that each customer is visited exactly once. Constraints (5) and (6) define the arc flows which are used to ensure vehicle

capacity. Constraints (7) – (9) enforce the time windows where L and K are large numbers. Constraints (9) define the time slot (time windows) which is defined by lower and upper bounds. Constraints (10) and (11) are used to estimate the total route times. Constraints (12) ensure that each vehicle travel time is limited by a certain time limit T . Constraints (13) – (16) define the non-negativity constraints. We propose to use (NTM, 2012) emissions model for the calculation of emissions.

To solve the vehicle routing problem for each order, the model must be solved for each time slot so that costs and emissions can be calculated. For example, assuming that time period for the next order will be decided between 6:00am and 7:00am. In this case, the cost should be calculated by setting the time windows constraints as $[a_i = 360, b_i = 420]$. Then, this should be continued until all costs are calculated for each time slot. Since the VRP is NP-hard, any solution to VRP will require high solution time. This time will be increased exponentially with the number of orders in the system. In order to deal with the complexity of the problem, we propose an enhanced version of the Clarke and Wright algorithm by Clarke and Wright (1964). This algorithm is a greedy algorithm, and, at each iteration, it merges the routes and selects the largest saving (i.e., costs). When two routes $(0, \dots, i, 0)$ and $(0, j, \dots, 0)$ can feasibly be combined into a single route $(0, \dots, i, j, \dots, 0)$, a distance saving $s_{ij} = c_{i0} + c_{0j} - c_{ij}$ is generated. The proposed algorithm works as follows:

Algorithm 1: The general framework of the proposed algorithm

Input: A set of orders (O), a set of routes (R) with starting and ending times, a new order (i), depot (node 0)
Output: A set of new orders ($O \cup i$), a set of new routes (R')

- 1 Create a new vehicle route $(0, i, 0)$
- 2 For each order j in set O
- 3 If node j is the only order in its route
- 4 Compute the savings $s_{ij} = d_{0j} + d_{i0} - d_{ij}$ & $s_{ji} = d_{0i} + d_{j0} - d_{ji}$
- 5 Else If j is the first node in the route
- 6 Compute the saving $s_{ij} = d_{ij} - d_{i0} - d_{0j}$
- 7 Else if j is not the last node in its route
- 8 Compute the saving $s_{ij} = d_{0i} - d_{i0} - d_{ji} - d_{ik}$
- 9 Else if j is the last node in its route
- 10 Compute the savings $s_{ij} = d_{0i} - d_{i0} - d_{ki} - d_{ij}$ & $s_{ji} = d_{0i} - d_{j0} - d_{ji}$
- 11 End for
- 12 Order the savings in a non-increasing fashion
- 13 For each saving s_{ij} or s_{ji} (starting from the top of the savings list)
- 14 Determine whether there exist two routes that can be merged, and feasibility of the new route still holds
- 15 Calculate the cost of corresponding time slot
- 16 Calculate the emissions of corresponding time slot
- 17 End for
- 18 If costs/emissions are not calculated for each time slot
- 19 Calculate the cost of remaining time slots
- 20 Calculate the emissions of remaining time slots

Algorithm 1 provides an enhanced version of the CW algorithm for the generation of customised delivery slots for each order.

CONCLUSIONS AND FUTURE RESEARCH DIRECTIONS

Online shopping creates challenges for logistics service providers due to customer preferences and requirements (i.e., 1-hour time slots). Even though these requirements must be satisfied by companies, there are alternative mechanisms (i.e., green logistics) to reduce the environmental impacts. The solutions could be variable costing for each time slots or emissions calculation. Such remedies will motivate customers to consider

alternative delivery slots rather than their first choice. Especially, the emissions will be a good motivation for customers to decide their delivery options.

This ongoing research is trying to model the delivery slots along with the routing of vehicles. We have presented a mixed-integer linear programming model and a greedy heuristic algorithm to generate a greener delivery plan for each customer order during the selection of delivery slots. In the conference presentation, we aim to provide numerical examples to show insights into the customised delivery plans with the help of green logistics. The ultimate goal of this research is to develop a simulation-based optimisation tool to investigate reasonable size of networks.

ACKNOWLEDGMENTS

The authors gratefully acknowledge funding provided by Cardiff University under grant SPARK/ESRC/Panalpina Seedcorn funding 513391.

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AN INVESTIGATION INTO COMPETENCY REQUIREMENTS OF OPERATIONS MANAGERS IN THIRD-PARTY LOGISTICS (3PL) FIRMS: A CASE OF INDONESIA

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ABSTRACT

Purpose of the paper: This study investigates operations managers' competency requirements and develops a comprehensive model of competency for operations managers in the 3PL sector in Indonesia.

Design/methodology/approach: Through an extensive literature review a comprehensive model with four competency-categories and fifteen competencies is developed. A survey questionnaire is employed to collect data against the competencies of the proposed model. The contact details of the potential participants are obtained from Asosiasi Logistik Indonesia (ALI) and Supply Chain Indonesia databases. A total of 368 Indonesian 3PL firms are invited to participate, of which 303 firms agreed to participate, and finally 137 firms participated. Data are analysed using multi-criteria decision-making method called Analytic Hierarchy Process (AHP).

Findings: The results suggest that of the fifteen competencies considered in the model, the most important five are transportation and distribution management (TDM), project management (PM), warehouse and inventory management (WMI), continuous improvement (CI), and leadership (L).

Originality/Value: The competency model developed and used is unique. Furthermore, the proposed recommendations could provide guidelines for the public policy makers to devise strategies for efficient delivery of 3PL activities.

Practical implications: From the practical perspective, the results could be used by the higher education sector and professional bodies to design relevant and comprehensive academic and training modules. Furthermore, the recommendations could be used as a guideline for effective delivery of 3PL activities by the operations managers operating in Indonesia's 3PL sector.

Research Limitations – This study is conducted in the context of Indonesian logistics sector and therefore the findings may not be generalizable for other nations.

Keywords: 3PL firms, Analytic Hierarchy Process, Competency, Indonesia, Operations manager.

INTRODUCTION

Having survived the recent global financial crisis and the subsequent world-wide economic downturn, Indonesia has maintained a vibrant economy with an annual GDP growth of over 6 per cent since 2003. Recently, the Indonesian government has identified the logistics industry as a key sector for further economic growth. However, lack of competencies and skills amongst managers of the logistics providers has become one of the major hurdles for the Indonesian logistics industry. The gap between the supply and demand of competent operations managers is huge. Furthermore, there is an

inadequate training and education program available to cater the need of the logistics sector (Gaol, 2013; Ministry of Economics, 2010). As stated by the Chairman of Indonesian Logistics Association, the infrastructures such as education, training and policy framework are needed to be developed to leverage on the emerging opportunities in the logistics sector in Indonesia (Gopal, 2014). Operations managers in third-party logistics (3PL) require a broad knowledge and know-how to manage interrelated functions of logistics systems. They must have a supply chain mindset, and develop competencies in team orientation, people and technology. For efficient and effective running of logistics operations, it is important that operations managers acquire skills and competencies across all functional areas and across organisations, be team players and become expert in ICT.

This study attempts to model the competency of operations managers in 3PL firms in Indonesia using the analytic hierarchy process (AHP) in order to create appropriate development and improvement programmes for this sector. The research outcomes could be broadly used as guidelines by government authorities or any other legitimate organisations in Indonesia, to create, maintain, and develop well-competent operations managers in the area.

The rest of the paper is organised as follows. A review of literature on competency and existing competency is provided followed by the development of a new, comprehensive model for operations managers in Indonesian 3PL firms. A brief description of the research methodology is then presented. Afterward results of the analysis including the sensitivity analysis are presented. Finally, implications for managers and theory are discussed, with limitations and opportunities for future research suggested.

LITERATURE REVIEW

Competency definition

Although there is no agreed-upon definition of competence, there are researchers and organisations that have sought to depict it. A review of literature finds that competence is often associated with knowledge, skills, or attitudes that enable one to effectively perform the activities of a given occupation or function to the standards expected by someone (Bartoska, Flegl, & Jarkovska, 2012).

Generally, competency itself could be understood as a combination between skill, personal attribute, and knowledge which are reflected to a planned, measured and evaluated job behaviour which will create a performance measurement. Furthermore, based on definitions above can be said that the performance of the organization obtained from the management of various objectives, targets and development of human resources in it in order to achieve the goals both short and long term. The role of leadership in this case is very dominant. The extent to which the leadership requires the organization's human resources to grow then the leadership has the authority in realizing the development of human resources through various development and training activities in accordance with their respective competencies employees.

Competency Model

Broader competencies that should be included in the logistics competency model were presented by researchers. They broke down the competencies model into several competencies and skills which are: logistics skills, global management knowledge, organisational awareness, understanding the logistics industry, general knowledge of finance, sales, marketing, customer service, corporate law, and information system, pro-activity, sensitivity and consciousness about logistics professional image, leading and mobilising others, communication skill, group management skill, integrity, ability to approach problem with clear perception, ability to work effectively, negotiation skills, strategic focus and value-adding skills. Logistics competency indicates dimensions within strategic management skills, business knowledge, and effective leadership skills. These dimensions provide outstanding inputs for the Malaysian higher education sector and also for logistics managers for integrating competency into logistics programs, recruitment, and development functions (Daud, Ahmad, Ling, & Keoy, 2011).

From this literature review, it should be clear that the development and use of competencies is a complex endeavour. The development and application of a competency model is a proven approach to investing in human resources in order to achieve a more effective and productive workforce. The functioning of an organisation largely depends upon several distinctive components, with the talented employee occupying the central role in the accomplishment of organisational goals. In the present economic scenario, the need for a forward-looking and proactive approach to competency modelling is driven by the increasing pace of change in the business environment (Chouhan & Srivastava, 2014; Thai, Ibrahim, Ramani, & Huang, 2012).

Certification of competencies is needed to realise the right man with the right competencies in order to fulfil their duties and responsibilities. In the field of employment or certain professions in accordance with the demands of the company and the business environment. Certification of competencies is necessary to face global competition. In the ASEAN Economic Community (AEC), for instance, foreign professionals are free to enter Indonesian job market which has a very limited skilled person in this area. Job competence certification is the process of granting a certificate of competence are carried out systematically and objectively through competency test standard refers to the work of national and international competence.

Conducted an extensive literature review on the determinants of critical competency for operations managers in the context of logistics providers and found fifteen critical competencies as follow: leadership, people management, teamwork and communication, change management, negotiation, project management, transportation and distribution management, warehouse and inventory management, analytical, managing results, continuous improvement, creating and maintaining corporate social responsibility, cultural awareness, hardware and software knowledge, and information handling. From the identified competencies, the hierarchical (conceptual) model has been made as shown in Figure. 1 below:

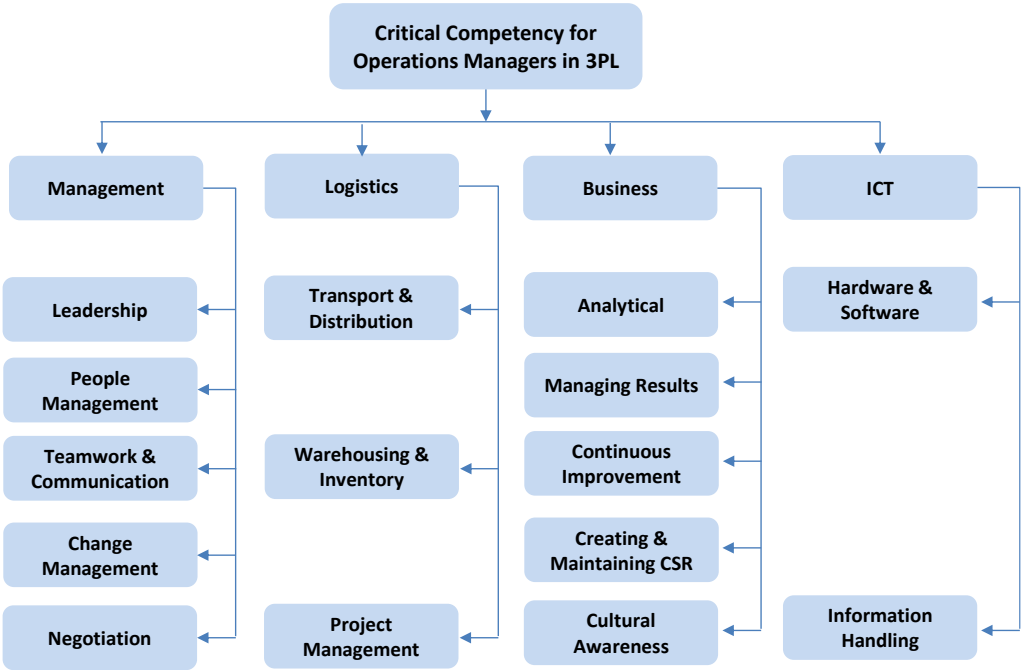


Figure 1. Hierarchical competency for operation manager in 3PL Industry

RESEARCH METHODOLOGY
Method: Analytic Hierarchy Process

This study employs the analytic hierarchy process (AHP) method for the analysis. It is a multi-criteria decision making approach that helps decision makers in breaking down a complex, unstructured problem into decision-making components in a hierarchical structure (Saaty, 1990). It is easy to apply and can produce the most credible results compared to other utility models for determining priorities e.g., direct trade-offs, point allocations, and unit weighting (Schoemaker and Waid, 1982). Since AHP is capable of dealing with qualitative aspects of criteria with subjective judgement (Subramanian and Ramanathan, 2012), the use of AHP as a research method is an appropriate approach for the study.

The process of AHP involves three steps:

Step 1 - identification of competency-categories and competencies, and construction of the AHP hierarchy (see Figure 1),

Step 2 - evaluation of priorities through pair-wise comparison of competency-categories and competencies. A scale of 1- 9 is used for the comparison of competencies, and

Step 3 - determination of critical competencies and validation for consistency.

Questionnaire

A three-part questionnaire is used for interviews and data collection. Part 1 contains general questions about the firm and respondents' background, while, Part 2 contains fifteen open-ended questions designed to capture respondents' opinions on the importance of fifteen competencies of the proposed competency model. Part 3 contains pair-wise comparisons questions between fifteen competencies to determine the level of importance and the priorities among individual competencies.

Sample

A total of 368 local 3PL firms were invited via email to participate in this study of which 303 firms agreed to participate, and finally 137 firms participated. These firms are in operation over 20 years. Approximately, 48.9% are involved with consumer goods industry, 23% with agriculture, oil and minerals industry, 7.2% with pharmaceutical and chemicals products industry, and 20.4% with automotive and metal products industry. Of the respondents 34.5% were mid-level and 65.5% senior level managers.

RESULTS

The priority weights from all respondents, represent the value of the competency-categories and competencies are presented in Table 1 below:

Table 1. Priority Weight Competency Model for Indonesian 3PL

Priority Weight Assigned by Respondents				
Number of Respondents	137			
	Local value weight	Global value weight	Final Rank	Sensitivity
Overall CR of all respondent	0.050			
CR of dimension with respect to the goal	0.035			
Competency- Competencies category				
Management	0.210		3	0.214
Logistics	0.503		1	0.505
Business	0.220		2	0.218
ICT	0.067		4	0.063
Management				
CR with respect to "Management"	0.060			
Leadership	0.292	0.062	5	0.084
People management	0.231	0.049	8	0.063
Teamwork	0.232	0.047	9	0.071
Change management	0.113	0.024	13	0.034
Negotiation	0.132	0.028	12	0.034

Logistics					
CR with respect to "Logistics"		0.080			
	Transportation and distribution management	0.433	0.212	1	0.199
	Warehouse and inventory management	0.226	0.113	3	0.134
	Project management	0.341	0.175	2	0.84
Business					
CR with respect to "Business"		0.070			
	Analytical	0.215	0.049	7	0.057
	Managing results	0.278	0.062	6	0.086
	Continuous improvement	0.362	0.081	4	0.076
	Creating and maintaining CSR	0.072	0.016	14	0.017
	Cultural awareness	0.072	0.016	15	0.019
ICT					
CR with respect to "ICT"		0.000			
	Hardware and software handling	0.429	0.029	11	0.016
	Information handling	0.571	0.037	10	0.025

It could be seen that the final judgement ranking from the respondents shown that logistics competency-categories are the most important for operations managers in 3PL firms in Indonesia. Furthermore, the results demonstrate that the top five competencies are Transportation and Distribution Management (TDM), Warehouse and Inventory Management (WIM), and Project Management (PM), continuous improvement (CI) and leadership (L).

SENSITIVITY ANALYSIS

Sensitivity analysis is used to measure the performance of every single criterion in the model based on the goal which reflects the relative importance of the criterion for future development of the business. Sensitivity analysis therefore provides information of the stability of the ranking.

Since the transportation and distribution competency is found to be the most important, this competency has to be maintained and even improved to ensure firm success. In terms of Indonesian logistics businesses, an operations manager has to master the knowledge of the transportation and distribution process as the first step to achieving success. Although the operations managers in each of the surveyed companies have different educational backgrounds, they are able to manage their subordinates effectively and encourage them to strive for excellence. The warehouse and inventory management and project management competency can be a leading factor in company success as well, since almost all of the respondents have the specific task of providing warehousing services and managing the customers' inventory.

Continuous improvement and leadership are also critical, especially while an operations manager deal with a lot of tasks, he has to able to determine performance from the intangibility and heterogeneity of resources, accommodate and manage them together including control and monitor for a specific result.

DISCUSSION, IMPLICATIONS AND CONCLUSION

One of the tasks of this study has been to develop a comprehensive logistics education and training program for the current and future operations managers working in the 3PL industry. Even the value of change management is far below the most important competency, but the manager should able to achieve personal change to be more successful by entails thoughtful planning and sensitive implementation, consultation with, and involvement of, the people affected by the changes. Regarding all the respective competencies, operating supporting software and hardware is a must. An operations manager has to show their ability to operate the tools as good as their subsidiaries.

Cultural awareness and creating corporate social responsibility were shown as the least important competencies reflect an obligation for company to give more attention to their community and constituents. The cultural awareness probably can be named as the

greatest complexity, and the challenge is how to reduce the mistakes. Since the nature of Indonesian which can be said as "take it for granted" this not become a big issue (yet) could be a big issue in the future. While the CSR regulation is not settled yet, the logistics providers companies feel that they don't need to put a big attention in this area. They better put attention and underlined the critical areas that they have to improve most.

Certification of competencies is needed to realise the right man with the right competencies in order to fulfil their duties and responsibilities. In the field of employment or certain professions in accordance with the demands of the company and the business environment. Certification of competencies is necessary to face global competition. Job competence certification is the process of granting a certificate of competence are carried out systematically and objectively through competency test standard refers to the work of national and international competence. Indonesian National Competence System (SKKNI) is a formulation of workability covers aspects of knowledge, skills, expertise, and work attitudes that are relevant to the duties and terms of office are set in accordance with the provisions of Law No. 13 of 2003 on Labor and PP 23 of 2004 on the National Professional Certification Board (BNSP) and Regulation 31 of 2006 on the National Vocational Training System.

Therefore, the results of this study could be beneficial to students who want to enter the logistics profession or individuals who already working in this industry. Educators should also find the results interesting in terms of planning and designing curricula for current students as well as planning continuing education and executive development programs for logistics managers already in the profession (Rahman, Khan, & Abareshi, 2010). Professional organisations can use the findings to enhance their roles in the development of such programs. More specifically, the results may prove insightful for planning annual conferences and educational tracks, regional roundtable/chapter meetings, internet seminars, and distance learning programs.

The output of the AHP has many advantages. One is the ability to know precisely what the decision-maker's priorities are, in terms of both the factors that make up the decision, and the alternatives that have been considered in the actual decision as well. Further, knowing the mechanics of the AHP one is able to test the decision output for its susceptibility to rank reversal, the knowledge of which is useful. Finally, one can use the AHP decision output to gain an understanding of the decision-maker, allowing the decision-maker to be misled using the techniques of under estimation, overestimation, or misinformation. In order to complete the AHP model, there must be a valid justification from the expert or authorised person who understands the real situation.

In addition, it is critical to establish collaboration and cooperation between government, academia, entrepreneurs and logistics associations to develop a comprehensive logistics curriculum based on the competencies for every managerial level. Accommodating logistics associations that are concerned about national logistics certification in the field of human resources is a must. Also, companies which already provide logistics training for their employees can be motivated to collaborate. Under the supervision of the Ministry of Education, vocational high schools and tertiary institutions should devise and deliver courses specifically for logistics, and offer qualifications at all levels of education.

Finally, certification of competencies is required if companies are to survive in the face of increasingly global competition. Job competence certification is the process of granting a certificate of competence carried out systematically and objectively through a competency test that is related to work competency standards nationally and internationally. The certification of competencies ensures that the right man with the right competencies is given an appropriate role and can successfully undertake the tasks and responsibilities associated with certain professions, in accordance with company demands and the business environment.

LIMITATIONS

This study assumes that criteria in the competency-category and competency level analyses are independent, while in reality, there are interactions and interdependencies between criteria in both level. In other words, each of the competencies may influence other competencies. Similarly, each of the four competency-categories may impact on the other dimensions. Hence, to build a more realistic model in a future research, these interactions, interdependencies and feedbacks can be considered in the process of evaluation by using analytic network process (ANP) or by employing the decision making trial and evaluation laboratory (DEMATEL) to obtain the causal relationships between criteria.

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Session 11: Sustainability in Logistics and Supply Chains

AN INVESTIGATION OF ENVIRONMENTAL DISCLOSURES OF GLOBAL LOGISTICS FIRMS USING SOCIAL NETWORK ANALYSIS

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ABSTRACT

Aim/Purpose: This study examines the characteristics of environmental reporting of global logistics firms and investigates the links between these firms to work together for the facilitation of an improved reporting system.

Design/ Methodology/ Approach: A sample of seventy-one global logistics firms who report environmental aspects using Global Reporting Initiative (GRI) are selected from the sustainability disclosure database. Social network analysis (SNA) is used to investigate the characteristics of environmental reports.

Findings: Results demonstrate that European firms are active in reporting most of the Environmental aspects followed by Asian firms. On the other hand, North American firms are reporting minimum amount of environmental aspects. Among environmental aspects energy and emissions have a higher degree, closeness, and betweenness centrality values. Centrality values suggests that energy and emissions aspects are mostly reported by the sample firms from all the geographical regions. Furthermore, results of the network density, core and periphery analyses demonstrate that more than 40 per cent of the sample firms are connected to each other.

Originality/ Value: The use of SNA is unique in the context of reporting. This study is the first of its kind research to examine the nature and characteristics of environmental reporting using the social network analysis. By examining the firm's relationship with environmental aspects, this study provides an important basis for environmental reporting research in the field of logistics.

Research Limitations/ Implications: Major limitation of this study is the generalization of the findings. This study is conducted in the context of logistics industry, so the results may not be generalizable to other industries. Therefore, future research should consider environmental reporting from other industry sector samples and compare the findings.

Practical Implications: Results of this study assists managers to learn from the firms with a similar opinion on environmental aspects and improve their environmental reporting system.

Keywords: Centrality measures, Environmental reporting, Global logistics firms, Global reporting initiative, Social network analysis.

1. INTRODUCTION

Globalisation has resulted in complex supply chains that are expanded into international locations. Greater dependency on logistics services for distribution of products from sourcing to consumption through production in global supply chains has made the logistics industry a subject of closer scrutiny for environmental impacts (Kudla & Klaas-Wissing, 2012). With the predicted growth in freight transport, the challenge is to raise the efficiency and competitiveness of the logistics sector and to reduce the sector's environmental impacts. To achieve environmentally sustainable logistics industry, logistics firms are adopting environmental reporting practices. Reporting environmental aspects assists in enhancing a firm's credibility as an environmentally friendly organization and also assists in building relationship with stakeholders (Ti, 2017).

Over the past two decades, increasingly greater emphasis is given to develop and disclose social and environmental performances of business operations (Barkemeyer, Preuss & Lee, 2015). By 2010, over 80percent of the Fortune 500 companies have published environmental or sustainable reports (Li & Lee, 2012) and the content of reports have grown from just a page devoting to employee related disclosure to detailed stand-alone sustainability reporting (Qiu et al., 2014). Since the stakeholder interests differ in different industries, contents disclosed in an environmental report vary from industry to industry (Chen et al., 2015). In particular, it is not clear which environmental aspects are reported by logistics firms and how efficiently firms make use of their reports (Piecnyk & Björklund, 2015).

Environmental report of a firm is a network of aspects such as energy, emissions, and resource consumption that are inter-connected to each other. To understand the environmental characteristics and their interrelationships, it is important to adapt to social network perspective. Against this background, using Social Network Analysis (SNA) the study examines the nature and characteristics of environmental reporting of global logistics firms and investigates the ties between these firms to work together for the facilitation of an improved reporting system.

2. LITERATURE REVIEW

2.1 Environmentally Sustainable Logistics

Logistics industry is considered as major environmental polluters with 7percent of total global emission (LPI, 2016). As long as more and more goods are transported around the world, there will be an increase in the freight transport related emissions. It is expected that the share of freight logistics to reach 60percent of the transport emissions by 2050 (LPI, 2016). Governmental regulations, economic considerations, and increasingly strong market signals from environmentally conscious consumers have resulted in the environmentally responsible logistics (Piecnyk & Björklund, 2015). To minimize the environmental impact, logistics industry have taken several initiatives such as the use of electric vehicles for road freight, use of alternative energy sources such as installation of solar panels on the warehouse facilities, and reduction of shipping carriers speed. Despite these efforts, environmental impact of logistics firms still remained as a major concern. To be a good corporate citizen, logistics firms are implementing and reporting innovative and comprehensive environmentally responsible practices.

In comparison to the practitioners, researchers are slow in understanding the environmentally responsible practices of logistics firms. Although several researchers have studied the concept of environmentally responsible logistics firms for a decade (Piecnyk & Björklund, 2015; Wolf & Seuring, 2010) the identified dimensions of the topic tend to be considered in isolation, without consideration of their relationship to one another. This study aims to examine the aspects of environmental responsibility and their ties to one another by using SNA.

2.2 Environmental Reporting

Since 1970, non-financial corporate communications has increased dramatically (Cho et al., 2015). Sustainable reporting is defined as 'the disclosure of company initiatives that demonstrate the inclusion of social and environmental concerns in business operations and interactions with stakeholders' (Pérez 2015 p.11). The factors that led to increase in non-financial reporting are availability of several standards, changes in regulatory environment, increased social responsibility investments and establishment of rating agencies (Cho et al., 2015). The extent and content of reports depends upon time, organisation, industry, and institutional factors (Patten, 2002). Content expressed in non-financial corporate disclosures signal the market on how organizations are proactively managing social and environmental risks (Chen, Feldmann & Tang, 2015).

GRI is perceived as a credible organisation engaged in developing guidelines for non-financial information reporting (Knebel & Seele, 2015). Today, GRI guidelines are regarded as 'the de facto global standard' (KPMG, 2011, p. 20) and is considered as a solution to the inconsistencies in the quality of the reporting (Colicchia et al., 2013). Being an internationally recognised standard, GRI based sustainability reports can be used to compare the environmental performance across industries and nations. GRI report has been selected as the data source for this research, since it is expected to be commonly adopted global criterion for environmental reporting. Based on GRI, environmental aspects used in this study to measure the performance are identified (refer to Table 1).

Aspect	Description	Indicators
Materials	Organisation's contribution to conserve the global resource base and efforts to reduce the material intensity and increase the efficiency of the economy.	EN1, EN2
Energy	Energy aspect include direct and indirect energy use, energy saved, and energy efficient products and services	EN3, EN4, EN5, EN6, EN7
Water	Organisation's reporting on the withdrawal of water from the sources and how the sources are affected. It also reports on the amount of water recycles and reused	EN8, EN9, EN10
Biodiversity	Biodiversity reporting includes the information on the organisational presence in protected areas and the impact of products, service and operations on biodiversity in protected areas.	EN11, EN12, EN13, EN14, EN15
Emissions	Emissions aspects include air emissions, effluents, solid waste. In addition, international conventions greenhouse gas emissions are included in emissions	EN16, EN17, EN18, EN19, EN20, EN21, EN22, EN23, EN24, EN 25
Products	Organisation's reporting on the initiatives to mitigate environmental impacts of product and service, and effective recycling of the products at end of use and the related packaging materials	EN26, EN27
Compliance	Reports on the sanctions of non-compliance with environmental laws and regulations.	EN28
Transport	Reporting on the environmental impacts of transporting products, goods, and materials used for the operations and the impact of transporting the workforce.	EN29
Overall	Total environmental expenditure and investments by type	EN30

Table1: Environmental aspects and related indicators

3. RESEARCH METHODOLOGY

3.1 Selection of firms

As mentioned earlier that GRI guidelines provides a comprehensive reporting system for environmental and social performances. Therefore, in this study we use the Sustainability Disclosure Database published by GRI for choosing the sample firms. The following criteria are applied to select the firms. The firm must

- belong to the logistics industry.
- publish standard GRI reports following sustainability reporting guidelines either version 3.1 or version 4.

Among 105 logistics companies listed in the Sustainability Disclosure Database, 71 firms satisfied both the selection criteria. Appendix1 presents the demographic profile of 71 firms. The sample includes companies across the world from countries with and without mandatory reporting.

3.2 Measures of Environmental Performance

GRI reports of the sample firms are content analysed to measure the quality of firms' environmental disclosures. An indexing technique is considered as an effective tool to gauge the level of disclosure (Bewley & Li, 2000; Cho & Patten, 2007). Each performance indicator in the GRI framework is measured using a grading scale of 0 to 5; where 0 indicates 'not reported', 3 indicates 'partially disclosed' and 5 indicates 'fully disclosed'. The score for each environmental aspect of the firm is evaluated based on the Equation (1) (see for example Cho & Patten, 2007; Meng et al., 2014).

$$ED_i = \sum_{j=1}^n I_{ij}/n_j \dots\dots\dots (1)$$

Where ED_i is the score of energy aspect of environmental disclosure for firm I ; and I_{ij} is the indicator score of the j^{th} term for firm I and n is the total number of indicators in which $j = 1, 2$ for energy. Likewise, scores of all the other eight aspects are calculated.

3.3 Social Network Analysis

SNA is used to examine the characteristics of environmental reporting of global logistics firms. Underlined by graph theory, network analysis assists to model, analyse, and visualise the structure of the interactions between the members. A network views any system as a set of nodes and ties that connect these nodes. SNA is used to understand the social relations among the nodes. In this regard, firms and environmental aspects are considered as the nodes.

The scores of environmental performance obtained from content analysis is presented in an adjacency matrix. The scores of the adjacency matrix exhibit 2-mode data characteristics. In SNA, 2-mode data refers to data recording ties between two sets of nodes from different classes. In this study, firms and environmental aspects acts as a two sets of nodes connected through the network of ties. The sociogram of a two mode matrix exhibits a bipartite graph. In addition to the sociogram, this study also computes a range of node and network metrics. Table 2 provides an overview of key metrics and their interpretation in the study context. As this study examines two mode data, centrality measures are computed for the two modes.

Node-Level Metrics	Conceptual Definition	Explanation- Environmental Disclosures
Degree Centrality	Degree centrality measures the number of nodes connected directly	Extent to which a firm discloses the aspects of environmental indicators.
Closeness Centrality	Closeness centrality refers to the average shortest distance of the node from all the other nodes.	Firm's distance to the environmental aspects indicates the most effective communicator.
Betweenness Centrality	Betweenness centrality measures the number of times a particular node lies between the various other nodes in a network.	The firm with higher betweenness centrality plays a gate keeper role and impacts the other firms reporting
Network-Level Metrics		
Network Density	Network density refers to the number of total ties in a network relative to the potential ties.	It refers to the portion of firm's disclosure of environmental aspects
Network Complexity	Network complexity refers to the number of dependency relations with in a network.	Complexity measure of Closeness indicate that the firms can work together to promote sustainable disclosure

Table 2: Node and network level metrics

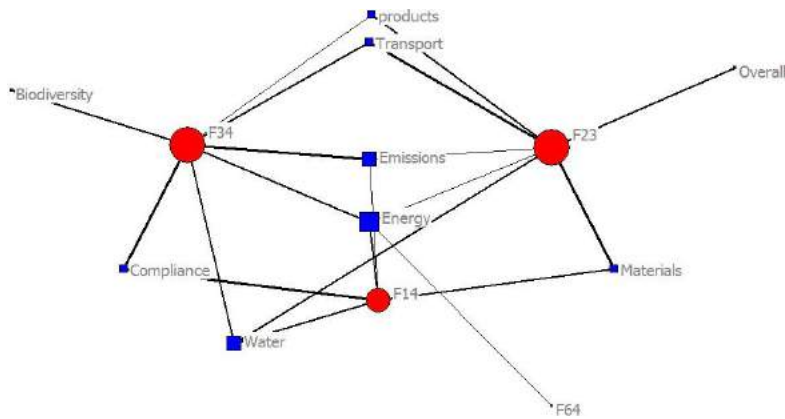
Further, to examine the differences in environmental reporting based on the geographical region; data is clustered into four regions Asia, Africa, America, and Europe. Four different data types results in four network structures. An open source mapping software tool UCINET® software package is used to visualise the network structure in SNA. This software assists in calculating network measures such as centrality, density, sub-group identification, and elementary graph analysis.

4. ANALYSIS & RESULTS

4.1 Sociogram

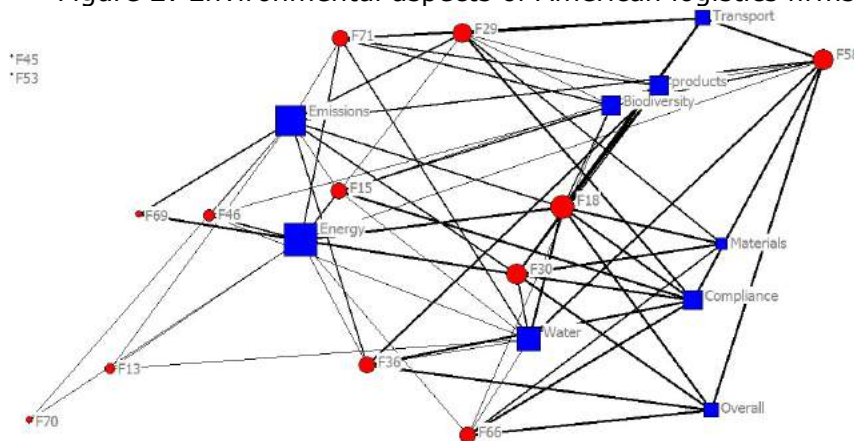
Visualisation of networks of four regions is shown in Figures 1-4. In each figure, firms are presented in red circular nodes and environmental aspects in blue squares. Size of the node represents the degree centrality and thickness of the tie presents the strength of the relationship. Position and closeness of the nodes indicate how the firms are disclosing environmental aspects.

Figure 1: Environmental aspects of African logistics firms



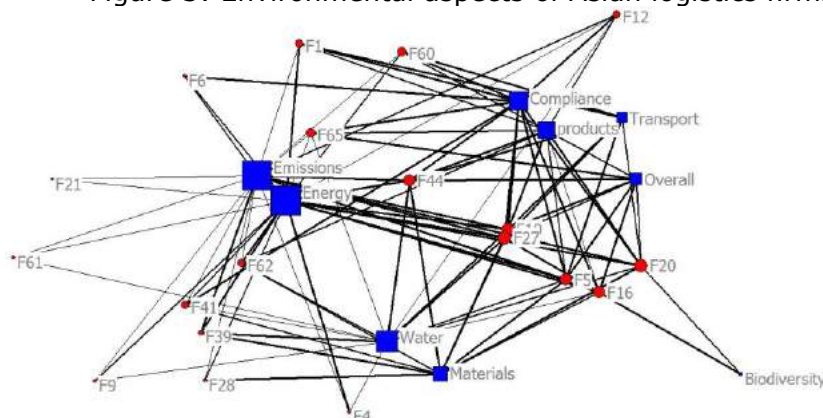
African Firms: In this there are four African firms that disclose environmental aspects. Figure 1 represents sociogram of four African firms (F14, F23, F34, F64) connected to nine environmental aspects. F34 and F23 are the two firms with higher centrality measure and F64 has the lowest level of environmental disclosure. In regards to environmental aspects, energy, emissions, and water are the most disclosed aspects among the firms.

Figure 2: Environmental aspects of American logistics firms



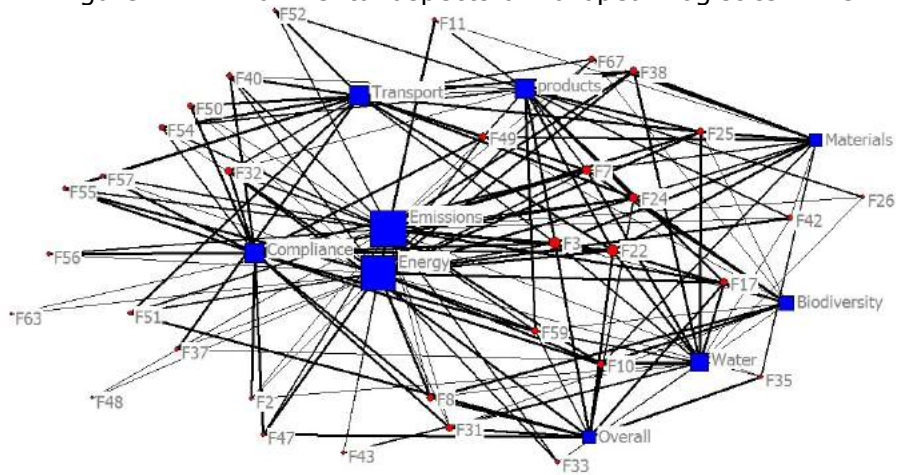
American Firms: Sociogram of the fifteen American firms and their ties with environmental aspects is shown in Figure2. Firm F18 at the centre of the network connects to all the aspects. Following, firm F29 reports seven environmental aspects and its position and tie strength indicates that the firm discloses transport aspect to a higher degree. Similarly, F58 also discloses seven aspects and in particular transport is referred to a higher degree. Therefore, the transport aspect is placed between F29 and F58. Emissions and energy are the two often referred aspects by all the firms. The two environmental aspects are placed close to the firms F69, F70, and F13 that only present emissions and energy aspects.

Figure 3: Environmental aspects of Asian logistics firms



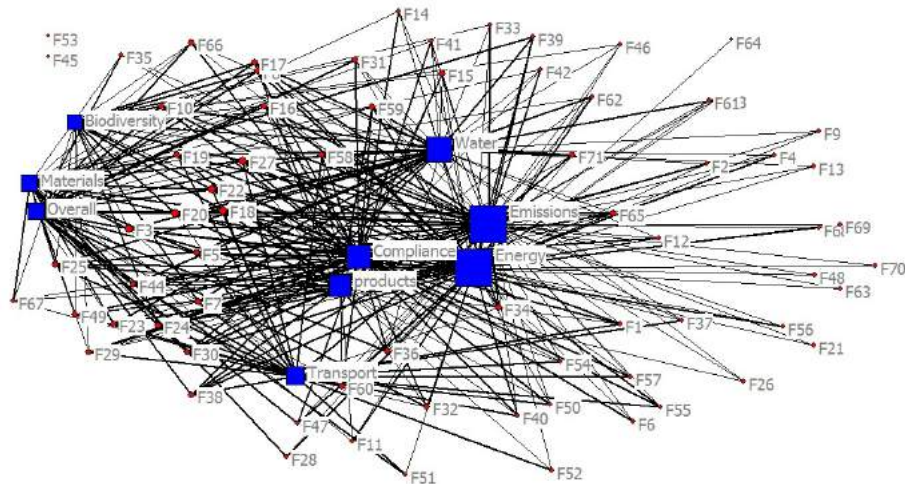
Asian Firms: Figure 3 presents the sociogram of nineteen Asian firms that are connected to nine aspects. Firms F19, F27, F44 are at the centre of the network connected to most of the aspects. Firm F20 also presents most of the aspects and is strongly associated with the biodiversity and overall aspect of environment, so it is positioned between biodiversity and overall aspects.

Figure 4: Environmental aspects of European logistics firms



European Firms: Figure 4 presents 32 European firms and their relationship with the environmental aspects. Firms F3, F7, F22, F24 at the centre of the network discloses most of the aspects. Energy and emissions are the most referred environmental aspects among the European firms.

Figure 5: Environmental aspects of logistics firms- overall



All Firms: Finally, social network of all the firms is shown in the Figure 5. Clusters of firms and environmental aspects can be identified in the figure. Most often referred energy, emission, water, compliance, and products aspects are at the centre of the network and connected to most of the firms. However, biodiversity, materials, and overall are relatively less referred aspects and are position towards left. Group of firms (F3, F5, F7, F18, F19, F20, F22 etc) reports most of the environmental aspects and connects the two sets of aspects. Firms at the bottom of the network reports transport aspect. On the other hand, firms at the extreme right only report emissions and energy aspects. Firms F45 and F53 are the two firms that did not disclose any of the environmental aspects.

Overall, the dense social networks facilitate organisations to understand the dynamics of firms with respect to environmental aspects and how they influence each other. Similarities in firms reporting assist them in developing relationships in future. Following section provides node and network metrics from UCINET®.

4.2 Node-level Results

Table 4 lists firms and environmental aspects with top centrality measures from different geographical region. Top firms are identified based on the cut off values of degree centrality greater than 0.5, closeness greater than 1 and betweenness greater than 0.1. Africa firms F23 and F34, American firms F26 and F29, and firm F1 in Asia are acting as connectors impacting the reporting of other firms in the respective region. Moreover, with respect to environmental aspects emissions and energy are the top most critical aspects with respect to all the centrality measures across all the regions.

	Firms				Environmental Aspects			
	Africa	America	Asia	Europe	Africa	America	Asia	Europe
Degree	F23, F34	F15, F18, F29, F30, F36, F58, F66, F71	F5, F16, F19, F20, F27, F44, F65	F3, F7, F8, F10, F17, F22, F24, F25, F31, F32, F38, F49, F59	Energy, emissions, Water	Energy, emissions, Water	Emissions, energy, water	Energy, emissions
Closeness	F23, F34	F18, F29, F30, F58	F20, F27	F3, F22	Energy, Water, emissions,	Energy emissions	Energy emissions	Energy emissions
Betweenness	F23, F34	F29, F26	F1		Energy	Energy emissions	Energy, emissions	Energy, Emissions

Table 4: Firms and environmental aspects with top centrality measures

Table 5 presents centrality measures of the top firms. Firms F3, F18, F20, F22, and F27 are the firms with degree centrality of 1 and closeness value of 1.028. The top firms are predominantly European and Asian firms. From Figure 5 it is clearly evident that most of these firms play a bridging role in connecting two clusters of environmental aspects. On the other hand, among bottom 10 firms, firms F45 and F53 headquartered at Brazil did not disclose the environmental aspects that fit with the chosen GRI framework. In addition, other firms such as F68, F69, and F70 are Latin American and North American firms.

Top most important firms				Least important firms			
Firm	Degree	Closeness	Betweenness	Firm	Degree	Closeness	Betweenness
F3	1	1.028	0.004	F45	0	0	0
F18	1	1.028	0.004	F53	0	0	0
F20	1	1.028	0.004	F64	0.111	0.903	0
F22	1	1.028	0.004	F21	0.222	0.937	0
F27	1	1.028	0.004	F48	0.222	0.937	0
F5	0.889	1.014	0.003	F63	0.222	0.937	0
F7	0.889	1.014	0.003	F68	0.222	0.937	0
F16	0.889	1.014	0.003	F69	0.222	0.937	0
F19	0.889	1.014	0.003	F70	0.222	0.937	0
F24	0.889	1.014	0.003				
F30	0.889	1.014	0.003				
F44	0.889	1.014	0.003				
F58	0.889	1.014	0.003				

Table5: Firms with top centrality measures

Centrality values of environmental aspects can be seen in the Table 6. Energy and emissions aspects have higher values in all the centrality measures. The higher values of the betweenness value indicate that the deletion of these aspects can affect reporting of the other environmental aspects.

	Degree	Closeness	Betweenness
Materials	0.394	0.521	0.029
Energy	0.944	0.978	0.278
Water	0.592	0.626	0.079
Biodiversity	0.338	0.497	0.019
Emissions	0.944	0.978	0.272
Products	0.521	0.584	0.052
Compliance	0.549	0.6	0.061
Transport	0.437	0.54	0.036
Overall	0.366	0.509	0.023

Table6: Centrality values of environmental aspects

4.3 Network-level Results

Network metrics such as network density, centralization, and complexity provides an overview of how ties are organised in a network. Table 7 and Table 8 presents network density and network complexity measures. Results demonstrate that the African region has the least number of firms which are densely connected together with a network density of 0.556. In addition, it is not possible to cluster the African firms into core and periphery categories resulting in zero density values. On the other hand, closely connected American firms are clustered into eight core firms. Among Asian and European firms there are five and fifteen core firms.

Network Density

	Network size	Network density	Core Size	Core density	CTP density	PTC density	Periphery density
Africa	4	0.556	0	0	0	1.526	1.911
Asia	19	0.602	5	4.665	3.414	1.787	0.563
Europe	32	0.569	15	3.650	2.410	1.836	0.590
America	15	0.511	8	4.454	3.438	1.234	0.794

Table 7: Network density measures across geographical region

	Network size	Network density	Average Distance	Radius	Diameter	Norm Distance
Africa	4	0.556	2.026	2	4	0.759
Asia	19	0.602	1.907	2	3	0.811
Europe	32	0.569	1.952	2	3	0.848
America	15	0.511	1.909	2	3	0.946

Table 8: Network complexity measures across geographical region

5. FINDINGS & DISCUSSION

5.1 Key Firms in the Network

Results demonstrate that the sample firms reporting environmental aspects are predominantly European. This is to be expected as there are number of sustainability reporting instruments that are more mature in the European region. Followed by European firms, many of the Asian logistics firms report environmental indicators. Increase in reporting in Asian firms is due to the financial market regulators. Though firms from North American region are leading Top50 logistics firms, environmental reporting of the firms from this region is not prominent. Of the fifteen American firms, only 4 North American firms are reporting environmental aspects. The greater number of Latin firms reporting

environmental performance is explained with the increase in the increasing pressure from stakeholders. Among all, firms from African region least dominant in reporting environmental aspects.

Centrality measures of the firms indicate that in most of the geographical regions less than 50percent firms have centrality measures above the threshold values. An exception is African firms with 50percent (two) of firms having higher degree, closeness, and betweenness centrality measures. Higher betweenness centrality measure of the two firms indicates their connector role. Higher closeness centrality of American firms indicates that the firms are effective communicators. Meanwhile, two Latin American firms do not report environmental aspects that fit with the selected framework. Environmental reports of these firms are based on the other reporting instruments.

Although number of Asian firms reporting environmental disclosures are relatively less, they dominate the top environmental reporter list with higher centrality measures. Higher value of network density measure also indicates that the few Asian firms who report environmental aspects extensively are closely connected to each other and connected to European firms. Despite the number of European firms reporting environmental aspects, they do not lead in the top or least in the list of the firms reporting environmental aspects. North American and Oceania firms are only reporting energy and emissions. Latin Americans are closely related to the European firms in reporting transport and biodiversity aspects.

5.2 Key Environmental Aspects in the Network

Results signify that emissions and energy aspects are disclosed in most of the firm's environmental reports. Notably logistics industry is known as the biggest polluters with direct and indirect greenhouse gas emissions. In addition, it is projected that freight related transport emissions to be increased significantly and reaches to 60percent by 2050. Moreover, recent agreements at the UN have resulted in regulations governing the disclosure of carbon emissions by organisations. In regard to energy usage, transportation sector is the largest energy consumer with 35percent of global energy consumption in 2014 (IEA, 2017). This scenario provides an opportunity for the transportation sector to generate a significant energy savings. Moreover being the world's largest oil consumer, logistics industry can be a driver for the use of renewable fuel sources. To be specific, logistics firms are increasingly implementing and reporting practices related to the use of renewable energy resources and energy efficient vessels. If a logistics firm is not emphasising on reporting emissions and energy aspects, then firms need to clearly mention their focus.

Followed by energy and emissions aspect, water aspect is commonly referred by firms across Africa, America, and Asia region. Based on GRI framework, logistics firms in these regions disclose the water usage, the amount of recycled water used, and how the sources are affected by water withdrawal. On the other hand, only few firms have disclosed aspects of biodiversity in their reports. However, in practice shipping vessels have a major impact on marine biology. Firms are reporting biodiversity aspects as a reactive strategy to the disasters. Though environmental indicators studied are presented as discrete; they are interrelated to each other very closely. In particular, energy, emissions and water aspects are closely related to each other in most of firms.

6. CONCLUSION

This study explores sustainability reports of logistics firms and identifies the characteristics of environmental aspects. In this study seventy-one global logistics firms reporting environmental aspects based on GRI are considered for the analysis. Results indicate that across all the firms, European and Asian firms are leaders in reporting most of the environmental aspects. In regards to the environmental aspects, energy and emissions have frequently appeared across most of the firm's reports. To the best of our knowledge, this study is the first of its kind research to examine the nature and characteristics of environmental

reporting using the social network analysis. By examining the firm's relationship with environmental aspects, this study provides an important basis for environmental reporting research in the field of logistics. Despite its significance, major limitation of this study is the generalization of the findings. This study is conducted in the context of logistics industry, so the results may not be generalizable to other industries. Therefore, future research should consider environmental reporting from other industry sector samples.

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Appendix A: Demographic profile of sample firms

Code	Company	Country	Region
F1	Agility	Kuwait	Asia
F2	AIRFARM	Spain	Europe
F3	Ansaldo STS	Italy	Europe
F4	Aqaba Container Terminal (ACT)	Jordan	Asia
F5	Aramex International LLC	Jordan	Asia
F6	Asciano Limited	Australia	Oceania
F7	Autostrada Eksploatacja (AES)	Poland	Europe
F8	Balearic Islands Port Authority	Spain	Europe
F9	Bangkok Metro	Thailand	Asia
F10	Bolloré	France	Europe
F11	Bpost	Belgium	Europe
F12	Bumi Armada	Malaysia	Asia
F13	Cadena	Colombia	Latin America
F14	Cargo Carriers	South Africa	Africa
F15	CCR	Brazil	Latin America
F16	China Steel Express Corporation (CSE)	Taiwan	Asia
F17	CLH	Spain	Europe
F18	Copagaz	Brazil	Latin America
F19	COSCO Container Lines	China	Asia
F20	COSCO Group	China	Asia
F21	CSC Australia	Australia	Oceania
F22	CTT	Portugal	Europe

F23	DAWN	South Africa	Africa
F24	Deutsche Post DHL	Germany	Europe
F25	Die Schweizerische Post	Switzerland	Europe
F26	DSV	Denmark	Europe
F27	Egged Israel Transport Cooperative Society	Israel	Asia
F28	EMIRATES TRANSPORT	United Arab Emirates	Asia
F29	FedEx Corporation	USA	Northern America
F30	Femsa Logistica	Mexico	Latin America
F31	Gebrüder Weiss	Austria	Europe
F32	Green Cargo	Sweden	Europe
F33	Grieg Star	Norway	Europe
F34	Grindrod	South Africa	Africa
F35	Grupo Correos	Spain	Europe
F36	Grupo Libra	Brazil	Latin America
F37	Hermes	Germany	Europe
F38	HHLA (Hamburger Hafen und Logistik)	Germany	Europe
F39	IETT General Directorate	Turkey	Asia
F40	Itella	Finland	Europe
F41	Keppel T&T	Singapore	Asia
F42	Konecranes	Finland	Europe
F43	LOGIFRUIT	Spain	Europe
F44	Mars Logistics Group	Turkey	Asia
F45	Metrô de São Paulo	Brazil	Latin America
F46	Murphy	USA	Northern America
F47	Neptune Lines	Greece	Europe
F48	NORDEN	Denmark	Europe
F49	Österreichische Post AG	Austria	Europe
F50	Panalpina	Switzerland	Europe
F51	Port of Rotterdam	Netherlands	Europe
F52	Porto de Sines	Portugal	Europe
F53	Portonave	Brazil	Latin America
F54	Posten Norge	Norway	Europe
F55	PostNL	Netherlands	Europe
F56	PostNord	Sweden	Europe
F57	Royal Mail Group	UK and Northern Ireland	Europe
F58	Santos Brasil Participações S.A.	Brazil	Latin America
F59	Schachinger Logistik Holding GmbH	Austria	Europe
F60	Sinotrans Air Transportation Development	China	Asia
F61	Steamships Trading Company	Papua New Guinea	Oceania
F62	Tianjin Port	China	Asia
F63	TNT Express	Netherlands	Europe
F64	Transnet	South Africa	Africa
F65	Tristar	United Arab Emirates	Asia
F66	Triunfo Participações e Investimentos (TPI)	Brazil	Latin America
F67	Tuko Logistics	Finland	Europe
F68	UniGroup	USA	Northern America
F69	UPS	USA	Northern America
F70	Zarcam	Argentina	Latin America
F71	Zona Franca Barranquilla	Colombia	Latin America

CHALLENGES AND OPPORTUNITIES OF GREEN LOGISTICS IN HUNGARY. AN EXPLORATORY RESEARCH

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Abstract

Purpose:

In 2015 the EU the transport sector emitted 1,036.2 million tons of CO₂ (EC, 2017) and the emissions show further increasing trend. Nonetheless, relatively little research has been published on the sustainability strategies and actions adopted in the logistics service industry. The main purpose of this paper is to investigate the environmental sustainability practices of Hungarian third-party logistics service providers (3PLs).

Design:

A multiple case study approach was chosen for this research. The sample consisted of ten companies, which supports explorative investigations.

Findings:

The results show that companies investigated had undertaken a variety of green actions. The main reason connected with the adoption of green initiatives is cost reduction, while the benefit for environment is just considered a positive by-product. More advanced and sophisticated actions (e.g. action having effect at supply chain level) are not so frequent by the companies analysed.

Value:

The main value of this paper lies in being the first green logistics study in Hungary. It thus carries the responsibility of awareness raising about sustainability among logistics service providers and creates connection between research and industry practices.

Research limitations/implications:

The research summarized in this paper is of exploratory character is subject to some limitations. The main limitation lies in the fact that the sample investigated is relatively small partly as a consequence of the selected research method. For this reason, empirical generalization may be achieved through increasing the number of case studies and complementing them with a questionnaire survey.

Practical implications:

This study may have value for 3PL's managers engaged in green programs to improve the efficiency of their company and contribute to the reduction of CO₂ emissions. The results may also be used to suggest some policy directions to accelerate the evolution of the logistics service sector in Hungary toward a more environmentally friendly approach.

INTRODUCTION

In today's competitive scenario, companies are increasingly asked to implement measures and programs to reduce the environmental footprint of their activities in the supply chain (Zhu et al., 2008). Generally transport and logistics activities provide a number of positive effects at both country and company levels, but due to a number of factors, such activities have a relevant negative impact on the environment mainly (but not exclusively) in terms of greenhouse gas (GHG) emissions. In fact, transport and logistics activities are the

second biggest contributor to GHG emissions after electricity production (EC, 2017). This trend will continue over the next years due to the increasing demand for moving goods that is expected to grow further in the near future (ITF-OECD, 2013). As a result, environmental sustainability is an expected dimension of the logistics service providers (3PLs). With other words, 3PLs are requested that their operations and strategies should be oriented to reduce the negative externalities for the environment (Lieb and Lieb, 2010b).

From the research point of view, while the number of studies on environmental issues in logistics and supply chain management have increased substantially over the last decades, relatively little attention has been paid to the logistics service industry (Lin and Ho, 2011; Lieb and Lieb, 2010b). Moreover, although the environmental sustainability in the freight transport and logistics sector is a matter of common concern at global level, in some geographical areas this topic has been investigated less than others have. This is particularly true for Eastern Europe, since there are only a few relevant articles available if any, in Poland, Czech Republic, Slovakia and Slovenia (Lorincova and Balazova, 2014; Klupalova, 2012; Klopott and Miklinska, 2017; Bajec, P., et. al 2015). Hungary is not an exception, despite the relevant role that this country plays in the European transport and logistics scenario (Skowron-Grabowska, 2009; Chan, 2014). The total freight traffic activities in Hungary are estimated around 287 million tons in 2017, which shows 5.1% yearly increase. In 2017, the share of road freight transport from the Hungarian modal split was 65%, rail transport 19%, pipelines 12%, inland waterways 3.3% (KSH, 2018) and the remaining 0.7 % was airfreight. In 2016, the number of transported International Transport Units (ITUs) was 376 thousand (9.3% more than in the previous year) (KSH, 2016). In December 2016, 1.8 million companies operated in the Hungarian economy in total, and 37.4 thousand operated in the transport and storage services sector (including postal and courier activities). Within the Hungarian transport and storage service sector, 73% of the companies employed from 1 to 9 people, 5.1% of companies employed from 10 to 49 people and only 1.1% of the companies employed more than 50 people. In 2016, the transport and storage services sector employed 190 thousand people full time, which is 7.1% of the total workforce. (KSH, 2016). In Hungary, the total amount of CO₂ emitted by transport and logistics activities were 63,5 million tons in 2015. (KSH, 2018) The transport and storage service industry accounts for 4,973 thousand tons of CO₂, which is almost 8% of the total CO₂ emissions at national level. (KSH, 2018). Despite the importance of the Hungarian 3PL market in the European scenario, there are no researches on the environmental sustainability practices of Hungarian 3PLs. Considering this gap, it is possible to define the following two research questions for this study:

- RQ1) what type of green initiatives are adopted by Hungarian 3PLs?
- RQ2) what are the main factors (both barriers and drivers) affecting the adoption of green initiatives by Hungarian 3PLs?

The main objective of this paper is to investigate environmental sustainability practices of Hungarian 3PLs. In particular, main actions adopted by 3PLs among the drivers and barriers influencing their adoption. The rest of the paper is organised as follows: The next section summaries the literature on environmental sustainability in the 3PL sector. The third section provides details about the methodology used. The main findings obtained from the case study investigation are presented in the fourth section. Finally, conclusion and implications deriving from the study are drawn in the fifth section.

LITERATURE REVIEW

This section is organised into two sub-sections reflecting the main areas investigated by this study: the adoption of green initiatives and the main factors (drivers and barriers) affecting the adoption of such initiatives.

Adoption of green actions by 3PLs

In relation to green initiatives implemented by 3PLs, several research contributions have been published on this topic along the last decades. The work of Rondinelli and Berry (2000) emphasized the role of multimodal transport to minimise the environmental impact of 3PLs' operations. Facacha and Horvath (2005) used the life cycle of an automobile as

an example to show the higher potential of logistics outsourcing to reduce energy use, global warming potential and fatalities in comparison with the management of logistics in-house. Lieb and Lieb (2010a) analysed the green initiatives undertaken by a sample of large 3PLs operating in the US logistics service market. The findings indicated that all the surveyed companies have made significant progresses in the adoption of green practices despite the recession. The role of customers and competitors in stimulating the adoption of intermodal road-rail transport arrangement to reduce the carbon footprint was the focus of the study of Lammgard (2012). The study of Pieters et al. (2012) investigated the relationship between the changes in the 3PLs' green strategy and the new types of physical distribution networks in a sample Dutch 3PLs. The findings indicated that most successful practices are based on internal actions. Perotti et al. (2012) analysed how green initiatives affect the company performance in a sample of Italian 3PLs. The results highlighted that the adoption of such initiatives and their impact on company performance is still very limited. The paper of Colicchia et al. (2013) investigated the adoption of green actions in a sample of 3PLs through analysing environmental reports. The findings revealed that the most implemented actions related to distribution and transportation activities, while initiatives involving internal management were not broadly adopted. Kellner and Igl (2015) analysed the impact of different logistics network on CO₂ emissions in the distribution stage. The findings shown that logistics providers that are able to adopt a decentralized shipments consolidation approach obtain the most relevant results in terms of reducing emissions. Bajec et al. (2015) investigated the relationship between environmental standard and green actions implemented by 3PLs in Slovenia. The study found a weak correlation between ISO 14001 implementation and environmental efficiency, on the one hand, and a low influence of quality standards on the investment in environmental protection, on the other. The work of Abdullah et al. (2016) investigates the involvement of 3PLs in green logistics initiatives in the Malaysian logistics service market. Those actions were classified within three areas such as customers, logistics operations and logistics amenities. The results indicated both positive and negative impacts when adopting green initiatives.

Drivers and barriers influencing the adoption green actions

A number of research contribution have investigated the factors facilitating and inhibiting the implementation of environmental sustainability initiatives in the logistics service industry. Wong and Fryxell (2004) in their paper argued that internal rather than external pressures mainly drove the adoption of environmental actions in managing fleet in Hong Kong. The study of Jumadi and Zailani (2010) concluded that customer relationships have a positive influence on the adoption of green initiatives in the logistics service sector in Malaysia. Beskovnik and Jakomin (2010) discussed the role of green logistics in Southeast Europe and they identified long-term contracts as the most prominent driver of the implementation of green measures by logistics companies. Lin and Ho (2011) carried out a survey on a sample of 3PLs in China revealing that the adoption of green practices were affected by both internal (organizational support and the quality of human resources) and external factors (regulatory pressures, governmental support). Environmental uncertainty and the complexity of green practices were identified as barriers. The paper of Oberhofer and Dieplinger (2014) identified a number of influencing factors such as the pressures coming from upstream actors in the supply chain, the structure of the logistics sector and the perceived long-term importance of energy efficiency. Perotti et al. (2015) investigated drivers and barriers to the adoption of green supply chain practices (GSCP) in a sample of 15 Italian 3PLs. The authors found that the environmental reputation and the need to establish a green corporate image were the most influencing drivers. High investment, lack of interest of suppliers and customers in environmental sustainability, as well as difficulties in identifying and measuring environmental performance, have been identified as main barriers. The work of Salhieh and Abushaikha (2016) investigated the main motivations for implementing green actions in a sample of 3PLs in United Arab Emirates. Legislations, customers' pressures, and organisational awareness were found as the most important influencing factors especially in the areas of warehousing, packaging and transportation.

METHODOLOGY

In order to achieve the objective and provide answers to the research questions, a qualitative approach has been used. Specifically, a multiple case study approach was adopted. One of the main benefits associated with the use of multiple case studies is that the comparison of two or more case studies supports explorative investigations (Eisenhart, 1989; Yin, 2003). The case studies are based on primarily information gained by face-to-face interviews with representatives of Hungarian 3PLs using a Data Collection Guide (DCG) previously prepared and tested by Evangelista (2014). The DCG was translated in Hungarian language and used during the interview meetings. The DCG contained a mixture of open and multiple choice questions. The interviews took place at the company site, and they comprised a company visit. Each interview generally lasted from 60 to 90 minutes. The interviews were recorded, typed and stored in a case study database. Interview reports were produced to enable data analysis. The information obtained from interviews has been integrated with information from company documents (such as internal presentations and reports), and external documentation (such as company web site, and article published on industry magazines) (Yin, 1994). Information from different sources were triangulated and thus improved the validity of this research (Yin, 1994). The information obtained allowed to prepare a case study description for each of the case companies considered. The selected companies are all operating in Hungary and have either Hungarian ownership or have independence in terms of business management from the parent company. The reason for this selection method is that it is more interesting to see what a company achieves and acts in terms of environmental protection without ready to use policies and programs provided by a multinational parent company. A call for participation in the research was set up under the umbrella of the Hungarian Association of Logistics, Purchasing and Inventory (HALPI). It was sent out in August 2017 to about 40 selected companies (according to the above mentioned criteria and within the network of the HALPI). From the companies contacted, 10 accepted to be interviewed. There is a variety of logistics service providers among the selected companies: e.g. road transport companies, terminal operators, shipping companies, warehousing companies and 3PLs as well. The interviews involved the company CEOs or the managers responsible for sustainability. The ten companies participating in the research (see Table 1) have their core business mainly in the provision of transport and warehousing services. The companies in the sample were also categorised according with the latest EU definition of SMEs (EU Commission, 2015). Most of the companies interviewed are small and large companies (eight companies). There are one micro and one medium-sized company only. According with the national data on the structure of the Hungarian logistics market, it is mainly populated by small rather than medium or large companies. In fact, Hungarian national statistics say that about 80% of the logistics and transport companies operating in Hungary fall within the scope of micro and small categories (KSH, 2017). In the sample, 40% of the case companies are large companies and half of them are Hungarian owned. The reason for this is that there are more large companies in the list of companies associated with HALPI. From the geographical reach point of view, most of the case companies operate at continental and global level, while only two of them operate at national level (one of them is a micro road transport company and the other one is a small warehousing company).

Case study companies	Main focus of service provision		Company size by employees bands				Geographical reach		
	Transport	Transport and Warehousing	Micro	Small	Medium	Large	National	Continental	Global
			(1-9)	(10-49)	(50-99)	(>100)			
1	•		•				•		
2	•			•					•
3		•				•			•
4		•		•				•	
5	•			•					•
6	•				•			•	
7		•				•	•		
8	•			•				•	
9	•					•		•	
10		•				•			•

Table 1: Main characteristics of the case study companies

MAIN FINDINGS FROM THE CASE STUDY INVESTIGATION

Our investigation concerns two areas: the type of green actions adopted; drivers and barriers affecting the green actions among logistics service providers in Hungary.

Adoption of green initiatives

Our first field of investigation was the adoption of green programs, because the nature, the depth and the amount of these suggest the commitment level of the firm towards environmental protection.

ID of case study companies	A1. Vehicle use			A2. Transport modes and intermodality		A3. Energy efficiency	A4. Recycling materials and packaging		A5. Warehousing and green building			
	Changing vehicle specifications	Reduce empty running	Improving vehicle loading phase	Using lower energy transport modes	Greater use of intermodality	Alternative fuels	Increasing waste recycling	Reducing packaging	Eco-friendly building design	Energy-efficient material handling equipment	Use of alternative energy sources	Efficient land use
1	•	•	•									
2	•			•	•							
3	•	•		•	•		•	•	•	•	•	•
4	•	•	•		•				•	•	•	
5	•								•			
6	•	•			•		•		•	•	•	•
7		•					•		•	•		
8	•				•		•		•		•	
9	•			•					•		•	
10	•	•	•		•		•		•	•		

Table 2: Green actions adopted by Hungarian 3PLs (A1-A5)

If we look at the Vehicle use category (A1) we can conclude that changing vehicle specifications is among the most popular solutions. Respondents mostly mentioned changing their vehicles to ones with better environmental performance. For example, in case of road transport companies this means updating the fleet from Euro 4 to Euro 6 engines.

The reduction of empty running was considered by the respondents as a necessary optimization process, they didn't consider it as an environmental initiative. The improvement of loading phase is out of responsibility of the logistics service providers according to more than half of the companies.

Regarding transport modes and intermodality (A2): the intermodal solutions are getting more and more popular especially with the most recent Chinese New Silk Road concept (Cao, 2018). According to many of the logistics service providers they see great business opportunity in the use of railways from and to China. And one of the 3PLs also mentioned intermodality as a solution for lack of employees in the freight forwarding business. They find it easier to employ drivers for last mile deliveries than for intercontinental deliveries.

In our DCG energy efficiency in transportation (A3) meant alternative fuels. None of the Hungarian companies use alternative fuels. Although they know about possibilities (e.g. hybrid-gas, biodiesel), but find it burdening and a threat for quality delivery at the moment. Waste management (A4) is mainly considered by the companies as selective waste collection. In many cases waste can be sold to recyclers and thus results in some extra income for the company, or at least covers the cost of waste transport. The reduction of packaging on the other hand is not at all popular. This could be reasoned with limited responsibility for packaging design or the fear of damage in the goods. Warehousing and green buildings (A5) is quite popular among the sample. Eco efficient building design is considered to be mainly insulation, doors and windows, energy efficient lighting, heating and cooling solutions. In only one case is the building designed and built in line with LEED (Leadership in Energy and Environmental Design) principles. Energy efficient goods handling equipment mostly mean electric trolleys inside the warehouses. Efficient land use appeared by two respondents in form of efficient warehouse and terminal design. It did not mean brownfield redevelopment for example.

ID of case study companies	A6. Environmental training and information			A7. Supply Chain re-organization		A8. Supply Chain collaboration on shared green targets		A9. Collaborative planning and environmental control		
	Employee training (including eco-driving)	Customer /supplier training	Information on carbon footprint	Transport planning	Changes in logistics system	With customer	With other 3PLs	EMS	Off-setting	SC GHG target
1										
2				•			•	9001		
3	•	•	•	•	•		•	9001	•	•
4	•			•		•		9001		
5		•						9001		
6	•						•	14001		
7	•	•						9001	•	
8	•									
9	•		•					14001		•
10	•	•	•	•				14001		

Table 3: Green actions adopted by Hungarian 3PLs (A6-A9)

Environmental training and information (A6) is mainly present in form of the very popular eco drive trainings in all transport modes. Customer/supplier trainings are rarely present in terms of environmental actions. More likely in terms of safety and operations. Carbon foot printing is present to the extremes by Hungarian 3PLs - meaning that some companies use it even in their quotations (estimated CO₂ emissions) and in their invoicing (actual CO₂ emissions prevented). Some companies admittedly do not know what carbon foot printing is. Supply chain level actions (A7,8,9) are very rarely used in the Hungarian sample. The case of environmental management systems (EMS) is interesting though. Only 3 companies have ISO14001, 2 large and 1 medium size company. At the same time, 90% of the enterprises have ISO9001 quality management system. According to some interviewees, this is due to the expenses of maintaining an EMS. Only on strong request of customers, supply chain partners will these companies invest in new certification and maintenance processes. The DCG contained questions about the performance measurement of the green initiatives. Every company keeps track of the fuel consumption of their fleet, but only three of the respondents (the ones having certified EMS) keep track of the environmental impact of their other operations e.g. energy and water consumption.

Factors influencing the adoption of green initiatives

The second part of the investigation was to shed light on the drivers and barriers of green actions in case of Hungarian 3PLs. Table 4. shows the drivers most influencing influencing the adoption of green actions by the respondents.

ID of case study companies	Cost reduction for company	Improvement of customer relationships	Improvement of the overall customer supply chain effectiveness	Green initiatives requested by customers	Green initiatives requested by management	Green initiatives implemented by competitors	Green initiatives implemented by 3PLs partner	Increase of the company's profitability (e.g. ROI)	International, national, regional or local regulations	EU, national, regional funding/economic incentives	Reduction of company risk	Improvement of corporate image on the market
1	•							•	•		•	•
2	•	•	•		•		•	•	•	•		•
3	•		•		•							•
4	•	•			•			•	•		•	•
5	•				•	•		•	•		•	
6	•	•		•	•	•	•	•				•
7	•	•	•		•			•		•		
8	•		•		•			•		•	•	•
9	•	•			•			•		•	•	•
10	•	•	•	•	•		•	•		•	•	•

Table 4: Highly influencing drivers of green actions for Hungarian 3PLs

Our research shows that all respondents denoted cost reduction as a highly influencing driver for adopting green initiatives. The second place is taken by the increase of profitability. Management request and improvement of company image act as main drivers of green actions. It is clear from the table that customer requests, competitors and partners are also considered as highly influencing factor in implementing green programs, but they are far behind the economic considerations.

ID of case study companies	High investment costs and lack of financial resources	Doubtful payback	Lack of human resources in green initiatives	Lack of ICT skills for managing green initiatives	Lack of customers environmental awareness	Lack of 3PL partner environmental awareness	Lack of funding/economic incentives	Lack of well defined regulations
1	•		•	•	•	•	•	
2	•		•	•	•		•	
3	•	•	•					
4			•		•	•	•	
5	•	•	•	•		•	•	
6	•				•	•		•
7	•	•	•	•	•		•	
8	•	•			•		•	
9	•	•			•	•	•	
10			•					

Table 5: Highly influencing barriers of green actions for Hungarian 3PLs

We can report that 80% of the respondents mentioned that the most important barriers are high investment costs and lack of financial resources in Hungary. Lack of funding, HR resources and environmental awareness of customers is following right after with 70%.

DISCUSSION

The main value of this paper lies in being the first green logistics study in Hungary. It thus carries the responsibility of awareness raising about sustainability among logistics service providers and creates connection between research and industry practices.

Two research questions were raised: RQ1) what type of green initiatives are adopted by Hungarian 3PLs? RQ2) what are the main factors (both barriers and drivers) affecting the adoption of green initiatives by Hungarian 3PLs?

The answers deriving from our work draw a picture of the state-of-the-art of sustainability practices in the Hungarian logistics service industry. Due to the exploratory character of the research, the results are subject to some limitations. The main limitation lies on the fact that the sample investigated is relatively small partly as a consequence of the selected research method. For this reason, empirical generalization may be achieved through increasing the number of case studies and complementing them with a questionnaire survey.

Type of green initiatives adopted by Hungarian 3PLs

We can categorize the green initiatives implemented by the companies in our sample according to Colicchia et al. (2013) into intra-organizational and inter-organizational initiatives (see table 6).

Type of green Initiatives	ID of case study companies										Total
	1	2	3	4	5	6	7	8	9	10	
Inter-organizational	0	1	3	1	0	2	1	0	2	1	11
Intra-organizational	3	5	16	9	4	9	6	6	6	11	75
Total	3	6	19	10	4	11	7	6	8	12	86

Table 6. Categorization of green initiatives adopted by Hungarian 3PLs

The intra-organizational category consists of e.g. distribution strategies and transportation execution, warehousing and green building, reverse logistics, packaging management, and internal management (from A1 to A5 in table 2). These initiatives have direct effects on the company level. On the other hand, there are green programs that have effects on the supply chain level, namely inter-organizational initiatives, which include collaboration with customers and external collaborations (from A6 to A9 in table 3). According to our respondents, 75 intra-organizational initiatives were implemented while only 11 inter-organizational were adopted. Many respondents did not adopt some initiatives e.g. route optimization, reducing loading phase as green initiatives. In their opinion these type of actions are purely for efficient operations, or legal obligations e.g. use of electric trolleys in the warehouses (AOHS, 1993). Looking at the green actions adopted we can say that the most popular ones in Hungary are that directly related to the company (intra-organizational) initiatives. More collaborative (inter-organizational) actions e.g. supply chain level emission targets are more rare in the sample.

The main factors affecting the adoption of green initiatives by Hungarian 3PLs

The analyzes of the motivating factors confirmed our previous findings. All respondents denoted cost reductions for the company the most important driver of green actions. 90 percent of the companies listed management request as a highly influencing driver and 70 percent reported on the lack of HR resources as a barrier to the implementation of green initiatives. This is in line with the findings of Lin and Ho (2010) stating that green actions are mainly affected by organizational support and HR resources available.

It is very interesting that the least important drivers mentioned are competitors and customers (Table 5.). Two occasions were mentioned by the respondents when elements of green procurement of 3PL services appeared. One of the respondents mentioned the request from their customer as a motivation for fleet update. This customer is operating in the automotive industry and requested, that their suppliers only use trucks above certain Euro- category engines. The other respondent reported a tender where carbon footprint data was a selection criteria. Another important selection criteria can be the use of environmental management systems, which is quite rare in the sample, one medium and two large enterprises have ISO14001 certifications. According to our respondents this is due to the high costs of certification, which is in line with the findings of Bajec et al (2015). This suggests that there is a low-level willingness to invest into certified green programs and cooperate with external stakeholders.

Related to this is that 80% of Hungarian companies listed improvement of company image a highly influencing driver (Table 4.) as suggested by the research of Lieb and Lieb (2010) and Evangelista et al. (2017), but at the same time customer request is only considered as a driver by 20% (Table 5.). This might suggest, that some of the companies in the sample are trying to manufacture demand for green services and use sustainability as a competitive advantage in terms of communication and operational efficiency. As

Evangelista et al (2011) suggest, it is crucial to share information among customers and 3PLs in order to green the whole supply chain.

Another interesting element is that the improvement of overall supply chain effectiveness is a highly influencing driver of green initiatives by 50% of the companies (Table 4.), but the green actions adopted do not reflect this (Table 2.). This might be in connection with the weaker position of Hungarian 3PLs in supply chain structures (Demeter et al,2006; Szegedi, 2008).

CONCLUSION

We can conclude that (1) there are a wide variety and a relatively high number of green initiatives implemented by Hungarian 3PLs. As a result, we found that (2) in our sample green initiatives are associated with cost saving, which is an important message refuting the supposition so popular among business practitioners that environmental protection is expensive and is not economically efficient.

(3) The level of performance measurement in the sample was very low, but in our opinion, it would be the most important to increase the efforts toward the use of performance management methods in order to understand the exact cost-benefit of green programs and to enhance the ability to use them as marketing tools. (4) There is a significant difference between the number of intra- and inter organizational initiatives, which means that the supply chain level collaboration for environmental sustainability goals is very low in Hungary. (5) Customer requests or with other words green procurement could boost the uptake of green programs among 3PLs and external funding/government initiatives can also be of support.

We believe that this study may have value for 3PL's managers engaged in green programs to improve the efficiency of the Hungarian logistics service providers and contribute to the reduction of CO₂ emissions. Since this research provides an update picture of the green practices and strategies implemented by 3PL companies in Hungary, the results may be used to suggest some policy directions for accelerate the evolution of the logistics service sector in Hungary toward a more environmentally friendly approach.

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OPEN-LOOP SUPPLY CHAINS: OVERCOMING SHORTAGES AND SUSTAINABILITY ISSUES IN REMANUFACTURING

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ABSTRACT

Purpose: The circular economy has become increasingly popular in industry and policy alike. Remanufacturing has the potential to contribute to objectives related to the circular economy idea and addresses the triple bottom line. However, remanufacturing faces supply shortages due to various reasons. Furthermore, in the context of remanufacturing, the concept of the closed-loop supply chain became almost an imperative for circularity and sustainability. This paper brings together five interconnected studies addressing supply and sustainability issues of (closed-loop) supply chains for remanufacturing to analyse an alternative perspective on circularity in supply chain contexts, which the presented research frames as “open-loop supply chains”.

Design: This paper explains the overarching research approach and process that yields to five interconnected studies, and discusses the chosen approach regarding its appropriateness to address the research objectives. Qualitative methods dominate the research approach following an inductive-deductive approach with elements of grounded theory.

Findings: The results regarding the research objectives show that open-loop supply chains bear considerable potential for improved sustainability outcomes of remanufacturing and other forms of reuse and recycling. However, systemic and managerial barriers currently hinder the efficient utilization of these potentials.

The research approach proved its appropriateness for addressing knowledge gaps about shortages in and sustainability of automotive remanufacturing. The explorative and iterative character of the method matched the environment wherein empirical data was collected, and it allowed for the necessary adjustments throughout this “learning process”.

Value: The presented and discussed research approach proved its effectiveness in addressing the complex system under study and may be of avail for future research on systems of reverse supply chains. The discussed studies contribute to the body of knowledge on remanufacturing supply chains regarding their contribution to circularity and sustainability. The paper indicates managerial and political means, derived from the five studies, to address supply shortages and sustainability issues in remanufacturing and in related circular economy strategies.

Research implications: The concept of “openness” in supply chains usefully frames those types of supply chains fulfilling activities like closed-loop supply chains though with other main actors than OEMs. However, the analysis of the systemic environment of remanufacturing supply chains and of lifecycle management implications due to the complexity at the end-of-life, and a lack of decision and process support for according management tasks highlight the need for further research from both policy and managerial perspectives.

Introduction

The circular economy (CE) has become increasingly popular in industry and policy alike (EC, 2015). Although the idea received some criticism (Skene, 2017; Zink and Geyer, 2017), the concept of the CE supports various objectives of the triple bottom line. CE-related approaches aim to conserve environmental and economic resources (such as materials, energy, labour and capital value) that are incorporated into products and product components (Thierry *et al.*, 1995). One of the CE approaches is remanufacturing. From the

perspective of the waste management hierarchy, remanufacturing is subsumed under re-use, while the next lower level of the hierarchy is (material) recycling followed by (energy) recovery (EC, 2015). The remanufacturing process restores the original characteristics of products or components with a quality comparable or exceeding the original product (ERN, 2015). The industry refers to used products undergoing this process as “cores”. Alongside the rise of CE ideas, remanufacturing is gaining interest by politics and researchers.

Remanufacturers are challenged by dispersed suppliers (potentially every individual product user can be a supplier) and certain time patterns of demand (when the original product starts to fail). Further challenges relate to reverse logistics such as allocation, collection and timely returns; in addition, different usage patterns affect the yield of remanufacturing. Although closed-loop supply chain strategies seem appropriate to tackle these challenges, initial findings revealed some tension between theory and practise questioning the economic and environmental advantage of such approaches.

The purpose of this paper is to present the overarching research approach and consolidate the findings from five individual yet coherent studies forming a PhD research project. The project aimed to shed light on shortages in supply chains for automotive remanufacturing and relations to sustainability outcomes from a systemic perspective. Instead of optimizing a selected supply chain or analysing remanufacturing decisions of one company, the research aimed to understand the systemic connections in remanufacturing markets and between supply chains of these markets. Thereby, the research contributes to the limited empirical research in this domain (Prahinski and Kocabasoglu, 2006). Guiding research questions were:

- (1) What characterizes supply markets for remanufacturing; which actors constitute these markets; and which managerial approaches dominate the corresponding supply chains?
- (2) How do remanufacturing supply chains consider environmental issues? Do normative and legislative approaches support an according long-run perspective for potential benefits in ecologically and economical terms?
- (3) How do the market actors apply supplier relationship management and could supplier relationship management in remanufacturing positively influence the supply of cores? What incentives exist to increase supply for remanufacturing besides the price for cores?

Remanufacturing Supply Chains and Supplier Relationships

Because of the consolidating character of this paper, this section only briefly summarizes the predominant theoretical background of the research project. Closed-loop supply chains (CLSCs) are regularly associated with remanufacturing, where procurement represents a major challenge (Östlin *et al.*, 2008). Core acquisition and the management of reverse logistics drive supply chain complexity. Although CLSCs are still complex (Battini *et al.*, 2017), they provide the opportunity to reduce complexity and risk through integration and the better control of material flows, for example, through deposits or by avoiding the transfer of ownership (Thierry *et al.*, 1995). The CLSC almost became an imperative for CE business models, and CLSCs are widely promoted (e.g. Ellen MacArthur Foundation 2013), though the focus on financial optimization in CLSC modelling may challenge the common assumption of a general sustainability of CLSCs. In addition to limitations of CLSC models in operational research regarding common assumptions and empirical relevance (van Wassenhove and Besiou, 2013), such models hardly consider third parties taking advantage of forward supply chains or of leakage from CLSCs (Saavedra *et al.*, 2013). Such third parties often involve intermediaries like brokers and agencies, who seem to be crucial for those remanufacturing supply chains that are not dominated by OEMs, though they are hardly considered (Prahinski and Kocabasoglu, 2006). These third-party supply chains are not to be confused with, for example, contracted- or outsourced remanufacturing where legally independent companies collaborate with and remanufacture on-behalf of OEMs in CLSC settings (Östlin *et al.*, 2008; Lind *et al.*, 2014), which limits their degree of independence. The independent supply chain discussed here (as “open-loop supply chain”) is distinct from the CLSC as their actors do not regularly collaborate with OEMs. Nevertheless, the independent supply chain may become relevant for the OEM-dominated supply chain when restocking with cores to compensate for losses. This theoretical gap is outlined in more detail in each of the five studies composing this research project.

In the domain of supply chain management (SCM), the importance of supplier relationships is recognized for efficient supply chains (Christopher et al. 2002); maintaining relationships with transaction partners is essential in remanufacturing to ensure return flows of cores (Subramoniam *et al.*, 2010). Relationships become vital especially for third-party supply chains. Relationships can support the establishment of organisations ranging between market and hierarchy. Distinct characteristics of supplier relationship management (SRM) indicate where such relationships are allocated on the market-hierarchy continuum.

Methodological Approach and Research Process

Qualitative methods dominate the research because of theoretical voids regarding market practice and independent third parties accompanied by a lack of statistical data on remanufacturing markets and trade. This research followed an inductive-deductive approach related to grounded theory to address knowledge gaps regarding circularity and sustainability issues of different supply chain types in automotive remanufacturing. The complex system of actors and institutions in remanufacturing and the limited theoretical knowledge justify an explorative approach (Corbin and Strauss, 2015). The approach further acknowledges the difficulty to reach the remanufacturing industry especially in Europe (ERN, 2015). Fig. 1 illustrates the research approach; the outlined studies provide results for the overall research objectives targeting at practical outcomes for policy, research and industry.

The qualitative approach facilitates iterations during exploration and empirical data gathering, literature research, coding and analysis. The predominant empirical methods were a combination of attendance and observation at trade fairs, interviews and case studies in two different regions, namely (Western) Europe and North America (Canada and the US). The constant revision of previous findings by repetitive attendances at trade fairs, by enlarging the base of key informants, and by repetitive interviews reflects the flexibility (Glaser, 2007) and the character of a learning-process (Alheit, 1999) of the grounded-theory approach. Studies in the domain of supply chains and sustainable management have applied grounded theory-based approaches effectively (e.g., Stindt *et al.*, 2016). The different methods used throughout the research (see Results section) and different data sources, such as interviews with representatives of different organisations and independent experts, support the credibility of the findings (Steenhuis and Bruijn, 2006).

The research process (Fig. 1) initiates with an expert consultation and a consecutive revision of theory from literature, which partly contradicted prevailing literature in the domain of remanufacturing supply chains especially regarding independent actors. The first phase included the development of a semi-structured questionnaire. Interviews and case studies were transcribed, coded, and clustered, both for studies 1 and 5, which also frame the research process. They utilize theories from new institutional economics as a reference for the analysis of dynamic institutional environments, relations between organizations and relationships between market actors. The analysis in study 2 builds mainly upon lifecycle theories and their relation to SCM. Utilizing a software framework at the intersection of business administration and computer science, study 3 marks a methodological exception though contributes to the evaluation of available management solutions for market actors in automotive remanufacturing. Study 4 builds on theories from SCM and from industrial ecology to evaluate the environmental impact of closed- versus open-loop supply chains in dynamic market environments. Although the chosen approach limits the generalisation of findings, using different data sources and methods and outlining how findings were analysed and interpreted strengthen their reliability.

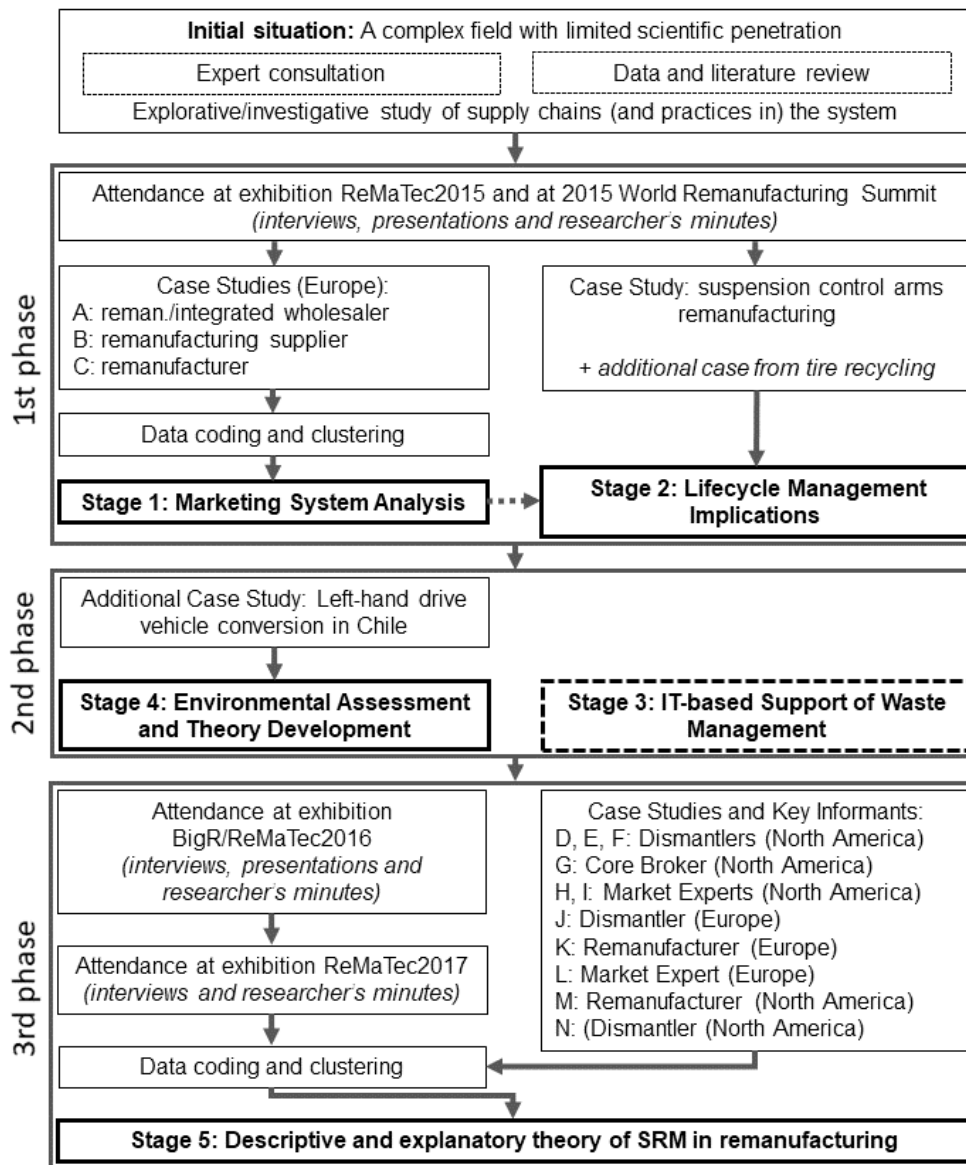


Figure 1: Grounded-theory oriented research approach to investigate the connections between supply-chain and sustainability issues in automotive remanufacturing

The empirical data comprises 39 companies or market experts, some of which comprise repetitive interviews and information exchanges. Some interviewees developed into key informants or the represented case/company into a case study. Interviews and key informants represent remanufacturers, a remanufacturer supplier, remanufacturing software providers, dismantlers, core brokers, an auto recycling expert, an aftermarket expert, and an integrated remanufacture/wholesaler. The case of "cambio volante" (2nd phase) is an exception since it deals with vehicle conversion and not remanufacturing in its strict sense. Literature reviews preceded and iterative in-depth reviews of literature and additional document studies succeeded the empirical data gathering steps at the different process stages. Although discouraged in grounded theory, literature reviews preceding the data collection creating awareness for the study ground are considered a balance between deductive and inductive approaches, though not serving the development of a theoretical framework for testing (Steenhuis and Bruijn, 2006).

Results

Systemic perspectives on circularity in automotive remanufacturing

Both the first study *Automotive Remanufacturing in the Circular Economy in Europe* (stage 1) and the second study *Cascade Use and the Management of Product Lifecycles* (stage 2)

addressed supply and related sustainability issues in remanufacturing from a systemic perspective. **At the first stage** of the research process, the European remanufacturing marketing systems was analysed to carve out those challenges affecting the sustainability of the macro system. The study addressed shortages in automotive remanufacturing; in particular, the study revised reverse channel issues and their impact on sustainability outcomes and asks how reverse-oriented marketing systems can improve their contributions to sustainability (Kalverkamp and Raabe, 2017). The study applied a marketing systems theory approach and utilized new institutional economics as a means of analysis to identify institutional settings contributing to shortages or undesirable outcomes.

The coding led to three clusters, namely the "legal environment and institutional setting", "supply shortages, supply channels, supplier relations, and use of deposits", and "supply shortages and innovation potential". In addition, three case studies of remanufactured component types ((A) starters and alternators, (B) transmissions and parts, and (C) mechatronics and electronics) allowed for a comparative analysis of organizational structures in the system. The chosen methodological approach proved useful for the empirical data gathering, the iterative reconstruction and the analysis of the system. Although the study confirmed that remanufacturing has potential for positive contributions to sustainability outcomes, the results contradict a general sustainability assumption of remanufacturing activities. Resource control and resource destruction potentially corrupt the sustainability outcomes of the system hence undermine some of the potential contributions to sustainability. The study highlights the importance of independent market actors such as core brokers, who can help to balance the power in the system. The importance of the independent actors in the system especially connects to the stages 4 and 5 of the research.

At the second stage, the corresponding study observed the complexity of circular systems such as remanufacturing and recycling from a product lifecycle perspective. The cascade use approach, borrowed from the biomass domain, supports the understanding of the complexity arising at the end-of-life or end-of-use of products or components (Kalverkamp *et al.*, 2017). This study acknowledged the function of third parties in circular systems and discussed implications for the management of product lifecycles and corresponding SCs. Product lifecycles can cover several of the waste management steps. At each step, waste streams may separate into intended or unintended lifecycles, regardless of the sustainability of each stream. The study analyses whether the "cascade use methodology" can contribute to a more sustainable management of product lifecycles.

Methodologically, the study borrowed from the biomass domain when developing and applying the cascade use methodology to two cases. The first case on tire recycling stands for similar waste streams where volatile markets for secondary resources influence the quantities of material flows. The second case of suspension control arms remanufacturing shows how an open-loop utilized by an independent remanufacturer provides an improved sustainable outcome. The cascade use methodology aims to shed light on circular economy opportunities in addition to and beyond the CLSC. If the variety of end-of-life waste streams would be considered as an opportunity for lifecycle management, environmental and economic benefits may arise that also "go beyond the originally designed lifecycle" (Kalverkamp *et al.*, 2017). The study sketched overlaps between the concept of loops in industrial ecology and SCM and hence served as a precursor to the fourth study elaborating on a theory of "open-loop supply chains".

Decision Support in Waste Management and Remanufacturing

Findings from the first two studies gave rise to the question whether IT-support is available for independent supply chains, as it is regularly for common supply chain processes. Therefore, at stage 3, different software solutions for waste management were analysed based on criteria derived from a subset of key features of Enterprise Resource Planning (ERP) software (Burger *et al.*, n.d.). Many of the results conflict with assumptions regarding remanufacturing, which is considered (a) to be customer and supplier centric (because customers become suppliers); (b) of having a high demand for customization and data processing because of the necessity to integrate external data (e.g. bill of components); and (c) requiring manufacturing, inventory and material management (e.g. disassembly, qual-

ity management, tracking). The results are important because they indicate a lack of support regarding relationship management, only partial support for supplier sourcing, and limited support regarding customer service and databases. Despite the necessity for data and knowledge management, advanced solutions are not widely available.

The identified shortcomings regarding crucial features show the need for better ERP(-like) solutions. Improved software offerings are needed to facilitate CE business operations at the reuse level. These findings motivated and contributed to the research at stage 5 on supplier relationship management presented after the following section.

Environmental Assessment and Theory Development of Open-Loop Supply Chains

Taking results from the first two studies further led to the fourth stage of the research process phrasing a theory *In Support of Open-Loop Supply Chains*. The fourth study considered the impact of market dynamics when explaining how open-loop supply chains provide a greater variety and thereby much more opportunities for improved sustainability outcomes. Thereby, this study also drew back on the systemic perspectives from the first phase of the research process. The study combined SCM and CLSCs with recycling knowledge from industrial ecology. The study defines the Open-Loop Supply Chain (OLSC) as a "system that maximizes value creation over the entire life cycle of a product including design, where the control and operation of the system, particularly reverse logistics, is open to a diversity of business actors" (Kalverkamp and Young, n.d.). Methodologically, the study mapped supply chain activities at the three levels: product, component and material, and identified corresponding case studies for each OLSC. Within these cases, the study focussed on market dynamics and relations between business actors in order to analyse displacement (Geyer *et al.*, 2016) and resulting environmental impacts.

The study argues to revise sustainability assumptions and to consider the OLSC as a complementary supply chain design that requires additional attention by research, policy and industry to utilize its potentials. Policy makers should carefully assess the role of the 'independent' and the sustainability assumption of closed-loops that may steer policy decisions. The results from this stage indicate how businesses may utilize some of the sustainability potential of OLSCs, for example, by licensing models adjusted to the needs of third markets. The study paved the way for the fifth study drawing on these results when investigating SRM practices in OLSCs for remanufacturing.

SRM in open-loop supply chains for remanufacturing

Finally, in the third phase of the research process, the fifth study moved closer to the meso- and micro-level of observation. The study resulting from the fifth stage of the process unveiled *Hidden Potentials in Open-Loop Supply Chains for Remanufacturing* by focusing on managerial and operational solutions to overcome supply shortages for remanufacturing (Kalverkamp, n.d.). The independent market actors, identified as crucial for CE objectives, became central at this part of the research.

The fifth study underlines the importance of core brokers as intermediaries and aims to understand characteristics of their relationships in OLSCs. This study connects to the first study, especially regarding the chosen methodological approach; additional empirical data allowed for a comparative analysis of European and North American OLSCs for automotive remanufacturing to identify reasons influencing differences in the supply of cores. The coding and clustering of the extended data revealed three distinct focus clusters, namely (a) practices of dismantlers regarding remanufacturing, (b) the role of core brokers in the OLSC, and (c) SRM between core brokers and their suppliers (e.g. dismantlers). The study applied SRM and transaction cost theory to analyze the results and to develop an explanatory theory of SRM practices in independent automotive remanufacturing.

An e-procurement solution identified in North America revealed that innovations in the SRM of core brokers can lower barriers in the supply of cores. Those solutions are considered "game changers" for the dismantlers who suffered from great information asymmetries. The analysis further indicated action fields for policy and industry. This study identified the specific field of SRM as a lever for increased supply for remanufacturing, because the identified procurement tool improves the identification of required cores and helps to balance supply and demand. Hence, the study revealed the importance of intermediaries in reverse

supply chains fulfilling essential functions of commerce for a circular economy. However, the study does not conceal that policy needs to ensure that the market environment supports those functions and those actors enabling circular economies beyond CLSCs.

Discussion

By considering systemic perspectives, the first and second study built the basis for the successive research stages. This first phase mainly contributed to the first research question, namely *“What characterizes supply markets for remanufacturing; which actors constitute these markets; and which managerial approaches dominate the corresponding supply chains?”* The first study analysed prominent means such as CLSCs though identified considerable issues that relate to the supply chain design and negatively affect sustainability outcomes. Both studies took a systemic perspective and thereby assessed the outcomes of potential micro-actions at the macro-level.

The third and fourth studies ran in parallel. The third study on IT-based decision support in the waste management domain covered remanufacturing as a prominent sub-domain. The value of this study is its comparative analysis of waste-related software solutions and the identification of critical shortcoming that hinder CE businesses at the reuse level of waste management. Results from the third study mainly contributed to the fifth study and thereby to research question 3, which is discussed below.

The findings from the first two studies merged into considerations of “openness” in supply chains. The fourth study assessed OLSCs in dynamic market environments from an environmental perspective and against its closed-loop counterparts; it identified business and environmental benefits created by independent market actors. Thereby, the fourth study mainly contributed to the second research question: *“How do remanufacturing supply chains consider environmental issues? Do normative and legislative approaches support an according long-run perspective for potential benefits in ecologically and economical terms?”* Although environmental considerations are not predominant in remanufacturing supply chains, the fourth study especially contributed by developing an initial theory of OLSCs and by revealing levers for industry and policy to increase the sustainability outcomes of circular market activities through displacement.

Studies 4 and 5 explicitly aimed for descriptive and explanatory theoretical concepts of phenomena observed in the context of so-called open- and closed-loop supply chains. The comparative character of grounded theory played a key role in the fifth study, which compared European and North American supply chain practices with an emphasis on supplier relationship management. The fifth study thereby mainly addressed the third research question: *“How do the market actors apply supplier relationship management and could supplier relationship management in remanufacturing positively influence the supply of cores? What incentives exist to increase supply for remanufacturing besides the price for cores?”* Although the core price is a major driver for remanufacturing, the value of the fifth study lies in its recognition that SRM (in OLSCs) bears a considerable potential to improve core supply. SRM can yield this potential when it (a) solves the issue of component (core) identification, (b) increases transparency, and (c) addresses shortcoming in logistics. The mapping of studies and overarching research questions remains an approximation, such as the first study, which also contributed to the second question regarding the legislative approaches. Similarly, the fifth study showed the need for a revision of legislation and its correct enforcement to increase the efficiency of OLSCs.

The systemic perspective paired with the broad variety of market actors represented in the empirical data are important for the research. The combination of the study results demonstrates that OLSCs bear a considerable potential for improved sustainability outcomes of remanufacturing. Most importantly, the results suggest scrutinizing the imperative of “closed-loops”. The industrial ecology community already started to question the implicit assumption that open-loops are less environmentally friendly than closed-loops; the SCM community should consider OLSCs next to CLSCs when discussing sustainability.

The chosen research approach has an explorative character and considers new findings throughout the process. This flexibility of the research process, which is also considered a “learning process” (Alheit, 1999), proved its appropriateness for the complex and so far only partly explored system under study, as it facilitated new perspectives on the study

ground; and it reduced the impact of limited availability of data, for example on market size and the international trade with cores. A distinct reluctance of European core brokers to collaborate challenged the research project, too. The chosen approach demonstrated its effectiveness in overcoming some of these obstacles by deducting information about third parties from a broad set of interviews with various actors. Therefore, the approach is of avail for future research in similar domains. However, the flexibility of the approach also imposes responsibility on the researcher not to neglect or ignore data, nor to forget about adjustments made. Especially the studies 1 and 5 represented all the identified groups of actors in the system under study. In addition, the first and the fifth study have a framing character that aimed to limit such risks by applying the same methodology to the data analysis and by revisiting the entire data.

Conclusion and Outlook

The contribution and value of this research builds upon two pillars mainly. First, the empirical approach addressing the system of actors and not solely one supply chain and hence not only an individual optimization potential. Second, the integration of knowledge from two domains, SCM and industrial ecology to shed light on inconsistencies regarding the sustainability of CLSCs. The homonymous term of "loops" obscures some differences between the communities' perspectives and may hinder a common understanding, yet both communities can learn from each other and thereby contribute to the debate on sustainability and the concept of the CE. The research fills a void in the debate about the sustainability of remanufacturing as part of the CE. It extends the body of knowledge about systemic interconnections in automotive remanufacturing supply chains and about the contribution of independent actors to the outcome of such systems.

From a research perspective, it may be especially interesting to specify further those management approaches that are able to adopt to the market dynamics at the end-of-life of products and components. Furthermore, developing and discussing the concept of open-loop supply chains to model these supply chains provides a fruitful ground for future research. An overarching objective for research and policy should be the improvement of the data quality on reuse activities (i.e. remanufacturing, refurbish, repair, etc.), namely the size of the industry and of international trade.

Politicians may be tempted to steer the development with tax incentives or quotas though should be alerted that some approaches might be counter-productive. Enforcing environmental legislation and reducing unnecessary market barriers (such as prohibitions of repairing mechatronics) may result in solutions more environmentally friendly and potentially more sustainable for the overall system. It would be a misconception to believe that single approaches such as CLSCs or certain design paradigms ('design for x') can solve the sustainability issues, because such solutions increase the necessity of single actors to protect their interests; nor would the OLSC concept be able to solve all challenges. However, the OLSC demonstrates that neither centralized solutions nor regulation alone will be able to tackle sustainability issues in the CE but that solutions exist and may develop that have not been in the minds of designers and business strategists at the begin-of-life of a product.

ACKNOWLEDGMENTS

The author was financially supported by the German Federal Ministry of Education and Research (Grant No. 01LN1310A) and by the German Academic Exchange Service (DAAD).

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WEEE FLOWS: A CASE STUDY OF A REVERSE SUPPLY CHAIN FOR MIXED SMALL ELECTRICAL WASTE

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Abstract

Purpose of this paper:

An empirical case study of a bespoke Reverse Supply Chain (RSC) for small household mixed Waste Electrical and Electronic Equipment (WEEE) – a difficult product stream owing to its heterogeneity (Bovea et al. 2016) and examples of which are lacking in the literature. The aim of the study is to ascertain the value recovery profile within the mixed WEEE and assess the financial viability of the RSC.

Design/methodology/approach:

A case study approach is adopted because the authors are evaluating a phenomenon that is taking place in a real world setting (Yin 2012). A three tier RSC for the collection, transport and treatment of mixed small WEEE is presented. The RSC comprised an independent electrical ReManufacturer (RM), a third party Collecting Firm (CF) and CF's newsvendor customers. CF's primary business is the national distribution of newspapers. To utilise surplus inbound capacity of CF's delivery vehicles, the WEEE collection and reverse logistics were integrated into CF's incumbent forward supply chain for newspaper distribution. The RSC was piloted in two West Scotland urban areas for a 12 week period and primary data collected. The data were analysed to evaluate the following; 1) Type of WEEE received; 2) Proportion of WEEE assigned to each value recovery stream; 3) Value derived from the WEEE. Direct and incremental costs associated with the operation of the reverse logistics and value recovery activities was collected and cost model constructed.

Findings:

A total of 692kg of WEEE was received by RM from value recovery activities. The largest WEEE product category was IT and telecommunication equipment (34%), followed by consumer equipment (14%). The majority of WEEE (58%) fell in the lower value Recycle (shredded) stream. No WEEE items were suitable for the highest value recovery method, Remanufacturing; whilst only 4% of WEEE generated zero financial value. Six percent was appropriate for Reuse value recovery; predominately comprising Toys, leisure and sports equipment, and IT and telecommunications equipment.

Analysis of the weekly cost model revealed that based on the current number of collecting newsvendors, the value recovery profile of the WEEE and captured tonnage, the RSC is not profitable. There is an overall weekly loss of £30 per week. Despite the unprofitability, the RCS's net treatment cost of £518 is significantly cheaper than a WEEE study conducted by WRAP (2009)'s at £1,787 per tonne.

Value:

The paper would be of interest to waste managers, reverse logistics researchers, and those wishing to explore uses of surplus logistic capacity within firms.

Practical implications:

The study is an example of how firms can collaborate to harness surplus capacity in one supply chain to complement activities of another chain to support environmental activities and potential business diversification opportunities.

INTRODUCTION

Waste Electrical and Electronic Equipment (WEEE), is the one of the fastest growing waste streams in Europe with 12 million tonnes expected to be generated by 2020 (European Commission, 2018). In terms of unit numbers, small WEEE represents the largest fractions of WEEE arisings and the reuse/recycling return rates for small WEEE items (e.g. household appliances, mobile phones, computers, toys) are much lower than large WEEE (e.g. white goods and televisions). WEEE contains hazardous materials so diverting these away from landfill is environmentally beneficial, and there are also economic benefits associated with recovering and reusing components. As a result there has been growing interest in the Reverse Supply Chains (RSCs) of electronic goods and what value can be extracted from these unwanted items. Whilst there are many examples of electronic reverse supply chains in the literature, these typically focus on one specific product type. This paper presents an empirical case study of a RSC for the recovery of a mixed electrical product stream. The authors design a bespoke three tier collaborative RSC for the collection, transport and treatment of mixed household WEEE. The RSC is unique in that it is a collaboration between an electronics ReManufacturer (RM), and a Collecting Firm (CF) whose primary business is the national distribution of news publications.

The live pilot implementation of the collaborative RSC allowed the researchers a rare opportunity to collect primary data into the potential value recovery of the mixed WEEE stream. From a practical perspective, the study is an example of how firms can collaborate to harness surplus logistics capacity to support environmental activities and potentially lead to business diversification opportunities. For academics, this paper would be a useful addition as unique, empirical case study.

LITERATURE**Reverse supply chains**

Guide Jr and Van Wassenhove (2002) define reverse supply chains as a series of activities required to retrieve a product from a customer for disposal or value recovery. Reverse supply chains are comprised of five fundamental activities (Guide Jr., Teunter, and Van Wassenhove 2003) which are shown in Figure 1; an overview of a RSC for returned products and the various value recovery pathways. Fleischmann et al. (2001) noted that recovery networks form a link between two markets; 1) the "disposer market" where used products are detached from their former users, and 2) the "reuse market" where there is demand for recovered products. Both markets may converge, creating a closed-loop goods flows where recovered components and remanufactured products are reintegrated into the original forward supply chain in Figure 1, or diverge to form an "open loop" in the case of recovered "Scrap" which is passed on to the Recyclates market to be used in another supply chain. The scope of our study will not be on the entire reverse supply chain but from Product Acquisition where customer returns a product to the Returns Evaluation stage.

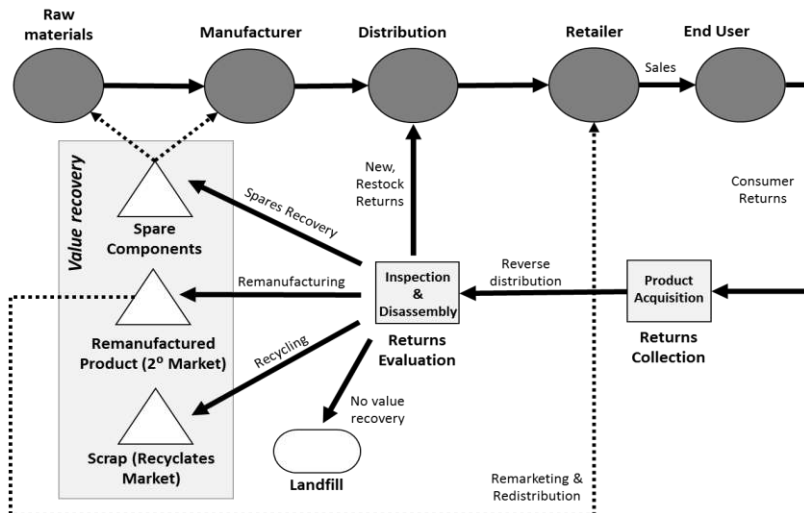


Figure 1: Schematic of a reverse supply chain for product returns. Adapted from Blackburn et al. (2004) and Guide and Van Wassenhove (2003)

Reverse supply chains for electronic goods

The literature contains many examples of reverse supply chains for electronic products. These studies tend to focus on large WEEE such as fridges, TVs and office printers (Krikke, Bloemhof-Ruwaard, and Van Wassenhove 2003; Fleischmann et al. 2001) or one specific small WEEE type such as printer cartridges and mobile phones (Dat et al. 2012). Studies by Wakolbinger et al. (2014), Toyasaki, Boyacı, and Verter (2011), focus on general WEEE but in the context of strategic network design problems and do not address the problem of heterogeneity of the waste stream. Therefore, a focus on mixed small household WEEE (such as mobile phones, games consoles, kettles, toasters, lamps, etc.), would be of interest to the research community – particularly in highlighting the challenges that firms may face in dealing with the heterogeneity of the products.

Value recovery in WEEE reverse supply chain

In reverse supply chains, the value of returned products can be recovered via a number of different recovery processes depending on product quality and extent of disassembly required. According to Thierry et al. (1995), there are six typical value recovery processes: (1) direct reuse, (2) repair, (3) refurbishing, (4) remanufacturing, (5) cannibalization, and (6) recycling. For returned electrical products, the preferred value recovery option would be reuse. This is supported by the EU WEEE Directive 2012/19/EU which aims to maximise the reuse of EOL products. Despite the potential benefits of reuse, these activities for WEEE remains limited especially in the case of household products (Bovea et al. 2016). Reuse and recycling for large WEEE items (e.g. white goods and televisions) have a high recovery rate, but capture rates for small WEEE are much lower due to supply uncertainty and the fact that they are ideally sized for disposal in household refuse bins so their value are lost in landfill (Noble 2013; Cole, Cooper, and Gnanapragasam 2016).

Greater value can be obtained if products underwent higher value recovery processing. For example, a study by WRAP (2011) shows that reuse of waste electrical appliances is preferable to recycling and that the resale values of small WEEE has the greatest economic potential on a £/tonne basis. In Ferrer (1997), the authors exemplify the financial benefits of remanufacturing computers for the OEM by extending their useful lives beyond the typical 2-3 years life-cycle. They were able to demonstrate a net financial benefit of £153 per machine if End of Life computers were upgraded with 6 months equivalent of technological development. These studies highlight the potential financial

benefits of reuse and remanufacturing activities but assume returned products are in a suitable condition for these higher value recovery activities. However, a trial conducted by WRAP (2009) revealed that the collection of WEEE using bulk waste skips (similar to those found in public Household Waste Recycling Centres) led to many items that were deposited in working order to become damaged and contaminated – effectively preventing their potential for higher value reuse. Therefore, to increase the potential of a WEEE item for reuse activities, the product must be returned in the best possible condition so needs to be appropriately handled and stored during the product acquisition stage. An efficient collection system for reuse application should also provide convenient access to local collections sites for end-users to dispose of their items responsibly (Khetriwal, Kraeuchi, and Widmer, 2009). Given the challenges of collection and value recovery, and the lack of empirical studies that focus on mixed small household WEEE, a study into alternative reverse supply chains for this product group would be of interest.

PROBLEM/CHALLENGE

The literature has not revealed any studies on the capture of mixed small household WEEE for value recovery activity. Therefore, more research on mixed WEEE product streams, particularly those that generates empirical data would be a useful contribution to the research community. Secondly, operational insights into collaborative RSCs and examples of how surplus logistics capacity from one supply chain could be harnessed to complement the activities of other SCs would also be useful contributions to the academic environ. Based on gaps identified in the extant literature, the authors have derived the following research questions:

R1: What is the value recovery profile of heterogeneous small WEEE?

R2: Is the proposed collaborative RSC for heterogeneous small WEEE financial viable?

The Case Study

The case study is a bespoke three tier RSC for the collection, transport and treatment of mixed household WEEE for the purpose of value recovery. The RSC comprises of an independent electrical ReManufacturing firm (RM) and a third party Collecting firm (CF) and CF's first tier customers (newsvendors). CF's primary business is the national daily distribution of newspapers and collection of unsold publications. CF's logistics infrastructure is extensive because their product are time critical (newspaper have a shelf life of one day or less), and they must serve all their customers 364 days a year. Failure to do so would mean lost sales for CF's their newsvendor customers. As part of their incumbent operational process, CF simultaneously pick up any unsold newspaper from the previous day (t-1) as part of the outbound delivery process for new newspaper. CF's incumbent forward and reverse supply chain for their newspaper distribution and collection service is shown in Figure 2.

Whilst CF have optimised the vehicle usage of their outbound delivery journeys, there is on average, 50% surplus capacity in their inbound journey. As such, a RSC for WEEE was designed to exploit 1) the surplus capacity that is inherent in CF's inbound journeys and; 2) CF's close relationship with their newsvendor customers who are typically located in community setting - close to end users of WEEE. These two factors were identified in the literature as being appropriate design features of a RSC for WEEE. Aras, Boyaci, and Verter (2010) noted that closer proximity to end users would maximise consumer participation in returning WEEE for value recovery, whilst Fleischmann et al. (2001), observed that few reverse networks are set up "from scratch" but typically intertwined with pre-existing forward logistics structures. As illustrated in Figure 2, a bespoke reverse logistics mechanism for WEEE items has been incorporated into CF's

incumbent forward and backwards logistics operations for daily newspaper deliveries. The end user handover their unwanted WEEE, the newsvendor carefully handle and place the WEEE item in a sturdy plastic container which provides protection to the item. The WEEE item(s) remain in the container during CF's collection and transport to RM in order to minimise damage and increase its potential for higher value recovery in line with WRAP (2011).

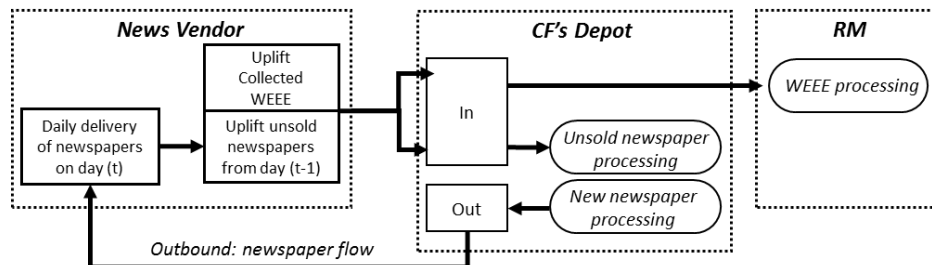


Figure 2: Schematic of the WEEE reverse supply chain integrated into CF's newspaper supply chain

THE RESEARCH WORK

Rubio, Chamorro, and Miranda (2008) state that research on "management of the recovery and distribution of end-of-life products" typically involve both quantitative and qualitative techniques, mathematical models and case study as main methodologies. Therefore, this study adopts a mixed method approach; A case study is appropriate because the authors are evaluating a phenomenon that is taking place in a real world setting (Yin 2012). The bespoke RSC was implemented by CF and RM for 12 weeks in November 2017 to January 2018. The live pilot was carried out in two urban areas in the west of Scotland and involved 12 newsvendors. During that time, WEEE end users could drop off their unwanted small WEEE items at one of the 12 collecting newsvendors. CF carried out the reverse logistics operation and RM triaged and carried out appropriate value recovery activities on the received WEEE. The live pilot allowed the collection of the following data; 1) Quantity and type of WEEE by category; 2) Quantity assigned for remanufacture, reuse and recycling, and; 3) Value recovered from remanufacture, reuse and recycling.

Following the conclusion of the 12 week pilot, the data was analysed to evaluate the following; 1) Type of WEEE received; 2) Proportion of WEEE assigned to each value recovery stream, and; 3) Value that could be derived from the received WEEE. In addition, the direct and incremental costs associated with the operation of the reverse logistics and value recovery activities of the RSC were analysed. A cost model was constructed to assess the financial viability of the RSC.

RESULTS/ANALYSIS

Over the 12 week period, a total of 692kg of WEEE was received by RM for value recovery activities. This equates to each newsvendor collecting on average, 4.8kg of WEEE per week. Based on the 10 categories in the EU WEEE Directive 2012/19/EU, the profile of the WEEE items received is shown in the first column of Table 1. The largest WEEE product category was IT and telecommunication equipment at 35%, followed by consumer equipment which comprises items such as hi-fi stereos, DVD players, games consoles, etc. Uncategorised WEEE denotes items where no descriptor was available in the dataset.

WEEE value recovery profile

Each WEEE item was evaluated and assigned to a value recovery stream. The value recovery activity applied to each WEEE category is summarised in Table 1. Recycle (stripped) denotes items which were manually dismantled to recover higher value materials/components, whilst the Recycle (shredded) process involved feeding the items through a shredder for reclamation as mixed recyclate material.

Overall, the majority of WEEE (58%) were assigned to the lower value Recycle (shredded) stream, with only 4% not generating any financial value. None of the WEEE items were suitable for the highest value recovery method, Remanufacturing. However, 6% was appropriate for Reuse value recovery; predominately comprising Toys, leisure and sports equipment and IT and telecommunications equipment. Consumer equipment and Display screens tended to be allocated to higher value recovery streams, with 73% and 100% assigned to Recycle (stripped) respectively.

Table 1: Value recovery profile of the WEEE received

	Input tonnage kg (%)	Reuse	Recycle (stripped)	Recycle (shredded)	No value (Non WEEE)
IT & telecommunications equipment	239 (35)	15%	46%	39%	0%
Consumer equipment	95 (14)	3%	73%	24%	0%
Small household appliance	93 (14)	2%	4%	94%	0%
Display screens	39 (6)	0%	100%	0%	0%
Lighting equipment	25 (4)	0%	0%	72%	28%
Non WEEE	18 (2)	0%	0%	0%	100%
Toys, leisure and sports equipment	6 (<1)	18%	4%	78%	0%
Monitoring & control instrument	1 (<1)	0%	0%	100%	0%
Uncategorised WEEE	178 (26)	0%	0%	100%	0%
Total tonnage (kg)	692				
Overall percentage		6%	32%	58%	4%

Weekly cost model for the RSC

Analysis of the weekly cost model of the RSC revealed that based on the current number of collecting newsvendors, the value recovery profile of the WEEE and captured tonnage, the RSC is not profitable. The overall weekly loss of £30 is shown in the Sankey chart in Figure 3. The chart summarises the incremental reverse logistics cost of £35 accrued by CF for providing one WEEE pick up per week for each of the 12 retailers, whilst £55 is RM's direct cost of processing the WEEE. In total £60 in value is recovered from WEEE, but this is insufficient to cover the £90 total reverse logistics and processing cost. In terms of per tonne "treatment" cost (collection and processing), this would equate to £1,552/tonne of WEEE of which; Collection = £603/tonne and Processing = £948/tonne. Meanwhile, value recovery would equate to £1,034/tonne.

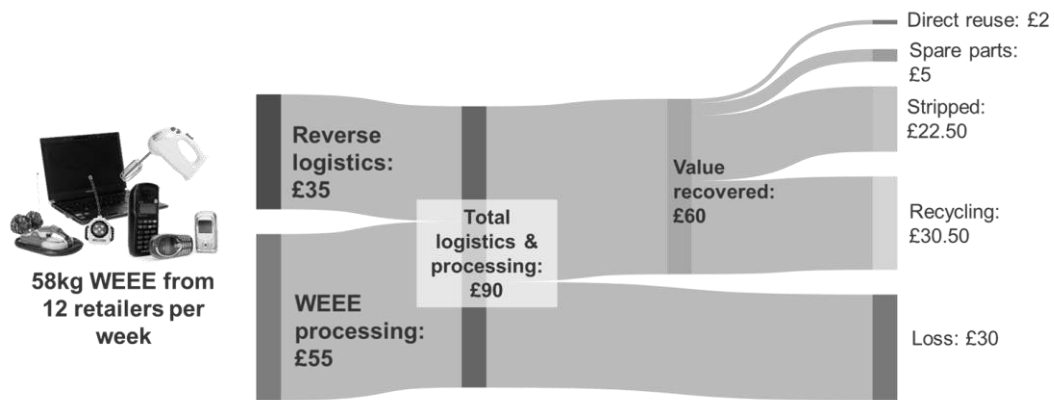


Figure 3: Sankey chart of the direct costs of the reverse supply chain

DISCUSSION

The profile of the WEEE items collected during the pilot is in line with WRAP (2009) and WRAP (2011) studies that found that the three biggest categories of mixed household WEEE were small household appliances, IT and telecommunication equipment and consumer equipment. At present, our results contained a 26% “uncategorised WEEE”, so the percentage composition of the other categories are likely to be higher.

In terms of answering R1, this study has been able to ascertain a value recovery profile for heterogeneous small household WEEE (Table 1). A limitation of the study is that it only covered two geographical area so there are implications in terms of their generalisability of the results. Another limitation is that 24% of our WEEE fell within the uncategorised WEEE category due to RM’s incomplete data collection. Nevertheless, the results provided a higher level of detail of the value recovery pathways associated with each WEEE category. No previous studies have been found which provide such detailed insights into the value recovery streams for different categories of the mixed small household WEEE products. These findings themselves are a valuable contribution to the both the academic and practitioner communities – particularly, waste managers.

The cost modelling of the RSC revealed that the processing cost were greater than the reverse logistics cost and this is associated with the labour intensive nature of RM’s evaluation activities. Upon receipt of the WEEE, RM must inspect and/or disassemble products to assess component quality and/or cleaning operations. Disassembly is time-consuming and labour-intensive (Kim, Lee, and Xirouchakis 2007) which impacts on operational costs. To directly address R2, based on the weekly cost model presented in our study and in its current operating model, the collaboration between RM and CF for the recovery and treatment of mixed small household WEEE is financially unfeasible because it is operating at a loss. This result supports previous industry studies by the European Commission (2014) and WRAP (2009) which both demonstrate no net revenue is generated for mixed household WEEE. Despite the unprofitability, the case study processing cost is significantly cheaper, with only a net treatment cost of £518 compared to WRAP (2009)’s £1,787 per tonne, as shown in Table 2. The WRAP (2009) cost is actually even higher because it does not include any transport/logistics costs. The WRAP (2009) study also focussed on the recovery of raw materials for recycling only whilst in the case study, RM considered the products for remanufacture and reuse streams so was able to achieve 10 times higher value recovery per tonne. The results of this study demonstrates that significantly more value could be obtained from mixed small WEEE streams if Reuse processing is considered and would contribute to reducing the treatment/revenue cost deficit.

Table 2 Comparison of WEEE treatment and revenue costs

	WRAP (2009)	Case study
Per tonne treatment cost, £	1,921 (excl. logistics)	1,552
Per tonne value/revenue cost, £	134	1,034
Net treatment cost, £	1,787	518

Although a few years have passed since the WRAP study was conducted, our results indicates that from a business perspective, revenue recovery from the small household WEEE stream is still not yet feasible. Although our RSC isn't financially viable, a sensitivity analysis indicated that based on the current value recovery profile, increasing the tonnage collected by the 12 collecting newsvendors from 4.8kg to 28kg per week (approximating to 17,800kg per year), the RSC could achieve break even. However, there are likely to be newsvendor storage constraints associated with collecting 28kg of WEEE per week. Previous studies (Atasu, Toktay, and Van Wassenhove 2013; Wojanowski, Verter, and Boyaci 2007), examine optimal solutions for the return of used goods to OEMs found that financial input will be required to stimulate and increase the flow of product returns, e.g. incentivising retailers to promote bring back schemes or consumer deposit-refund schemes. Although such incentives will improve returned WEEE product flow, the inclusion of a financial incentive will negatively impact the cost model of the collaborative RSC and change the breakeven point due to the additional cost of the financial incentive.

CONCLUSION

The findings of our study demonstrates that potentially much greater value could be obtained from small mixed household WEEE than previous studies suggested. However, the RSC cost model revealed that the current operating model, the system is not profitable. However, net treatment costs of small mixed WEEE appears to have decreased when compared to a previous WRAP (2009) WEEE recycling study.

Our study provided a greater level of detail into the value recovery profile (remanufacture, reuse, recycling) for small mixed household WEEE that has not been found in the literature. Another contribution is that this a unique study that examines a mixed electronic product stream; whilst the live pilot live implementation of the RSC provided an opportunity to collect empirical data on a heterogeneous WEEE product stream - examples of which are lacking in the academic environ. One limitation of this study is that it did not quantify the environmental benefits or impacts. As such, the development of a model that will capture both financial and environmental costs benefits would be a natural evolution of this research. Finally, with mixed small household WEEE becoming an increasing environmental and societal problem, the authors call for more research in the recovery of this waste product stream be conducted.

ACKNOWLEDGMENTS

This project was funded by the Scottish Institute for Remanufacturing.

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DETERMINANTS AND MITIGATION STRATEGIES FOR FOOD WASTE: A CASE STUDY FROM A UNIVERSITY'S STUDENT CANTEEN

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ABSTRACT

Purpose/aim

Given the growth of the catering sector and the change in consumers' habits, new sources and determinants of food waste along food supply chains have to be identified and properly managed. This study explores the determinants of food waste in the food service and catering sectors by illustrating a case study from the campus' canteen at Nottingham University. This paper aims at identifying the reasons why students waste food and its knock on impact on from the economic, environmental, and social point of view. The paper purports to suggest practice-ready impact mitigation strategies.

Design/methodology

The conducted study entails a two-step approach. First, an on-field monitoring campaign has been carried out to observe and track the main waste sources resulting from the students' consumption at the campus canteen. The part of the study considered the characteristics of layout and the processes deployed by the canteen management. Dealing with the layout, the food shelves and the consumers flows over the layout have been considered. The observation of the cooking phases and students' purchasing behaviour within a menu of 300 recipes dealt with the processes monitoring. The second step entailed an on-line questionnaire to better understand details about students' food purchasing and consumption habits, and their general awareness about the implications of food waste. Altogether 187 students completed the online survey. The quantitative parameters resulting by both steps have been combined and analysed to deduce general observations and guidelines and suggest practice-ready strategies for waste reduction.

Findings

The obtained results show that up to 74% of the total food waste is generated by consumers i.e. students. On-field observation confirms that students indeed take more food than they really consume. A correlation between such behaviour and the layout of the shelves seems to exist. The questionnaire also underlines a profound lack of awareness (up to 72% of respondents) about the potential economic and social impact of food waste.

Value

The collected empirical evidence offers an explorative analysis of the determinants of food waste from students' canteens. This study provides a valuable contribution by highlighting the scale of food waste in the catering sector and the central role of consumers play in waste prevention strategies. Among the suggested mitigation strategies, the establishment of incentives to avoid unacceptable consumer behaviours and re-design of canteen's layout and processes can result in waste-preventing strategies. Further developments might investigate other reasons for waste generation at students' canteens (e.g. over-production, over-cooking, spoilage), and extend the analysis to other campuses and countries.

KEYWORDS

Food waste, Case study, Food service, Students canteens, Material flow analysis

1. INTRODUCTION

In 2011, FAO claimed around 1.3 billion tons of food are wasted worldwide every year (FAO, 2011), and current statistics confirm a growing trend (FAO, 2015). As 795 million people worldwide still suffer hunger, food waste has relevant implications from the social point of view, but also from

economic and environmental perspectives. FAO estimated that economic losses associated to food waste as 750 billion \$ per year, and that the resulting carbon emissions due to waste disposal in landfills is around 3.3 billion tons per year (FAO, 2013 and 2015). This scenario is expected to worsen in future as intensification of food production propelled by exploitation of natural resources (e.g. soil and water) still does not couple with effective design, management and control of sustainable food supply chains from-farm-to-table that would contribute to food security, safety, affordability and long term sustainability of the whole sector (Godfray et al., 2010).

Recent studies highlighted the impact of the food consumers both at-home and out-of-home (i.e. in food service/catering sector) as primarily responsible of waste along food supply chain (WRAP, 2017).

With respect to the food service sector, explorative studies have been carried out to track and quantify the amount of food waste generated at universities and other educational institutions. For instance, Swiss food service companies serving the schools of Aargau canton produce 7.4 tons of food waste per year (Baier and Reinhard, 2007; Beth et al., 2015). Others estimate in 159-191 gr/meal the wasted food at secondary schools in UK (Cordigli et al., 2011). This study elicits comparison with the behaviour of other students worldwide, as for a Jordanian explorative analysis which accounts for 70 gr/meal of food waste by university students (Al-Domi et al., 2011). Costello et al. (2017) quantify the waste and associated environmental impacts by large-scale events at the college stadium and focused on the strategies and best-practice toward zero-food-waste.

Others provide better understanding on the causes of leftovers at canteens and on the determinants that lead consumers to leave food on the plate (Lowe et al, 2010; Lorenz, 2017).

In this paper, we illustrate a methodology to track and estimate the amount of food wasted from schools canteens. It combines primary data with questionnaires and on-field process observations. The methodology has been applied to the case of Campus' student canteens at Nottingham University, UK. Quantitative and qualitative findings lead to identifying main food waste determinants and suggesting strategies for their mitigation.

1.1. Area of research

The thirteen canteens (i.e. dining rooms) of the Nottingham University are similar in layout and all together serve breakfast, lunch and dinner every day to the 3973 students. All the canteens' costumers (i.e. students, academicians, staff members) benefit of "meal packages", which include pre-paid meals as follows:

- Breakfast Monday to Friday at one specific dining room;
- Dinner Monday to Sunday at one specific dining room;
- A weekend brunch at one specific dining room,
- A weekly allowance of £28.00 that can be used at multiple outlets within the Campus (this allowance will be cleared each Sunday if not expired).

Other rules describing what is allowed to students in terms of meal choices are summarized in Table 1.

Along with the preparation of food within the kitchens and to the consumption, different categories of waste are generated, each assigned to a specific stage of the process or accounted to an actor as illustrated in Fig. 1. The three main categories are: preparation waste (prep-waste in the following), spoilage and plate waste.

Prep-waste concerns the food that is discarded during preparation and cooking phases. Waste from fresh fruit and vegetable peelings, cut-offs and trim waste belong to this category. This waste comes from decisions and tasks handled by chefs and catering service's operators and thus is difficult to avoid as part of products have necessarily to be cut before eating. As a consequence, the amount of prep-waste typically fluctuates with the menu and the offered products.

Spoilage waste includes bruised or mouldy vegetables, spoiled seafood, unusable dry good, as well as expired products and unsold surplus meals. In the observed case, the greatest contribution to spoilage comes from over-production. To comply with University regulation, unsold meals can neither be consumed by canteens staff members, nor donated to external non-profit organizations.

Plate waste, finally, concerns the food that is discarded by consumers.

<i>Allowed</i>	<i>Not Allowed</i>
<ul style="list-style-type: none"> - Choose one main course (the fixed portion main course is served by a staff member) - Take carbs and vegetables from the buffet with no limitations - Take no more than one dessert and two fruits from the self-service area 	<ul style="list-style-type: none"> - Come back to the buffet once started the meal - Come back to the canteen after the meal consumption

Table 1 – Rules at Nottingham Campus’s canteens

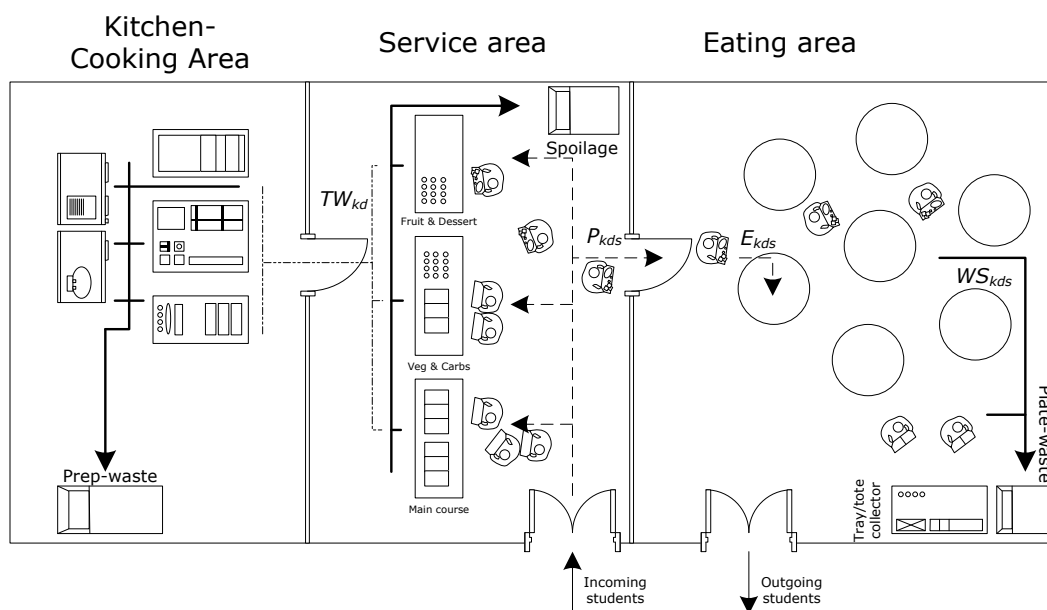


Fig. 1 – Canteen’s layout, flows and indicators

2. METHODOLOGY

The proposed methodology integrates quantitative and qualitative approaches to (1) quantify and estimate the waste flows from the observed University’s canteens, (2) to explore the main waste determinants, and (3) to identify possible mitigation strategies aimed at reducing the amount of waste, as well as its economic and environmental impacts.

The methodology is drawn in Fig. 2. First, an extensive collection of primary data on waste flows generated at Campus has been carried out over a time horizon of thirteen months. Such data has been combined with on-field observation of the whole food service process at the canteens for a sampling period of one week (i.e. five sequent dinners).

According to a Material Flow Analysis (MFA) approach, the gathered information led to calculate secondary data on food waste generation process and a set of performance indicators (detailed in the following sections) intended to quantify the impacts of food consumption. Such indicators are defined according to the sets and indices proposed in Table 2.

Third, the performance indicators have been interpreted in agreement with the responses of a questionnaire conducted among students to figure out the reasons why food is wasted.

Lastly, strategies for improving these indicators and mitigating food waste phenomenon have then been derived from the previous cross-analysis and iterated according to a closed-loop management toward continuous improvement.

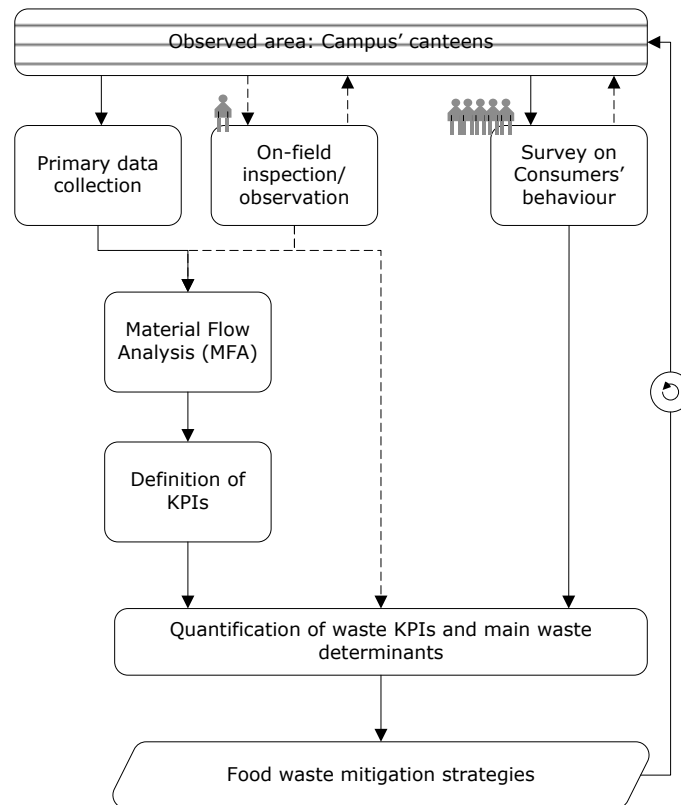


Fig. 2 – Phases of the methodology

Sets	Parameters
$i = 1, \dots, M$ month in the observation period (from October 2016 to January 2018)	(a) c_{ij} : flow of food waste of category j in month i [kg]
$j = 1, \dots, N$ category of food waste ($j=1$ for prep-waste; $j=2$ spoilage; $j=3$ plate waste)	(b) ec : cost of disposal [£/kg]
$k = 1, \dots, K$ type of course ($k=1$ main course; $k=2$ vegetable; $k=3$ carbs; $k=4$ dessert; $k=5$ fruit)	(c) NS : number of customers in the canteens
$s = 1, \dots, S$ gender of consumer ($s=1$ female and $s=2$ male)	(d) NC_{kd} : number of courses of type k prepared on dinner d
$f = 1, \dots, F$ location where to pick food ($f=1$ buffet with no limitations on portion; $f=2$ served by a staff member or taken from self-service area)	(e) W_{kd} : flow of a course of type k on dinner d [kg]
$t = 1, \dots, T$ location where to leave food ($t=1$ food as plate waste; $t=2$ food spoiled as unsold; $t=3$ food eaten)	(f) TW_{kd} : total flow of all courses of type k prepared on dinner d [kg]
$d = 1, \dots, D$ sample dinner monitored (from 1 to 5 in a sampling week)	(g) X_k : average flow of course of type k prepared on monitored dinners [kg]
$c = 1, \dots, C_d$ costumer observed during dinner d	(h) NL_{kd} : number of unsold k courses on dinner d
	(i) S_{kcd} : weight of all unsold meals kind k on dinner d [kg]
	(j) S_k : average flow of unsold courses of type k on monitored dinners [kg]
	(k) Y_{kcds} : number of meals of type k taken by costumer c of gender s on dinner d
	(l) L_{kcds} : number of courses of type k left by costumer c of gender s in dinner d
	(m) H_{cs} : 1 if costumers c is of sex s ; 0 otherwise
	(n) P_{kds} : flow of all courses of type k taken by all costumers of gender s on dinner d [kg]
	(o) WS_{kds} : weight of all courses of kind k left by all costumers of gender s in dinner d [kg]
	(p) E_{kds} : weight of all course of kind k eaten by all costumers of gender s on dinner d [kg]
	(q) Z_{kt} = 1 if course k can be taken from f ; 0 otherwise

Table 2 – Indicators sets and indices

2.1. Material Flow Analysis

The undertaken MFA approach is intended to assess and quantify the incoming flows of food and outgoing flows of waste generated along the food service process at the Campus' canteens. MFA is fuelled by two types of data: primary waste data and on-field observations.

First, primary data collected from the University's archives over a time horizon of thirteen months has been gathered. This deals with the monthly weight of food waste collected c_{ij} per each waste category j .

Then, the impact of each category has been quantified by means of three types of performance indicators, i.e. process-driven, economic and consumer-driven, built in Table 3 according to the glossary of Table 2.

Waste Indicators	
$PKM_{ij} = \frac{c_{ij}}{\sum_{j=1}^N c_{ij}} \quad (1)$	$WS_{kds} = \sum_{c=1}^C L_{kdc} \cdot H_{cs} \cdot W_{kd} \quad (9)$
$PK_j = \frac{\sum_{i=1}^M c_{ij}}{\sum_{i=1}^M \sum_{j=1}^N c_{ij}} \quad (2)$	$E_{kds} = P_{kds} - WS_{kds} \quad (10)$
$WM_i = \frac{\sum_{j=1}^N c_{ij}}{\sum_{i=1}^M \sum_{j=1}^N c_{ij}} \quad (3)$	$S_{kd} = NL_{kd} \cdot W_{kd} \quad (11)$
$EC_j = \sum_{i=1}^M c_{ij} \cdot ec \quad (4)$	$Q_{t=1} = \frac{\sum_{s=1}^S \sum_{k=1}^K \sum_{d=1}^D (\frac{WS_{kds}}{D})}{\sum_{k=1}^K X_k} \quad (12)$
$WC_{ij} = \frac{c_{ij}}{NS} \quad (5)$	$Q_{t=2} = \frac{\sum_{s=1}^S \sum_{k=1}^K \sum_{d=1}^D (\frac{S_{kd}}{D})}{\sum_{k=1}^K X_k} \quad (13)$
$WCM_i = \frac{\sum_{j=1}^N c_{ij}}{NS} \quad (6)$	$Q_{t=3} = \frac{\sum_{s=1}^S \sum_{k=1}^K \sum_{d=1}^D (\frac{E_{kds}}{D})}{\sum_{k=1}^K X_k} \quad (14)$
$TW_{kd} = NC_{kd} \cdot W_{kd} \quad (7)$	$Waste_s = \frac{\sum_{k=1}^K \sum_{d=1}^D (\frac{WS_{kds}}{D})}{\sum_{k=1}^K \sum_{d=1}^D (\frac{P_{kds}}{D})} \quad (15)$
$P_{kds} = \sum_{c=1}^C Y_{kdc} \cdot H_{cs} \cdot W_{kd} \quad (8)$	$CW_{sf} = \frac{\sum_{k=1}^K (\sum_{d=1}^D (\frac{WS_{kds}}{D}) \cdot Z_{kf})}{\sum_{k=1}^K \sum_{d=1}^D (\frac{WS_{kds}}{D})} \quad (16)$

Table 3 – Waste performance indicators

The process-driven indicators (1) and (2) quantify respectively the relative impacts of waste categories per each month and over the whole time horizon.

Another indicator (3) quantifies the impact of each months on the whole waste generated, in order to recognize potential seasonality among the consumers' behaviour.

The economic indicator (4) assesses the disposal cost accounted for each waste category over the observed horizon. The determination of such metric complies with the waste management policy undertaken at the Nottingham University, which bases on pay-for-load deal. This cost is 14.3 pence/kg and includes bin rental, truck loading, waste transportation and disposal costs.

The consumer-driven indicators (5) and (6) are to assess the per-capita waste generated per month for each category j and overall.

From a preliminary analysis of historical primary data, it came out as the most contribution of waste is given by plate-waste. As a consequence, a monitoring and on-field observation campaign has been carried out to explore reasons and determinants and quantify other more specific indicators. The monitoring campaign has been conducted over a week during 5 sequent dinners. Different flows and process phases have been tracked. The flow from kitchen to shelves has been considered to estimate the incoming food provided to consumers per each course k and dinner d as defined in (7):

The second tracked flow has been that of consumers from the picking location along with the consumption and finally to the totes container nearby the canteen's exit. Each consumer has been signed by the gender, the number and types of courses retrieved, and by pictures of leftovers on the tote. From such data, new KPIs have been quantified as the per-capita flow of food retrieved (8), consumed (10) or waste (9) by each gender during a dinner.

After the canteen's closure the number of unsold portions per each course has been collected to estimate the spoilage waste generated at each dinner as in (11).

Given the percentage of waste per each category determined along the monitoring campaign, the overall monthly flows of waste have been split accordingly and compared with the incoming food flows, in agreement with the consumer-driven KPIs (12), (13), and (14).

Lastly, the fraction of waste generated by each gender has been estimated with respect to the different courses and the limitations detailed in Table 1. These are accounted by indicators (15) and (16) respectively.

2.2. Survey

According to the proposed methodology, the MFA approach has been combined with the findings from a survey conducted among the Campus students. The survey investigated the preferences of consumers, their purchasing habits, their diets and consumption choices through a set of open and multiple-choices questions. The first section of the questionnaire deals with general socio-demography features, the second enquired the causes of waste and consumers' practice, while the third referred to the awareness of students on the food waste topic and social and environmental implications. A number of 187 students responded to this survey.

For sake of brevity the questions of the survey are not reported in this paper, while main findings are discussed in the following sections.

3. RESULTS

In the following, the values of defined waste generation indicators are summarized and discussed. The overall food waste generated by the Campus canteens along the time horizon is around 111 tons, uniformly distributed over the months within the range $5.17\% \leq WM_i \leq 9.15\%$ as illustrated in Fig. 3.

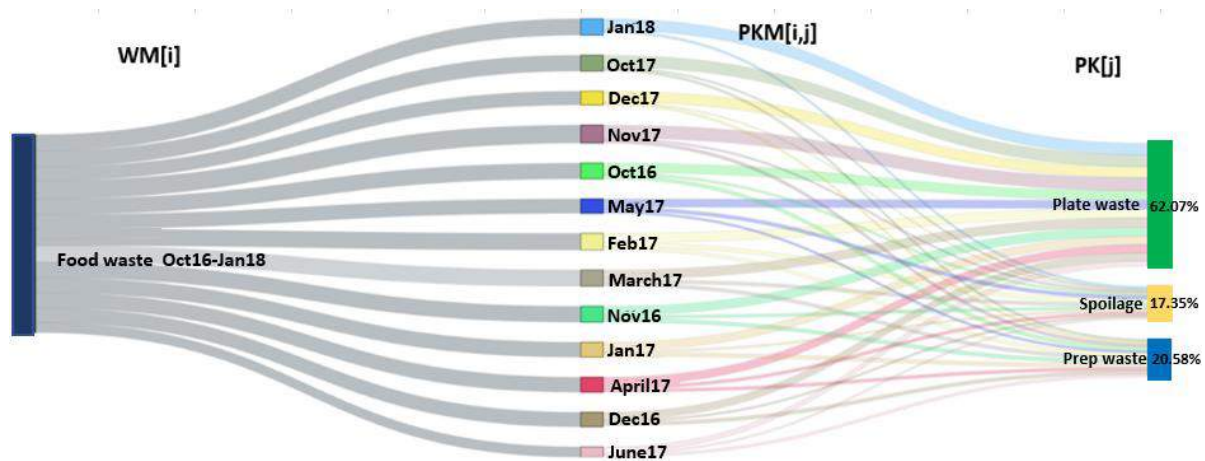


Fig. 3 – Monthly food waste flow in Nottingham canteens (observation period: Oct 2016-Jan 2018).

Fig. 3 distinguishes the main categories of waste as 62% accounted by plate waste, 17% for spoilage and around 20% as consequence of food preparation tasks. The highest contribution of plate waste is again confirmed over the months, but with a more evident variance in between the range 53-78% as comes out from Fig. 4.

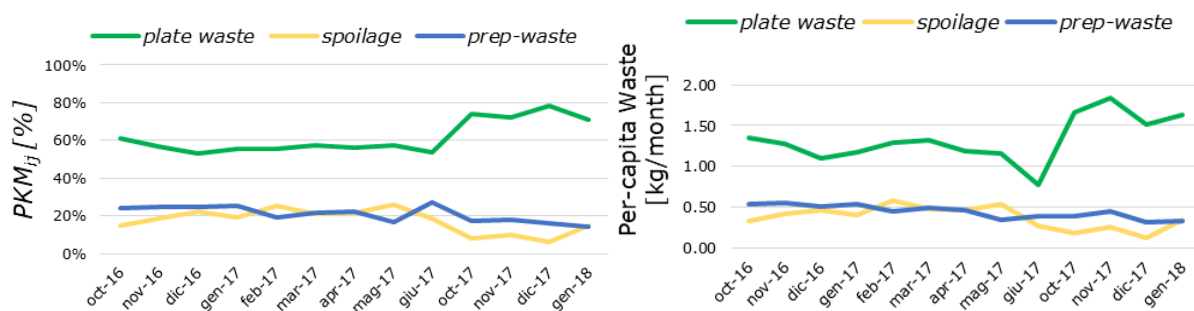


Fig. 4 – Relative impact of waste categories (a); Per-capita waste flow (b).

With respect to what achieved by Beth et al. (2014) and early Silvennoinen et al. (2012), the impact of spoilage waste is less than half for the observed area of study, as the totes used for food exposition are usually almost empty at the end of the service. In order to contain such waste indeed, the Campus' canteens implement a lot-for-lot food processing policy scaled on the coming of the students distributed over the service time.

The prep-waste accounts for 20% and confirms the findings by Wong (2011) (i.e. 18.55% for German canteens). However, this category is extremely affected by chefs and catering operators practices, by recipes, and by the raw products that compose the menu. Further investigation of

prep-waste and how this can be mitigated through accurate design of food catering production systems are left to other studies (Penazzi et al., 2017).

Plate waste results the most significant category and accounts for an overall waste management cost of £ 9836 over the observation horizon. The consumer-driven indicator of Fig. 4 showcases as the average leftover WC_{i3} is 1.33 kg/month representing in weight the equivalent of about 17 portion of pasta of 80gr each, while prep-waste and spoilage account for 0.44 and 0.37 kg/month respectively. The food waste per meal defined as the ratio between the overall waste and the served customers, has a value of 36.5 gr/meal, 26.3 of which due to leftovers. This value underrates what quantified by other studies (Al-Domi et al., 2011; Cordingley et al., 2011; Engstrom and Carlsson-Kanyama, 2004; Betz et al., 2015) which obtains mean values between 46 and 191 gr/meal.

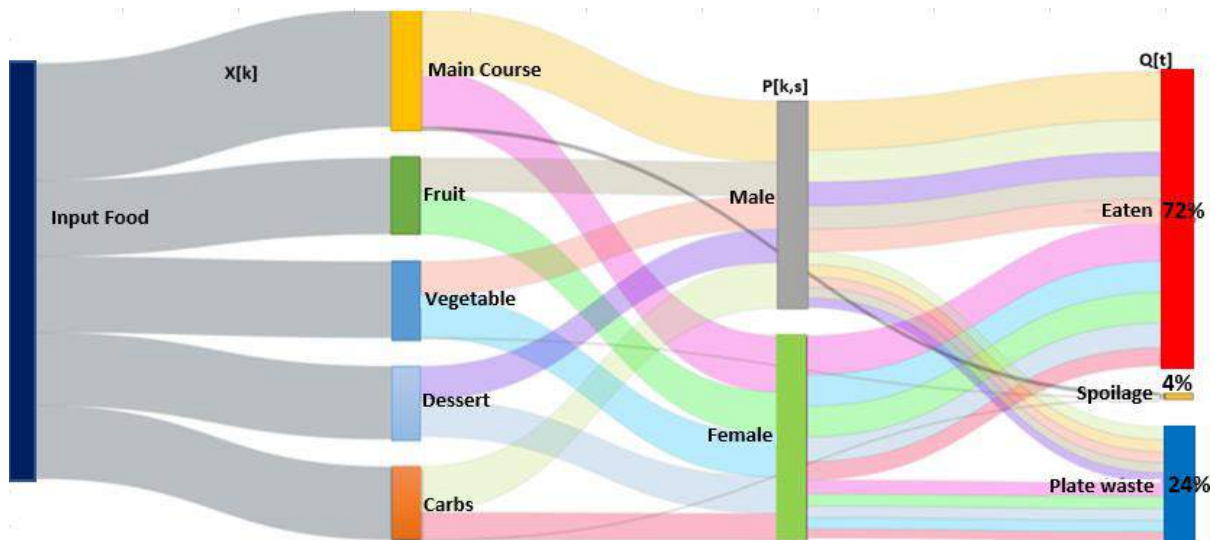


Fig. 5 – MFA from service area to customers (observation period: 5 dinners).

Fig. 5 illustrates the distribution of waste flows observed along the 5-days on-field monitoring campaign. It comes out that 72% of processed food is finally eaten by the consumers, 24% is leftover and just 4% is due to preparation. Both female and male consumers left the same fraction of food $Waste_s$ equal to 26% and 24% respectively. Differences are measured when looking at the behavior of female and male consumers with respect to the location where food is picked. When food is picked from buffet, male consumers grab more food than they need, and leftovers are higher $CW_{21} = 85\%$ than when they are served by the operators or they are self-served with fixed/limited portions ($CW_{22} = 15\%$). Female consumers confirm the same trend but are more virtuous as they tend to waste less than males when are self-served ($CW_{11} = 75\%$).

3.1. Survey results

Only the 69.8% of the 187 responding students declares to usually waste some food. Among this the 53.1% motivates the waste as "too big portion" are served, 36% because "food is not tasteful", 4.5% is uncertain about what to order, 3% retains that "food smells" and 3.4% because of poor visual appearance.

A general poor awareness of the costs, impacts and implications that food waste has derives from the survey. The 72.2% of the students is not acknowledged about any economic, environmental nor social impact of food waste, and 78.3% affirms that he is not even responsible for it and cannot contribute to its mitigation.

A common best practice is the adoption of doggy bags, pursued by 75.3% of consumers, whose 65% also perceives leftovers as an unfair practice underlining a correlation stated by the extant literature (Sirieux et al., 2013).

4. MITIGATION STRATEGIES

From the analysis of the waste indicators and the survey's results, it comes out that the most critical issue to address to reduce food waste at the Campus' canteens of Nottingham University is plate waste as it accounts for the 62% (i.e. $PK_3 = 62.07\%$) of the total flow. It is worth noting how this flow is significantly higher in the observed case than what found by other studies (33% from Eriksson et al., 2017).

The monitoring campaign and the resulting primary data even allowed investigating the reasons why consumers leave about 24% of the input food processed by the kitchen. As the main cause lies

on “*too big portion*”, and most of waste is generated when students serve themselves from the buffet with no limitations on portion size, we can assume that picking more food than necessary is a common practice among students.

In order to explain such behavior, the role played by the specific canteen’s and food service policies introduced in Section 1.1 can be investigated. First, the food service is pre-paid for all Campus’ students. Second, once a single student is served, back-trips to the food shelves or the buffet are not allowed to avoid congestions and for safety issues. As a consequence, students tend to grab as much food as the tote allows because they do not have to pay neither for the quantity picked nor for the leftover.

Furthermore, females tend to waste more main courses and desserts than males. All together, these findings lead to propose the following practical mitigation strategies as summarized in Table 4.

<i>Waste Category j</i>	<i>Indicator Involved</i>	<i>Strategy</i>	<i>Issues</i>
Spoilage	PK_2	<ul style="list-style-type: none"> - Share left food between food service operators members - Donate to ONGs or charity 	<ul style="list-style-type: none"> - Opportunistic behaviour by food service operators - Legal responsibility for spoiled food management (i.e. safety rules and insurance)
Plate waste	CW_{s1}	<ul style="list-style-type: none"> - Allow customers returning to the buffet more than once 	<ul style="list-style-type: none"> - Layout re-design to avoid congestions and food contamination
Plate waste	Q_1 Survey	<ul style="list-style-type: none"> - use doggy bags 	<ul style="list-style-type: none"> - cost of doggy bags - safety problems linked with storage and use of leftovers
Plate waste	Q_1 Survey	<ul style="list-style-type: none"> - Improve students’ awareness with educational and shocking campaigns 	
Plate waste	CW_{12}	<ul style="list-style-type: none"> - Allow portion customization particularly for main course and desserts 	
Plate waste	Q_1 Survey	<ul style="list-style-type: none"> - Penalties and incentives 	<ul style="list-style-type: none"> - Management and control for penalties and incentives

Table 4 – Waste mitigation strategies at Campus’ canteens

One of the more evident strategy to mitigate plate waste lies on allowing the customization of portions especially for main course and desserts. Calibers for self-portioning or at least differentiation between male and female customers might be implemented and tested (Lorenz et al., 2017).

Other strategies should be intended to enhance the awareness of students on the impact that food waste has, and on the key role each of them play in its reduction. Educational programs and informative campaigns on food waste-induced economic, environmental and social impacts could be useful to face the stated lack of awareness among the Campus’ population.

The systemic and encouraged adoption of doggy bags (e.g. by providing take-away totes or containers) could also support the reduction of plate waste.

5. CONCLUSIONS

This paper explores determinants of food waste from food service sector, by analyzing waste sources and determinants in the Campus’ students canteens of Nottingham University. An introduced methodology combines MFA and survey techniques to quantify and assess why and how students waste food. While the illustrated analysis is by no way comprehensive and generalizable, the findings contribute to shed light on the criticalities and challenges to be still addressed. Most of these lies on the poor awareness of consumers about the impact food waste has, and the crucial role they play to its mitigation. Such unawareness drives to bad practice and unfair behaviors by students. Furthermore, the obtained results contribute to identify some practical mitigation strategies for the reduction of food waste and related impacts.

ACKNOWLEDGMENTS

The authors would like to thank chefs and food service operators of the Nottingham University’s student canteens for their priceless support and the Nottingham Campus students for their cooperation to this research project.

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UNDERSTANDING BUYER STRINGENT ENVIRONMENTAL REQUIREMENTS IN THE CONTEXT OF SUSTAINABLE SUPPLY CHAIN

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ABSTRACT

Aim/Purpose

Due to uncertain changes in buyer environmental requirements, it is necessary to investigate how and to what extent supplier firms adopt these environmental requirements. This research aims to conceptualise 'stringent buyer environmental requirements' and investigating its impact on organization's environmental performance.

Design/methodology/approach:

Transaction cost economics theory is employed to explore and understand the concept of stringent buyer environmental requirements and dynamic capability framework is used to explain the role of capability. Although the quantitative survey is the prominent method used in this study, a qualitative pre-test has also been conducted to discuss and confirm the items or dimensions of the constructs. Using data from Bangladesh Ready-made garment (RMG) industry and employing structural equation modelling (SEM) technique this study investigates how the stringent environmental requirements from customers around the world impact the environmental performance of suppliers.

Findings:

Results demonstrate that stringent customer environmental requirements positively influence suppliers to develop their capability while that capability facilitates the translation of stringent customer environmental requirements into desired environmental performance. Furthermore, buyer-supplier relationship quality positively impacts supplier's environmental capability development while it also influences the strength of the relationship between stringent buyer environmental requirements and capability development.

Originality/ Value:

This research establishes the evidence for relatively new concept of stringent customer environmental requirements and develops a unique theoretical framework which demonstrates the relationships among the critical determinants around it. Results could be of interest to the future researchers in sustainable supply chains and managers to understand the dynamics of environmental requirements and gain vital insight on adopting these unpredictable changes into their system.

Research limitations/ Implications:

Environmental regulations are different in different countries and industries, so data may not reflect all the possible variations in environmental requirements. We consider that the theoretical framework will still be valid in other situations however need to be tested in other places before generalisation.

Practical implications:

The findings from this research substantiate the fact that Bangladesh RMG industry is escalating regarding their environmental practices and developing environmental capability in accordance with the buyer requirements. This is supported by the evidence that seven out of ten top environmentally friendly companies certified by LEED belong to Bangladesh RMG sector and the export of the sector has also increased significantly in the recent time.

Keywords: Bangladesh, Ready-made garment, stringent environmental requirements, Sustainable Supply Chain.

INTRODUCTION

Among the number of factors that drive firm's environmental performance improvement, stakeholders pressure is found to be one of the most dominant factors (Lee, Klassen, Furlan, & Vinelli, 2014; Sarkis et al. 2010); . Literature suggests that one of the most dominant stakeholder is 'customer' who can play a role in forcing its suppliers to implement environmental practices (e.g. introducing environmental friendly technologies, process, adopting standards, eco-design), and to improve environmental performance (Simpson, Power & Samson 2007; Sarkis et al. 2010). Therefore, within a supply chain, customer environmental requirement is one of the key factors that may encourage supply chain partners to improve their environmental performance (Lee & Klassen, 2008).

Moreover, with the growing customer concern over environmental sustainability, large corporations and firms demand their suppliers to maintain a minimum standard of environmental performance) such as industry based certifications (e.g. ISO14001) and product based standards (certified organic, fair trade) (Simpson, Power & Klassen 2012). The inclusion of these environmental performance requirements beyond the traditional customer requirements e.g. reducing cost, improve quality, is relatively a new and complex burden for organisation to manage (Simpson & Power 2007). However, even these requirements do not significantly impact firms environmental performance required by their buyers (Delmas & Montes Sancho, 2010; Simpson, Power & Klassen, 2012). Therefore, buyers are required to modify and introduce environmental requirements beyond the conventional customer requirements for improved environmental performance. For example, Sony introduced their 'Road to Zero'- Global environmental plan (Sony, 2015), Starbucks introduced ethical sourcing guidelines (Starbucks, 2015), BMW, Toyota, and Mitsubishi included supplier activities in their statement of environmental responsibilities. This may come to the supplier as unusual and even more complex requirements for which most of them are yet to be completely prepared.

This research aims to further extend a recent and growing body of research through understanding the concept- 'stringent customer environmental requirements' and investigating its impact on firm's environmental performance. In addition to exploring the existence of such requirements we also investigate how buyer-supplier relationships and supplier's capability may influence the relation of these environmental requirements and environmental performance.

LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

Over the last decade, firms (mostly original equipment manufacturers) are under intense scrutiny of government and customers to improve their environmental performance. This is because of the increasing customer concern over sustainability and climate changes which prompt significant changes in product based environmental regulations. The regulatory changes for environmental performance improvement flow back upstream in the supply chain (multi-tier) with uncertain consequences (Lee et al. 2014). Further, the changes are conveyed to the upstream suppliers as buying specifications (Green, Morton, & New, 2000) however these changes not necessarily match the original regulations and protocols. So the upstream suppliers might face more stringent environmental performance requirements (Lee et al., 2014) as indirect regulations from their buyers which is similar to the "rationing and shortage gaming" concept. Besides more strict requirements, firms typically plan to meet the new requirements well before the regulatory deadlines. The obvious reasons to create this 'time buffer' (Lee et al., 2014) are for instance, poor supplier commitment over green practices (Walker, Di Sisto, & McBain, 2008), customers might be reluctant to accept new concepts (Halldórsson et al., 2010), small suppliers might have limited capabilities that result in delayed implementation (Lee & Klassen, 2008). Therefore, to avoid any risk of missing deadline, buyers shift it to earlier than actual deadline when they pass it to the next tier of supply chain and thus become more stringent (Lee et al., 2014).

Customer environmental requirements and supplier's environmental capability

The pressure for environmental performance improvement are more intense nowadays especially among large corporations (Delmas & Montes Sancho 2010). Supplier firms are supposed to comply with new environmental regulations and standards required by their customer firms (Delmas & Montes Sancho 2010; Simpson et al. 2012). This causes supplier firms to develop more operational capabilities beyond their existing capability. To address the stringent requirements suppliers need to develop new capabilities and emphasize collaboration with buyers for technical and managerial assistance e.g. environmental training, education, and technical support (Lee et al. 2014). Thus we propose that,

Hypothesis 1: Supplier's capability to meet the environmental performance requirements is positively related to the 'stringency' of the customer environmental requirements.

Capability and environmental performance

To achieve the desired environmental performance threshold, firms required to have the necessary capabilities, especially for the complex problems (target performance level, pollution prevention etc.) which may lead to decreased motivation and increased difficulties perceived by them (González-Torre et al. 2010). Superior environmental performance can be achieved if the firm has the capability to exploit as well as preserve natural resources in its operating environment. Meeting environmental requirements from buyers in turn improves the 'green' performance (Zhu and Sarkis, 2004) of the suppliers as well as of the whole supply chain and these environmental performance goals are met by the suppliers through developing relevant capability. Thus we posit that,

Hypothesis 2: Supplier's environmental performance is positively related to their capability.

Hypothesis 3: Supplier environmental capability facilitates the relationship between stringency of environmental requirements and environmental performance.

Customer environmental requirements and environmental performance

The role of a customer in supplier environmental performance improvement has been investigated by number of researchers. For example Lamming and Hampson (1996) mentioned that customer firms by engaging collaborative dialogue with suppliers will be better able to understand and improve the environmental impacts of their supply chains. Customers often force their suppliers to implement environmental practices such as introducing environmental friendly technologies, process, adopting standards, eco-design and thus to improve their environmental performance (Simpson, Power & Samson 2007; Sarkis et al. 2010). Depending on the specific circumstances, the customer environmental performance requirements may vary and it may be more or less stringent (Lee et al. 2014) which ultimately affect supplier environmental performance. Thus, we posit-

Hypothesis-4: Supplier's environmental performance is positively related to the 'stringency' of the customer environmental requirements.

Influence of buyer-supplier relationship quality

In green supply chain literature, buyer-supplier relationship is indicated as a means of improving capability through joint development of collaborative programs, process, materials, training and other solutions to the environmental issues (Simpson et al., 2007; Sarkis et al., 2010;). It has been argued that, better supply chain performance can be achieved through tactics (joint forecasting, collaborative planning etc.) which are based on good buyer-supplier relationship. To be specific, quality of buyer-supplier

relationship such as trust and information sharing, adaptation, cooperation, commitment long-time relationship commitment plays a significant role in supplier's environmental capability development. For example, if the buyer firms share latest information about environmental requirements with their suppliers, have trustworthy relationship between them, then supplier firms will be motivated to develop their capability with respect to their buyer's environmental requirements. Thus we propose that-

Hypothesis 5: The buyer supplier relationship quality will positively impact the supplier firm's environmental capability development.

Hypothesis 6: The buyer supplier relationship quality will moderate the relationship between stringent customer environmental requirements and suppliers environmental capability development.

The conceptual framework is shown in figure 1 below.

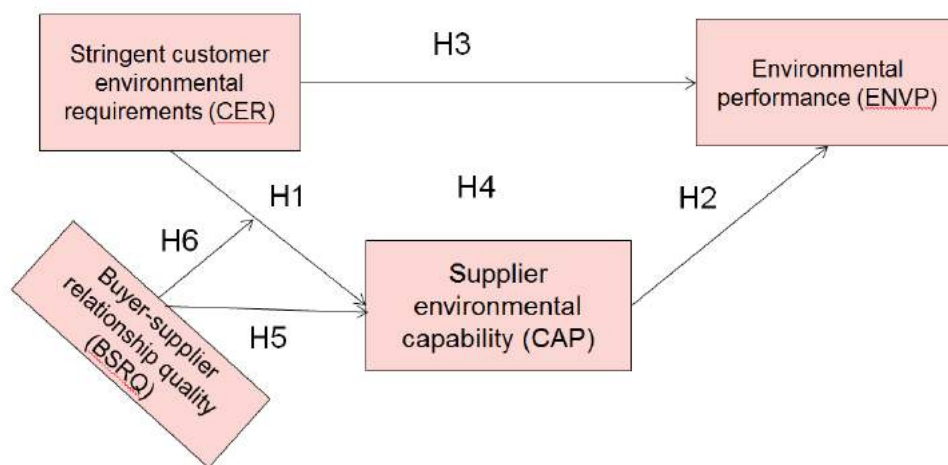


Figure 1: Conceptual framework

THEORETICAL UNDERPINNING

TCE perspective

In this study, the two major constructs of TCE can explain how stringency may affect the transactions that need to be managed. In this vein, it can be argued that stringent environmental requirements from buyers will lead to more transaction costs. For example, sudden changes/inclusion in/of environmental regulations (both local and destination) forces buying firms to implement new requirements promptly in their supply chain. As buyer passes these requirements upstream through the supply chain, suppliers face immense uncertainty regarding these requirements and the complexity of implementation in addition to added pressure of meeting the requirements in time. These become even worse when suppliers face variety of requirements from different buyers with a threat of penalty. The overall degree of uncertainty resulting from the aforementioned context increases supplier's transaction cost such as search cost, screening cost, bargaining cost, monitoring cost, enforcement cost in order to minimize risk and monitor contract information.

Dynamic capability view

In the context of our research, we see the suppliers being exposed to unpredictable changes in environmental requirements from the stakeholders. Such unpredictability is compounded with the variation in the requirements, the added complexity in operations and planning, and frequently with the risk of getting penalized if it fails to deliver to its promises. All these factors can characterize a highly dynamic environment for which the

concept of dynamic capability is intended (Eisenhardt and Martin, 2000). In order to cope with the highly dynamic environment, suppliers need to acquire and assimilate relevant knowledge, then transform them into capability and finally exploit the capability to gain and sustain competitive advantage over other suppliers (Zahra, 2002). In a highly competitive industry (Bangladesh RMG Industry); therefore, adapting quickly to the changes in environmental requirements is vital for their competitiveness as well as existence.

METHODOLOGY

Quantitative methodology has been chosen for this research to test the hypotheses that are developed based on theoretical assumptions. A structured questionnaire was used to collect data from Bangladesh read-made garment industry to understand how stringent environmental requirements from buyers impact the environmental performance of suppliers in Bangladesh. The questionnaire was comprised of two parts. Part A was used to collect information for company and respondents profile while Part B consists of questions related to three independent and one dependent constructs. The items for supplier's environmental capability, environmental performance and buyer-supplier relationships were adopted from existing scale in literature while the items for stringent customer environmental requirements were developed from literature review. Then, it was followed by pre-test with experts (3 from industry and 3 from academic) to check the content validity of the questionnaire. There are seven (7) items to measure stringent customer environmental requirements and these items measures newness in environmental requirements from customers, uncertainty in terms of meeting deadline, specifications, complexity of implementation, uniqueness, penalty. Further, environmental performance construct is assessed by seven (7) items which focused on three areas i) waste prevention before it occurs ii) waste reduction and recycling that arises from end-processes, and iii) more efficient use of its material resources. Firm's capability is measured by seven (7) items in several areas such as knowledge resources (environmental expertise), technologies, and programs for capability development. Buyer-supplier relationship is measured by five (5) items in the area such as investment, relational contract, collaboration, information sharing .

During pre-test phase experts suggested that fours items do not reflect the constructs well so we dropped that items. Afterwards, survey questionnaire piloted into 55 companies before large scale survey. Pilot test result reveals that Chronbach alpha coefficient of all items were more than 0.7 which demonstrates that the scale is reliable for final survey. Final survey was conducted by drop and collect method during November-December 2016. Out of 800 companies the questionnaire sent 262 responses were recorded after dropping six (6) incomplete questionnaires. Then, the data analysis was performed after initial cleaning and screening. Validity and reliability test was accomplished before testing the final structural model in AMOS.

DATA COLLECTION AND ANALYSIS

Demographic Profile

In the sample, most of the respondents were managers (39.7%) with significant experience in supply chain and operations. In regards to education, most of them have completed graduate studies (51.7%). The other 49.3% have post-graduate, diploma/higher secondary degrees of awards. Approximately 40.1% indicated that they have been working in the organization between 6 to 10 years followed by 34.4% having managerial experience 3 to 5 years. Of these 262 respondents, most (12.6%) had more than 10 years of managerial experience in RMG industry. It is also evident that the majority of respondents have vast work experience in the RMG industry.

Majority of the participated organizations were large-sized enterprises (82.5%) that have more than 1000 employees while the rest 17.5% were relatively small enterprise with

the employees in between 1 to 1000. Only 26% organizations are in operation for more than 20 years, majority (48.1%) are in operation between 10 to 20 years. Of the 262 responding companies, 138 are operating in knitwear sub-sector, 105 in woven wear sub-sector and only 19 in sweater sub- sector. Further majority of the companies (56.9%) generates handsome revenue in between 15-50 million USD in last financial year while 16.4 % had more than 50 million USD.

Dimensionality test: Exploratory factor analysis

Exploratory factors analysis has been performed to check whether the constructs are uni-dimensional or not. The analysis has been done in IBM SPSS 24 and found that one item in environmental performance construct did not load (below 0.35) so deleted from further analysis. Afterwards, all of the constructs generates one factor model so suitable for further analysis in CFA.

Validity test

Convergent validity test

Convergent validity evaluates the degree of correlation between two measures of the same concept (Straub, Boudreau and Gefen 2004; Hair et al. 2010). Convergence validity of a construct is usually assessed in AMOS by a) testing with one factor model fit (GOF) indices. In addition two other criteria has also been tested, b) Standard factor loading of the items should be greater than 0.5. c) AVE values ≥ 0.50 (Straub, Boudreau and Gefen 2004; Hair et al. 2010). Table 1 below shows the one factor model fit indices. As all of the model fit indices are within the acceptable level, so convergent validity is established.

Construct	Chi-square	DF	p-value	CMIN/DF	RMSEA	CFI	TLI
Stringent buyer environmental requirements	15.622	14	0.337	1.116	0.021	0.998	0.998
Environmental performance	10.041	9	0.347	1.116	0.021	0.998	0.999
Capability	38.645	14	0.000	2.760	0.082	0.968	0.978
Capability (after deletion)	10.293	9	0.327	1.144	0.023	0.999	0.998
Buyer-supplier relationship quality	6.359	5	0.273	1.272	0.032	0.998	0.996

Table 1: One factor model fit (GOF) indices

In addition to goodness-of-fit indices, standard factor loading and AVE values are also calculated to provide further evidence of convergent validity. Since both the conditions (b) and (c) are satisfied further evidences of convergent validity are also supported as shown in Table 2.

Construct	Lowest factor loading	AVE values
Stringent buyer environmental requirements	0.70	0.606

Environmental performance	0.80	0.688
Capability	0.74	0.635
Buyer-supplier relationship quality	0.74	0.602

Table 2: Further evidence of convergent validity

Discriminant validity test

When the model fit and convergent validity established, assessment for discriminant validity was carried out and the results have been presented in Table 3. Discriminant validity is supported because, in all of the cases, average variance extracted (AVE) of a construct is greater than its square correlation co-efficient with other constructs (Hair et al. 2006, 778; Holmes-Smith 2010).

Construct	Customer environmental requirements	Environmental performance	Capability	Buyer supplier relationship quality
Customer environmental requirements	0.606			
Environmental performance	0.393	0.688		
Capability	0.299	0.458	0.635	
Buyer supplier relationship quality	0.186	0.463	0.374	0.602

Table 3: Discriminant validity for the full measurement model.

Factorial validity through full measurement model

The statistics in Table 4 indicate an acceptable fit in several of the fit indices, except for in the case of the p -value associated with the chi-square value, which, at 0.000, is less than the threshold value of 0.05. The factor loadings are also sufficiently high, giving an acceptable value for convergent validity. As the degree of freedom of the model is 246, it is expected that the model will produce significant p -value as shown in the above table. However, we further assess p -value by using Bollen-Stine Bootstrapping which shows the better model fit with insignificant p -value 0.323 where the cut-off value is >0.05 .

Chi-square	DF	p -value	Bootstrap p -value	CMIN/DF	RMSEA	CFI	TLI	PCFI
314.02	246	0.00	0.32	1.27	0.03	0.98	0.98	0.88

Table 4: GOF statistics observed value for full measurement model ($m>12$ and $n>250$)

As all of the fit indices values of the full measurement model are within the acceptable range so, factorial validity of the model is supported.

Reliability

The reliability of the constructs has been assessed by using Chronbach alpha (α) which indicates the internal consistency of the items and the cut-off value is 0.7 or higher. The result of the reliability shows the values ranges from 0.881 to 0.929. We further assess reliability by using coefficient H because all of the constructs of this study are congeneric in nature. The result of coefficient H confirms the sufficient reliability through a) $H>0.80$ and b) $H>$ best item of the construct with regards to factor loading. Results are given below in Table 5.

Construct	Chronbach alpha (α)	Co-efficient H	Reliability of the best item
Stringent customer environmental requirements	0.913	0.92	0.72
Environmental performance	0.929	0.93	0.74
Capability	0.911	0.91	0.81
Buyer-supplier relationship quality	0.881	0.90	0.66

Table 5 Reliability of items measurement

Common method bias

Herman single factor test was done in CFA and result shows that- i) Unacceptable model fit indices (Chi-square =1739.255 DF=252, Normed chi square 6.90, RMSEA=0.15, CFI=0.648, TLI=0.614) ii) Standardized factor loading of many factors less than 0.50. These results suggest that one single factor cannot account for majority of variance in the data and thus any potential CMV is trivial. Hence, it can be concluded that common method bias (due to the method of data collection) is not of a great concern and so it is less likely to affect the interpretation of the results of this study.

Full structural model testing

Structural model fit indices demonstrate that the values are within acceptable level such as CMIN/DF 1.440, RMSEA 0.041, CFI 0.974, TLI 0.971, PCFI 0.875 (except p -value 0.000). Similar to the measurement model, p -value is significant due to the higher degree of freedom 248. So, Bollen-Stine bootstrapping has been performed using 500 samples to assess p -value again. After bootstrapping p -value becomes 0.103 which is greater than the cut of value 0.05. Therefore, it can be concluded that the model is accepted. The result of the structural model indicates that H1 to H6 are statistically significant with the co-efficient 0.39, 0.48, 0.38, 0.19, 0.50 and -0.197 respectively at a significance level $p < 0.05$. The result of hypothesized relationships with paths co-efficient is presented in Figure 2.

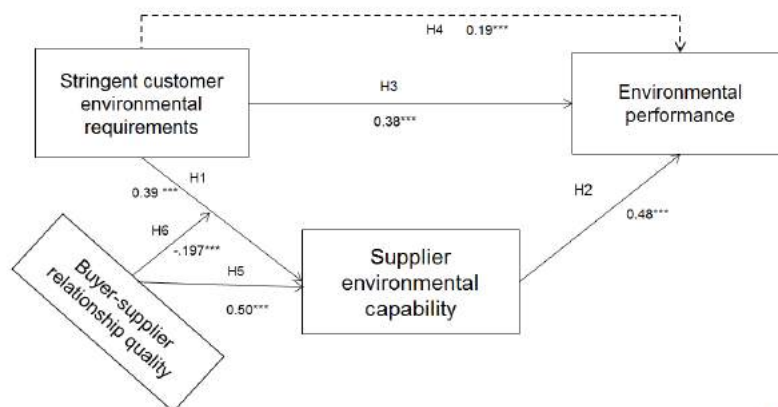


Figure 2: Result from structural model analysis

We further evaluate the moderating effect of buyer supplier relationship quality on the relationship between stringent customer environmental requirements and supplier environmental capability graph which is shown in Figure 3. Based on the figure, there was a positive relationship between stringent customer environmental requirements and suppliers environmental capability. However, the rate of change was greater for the low buyer-supplier relationship quality group compare to the high buyer-supplier relationship quality group. In other words, high buyer-supplier relationship quality provides a less profound effect on the relationship between stringent customer environmental requirements and suppliers environmental capability. Therefore, buyer-supplier

relationship quality is found to moderate the relationship between stringent customer environmental requirements and suppliers environmental capability.

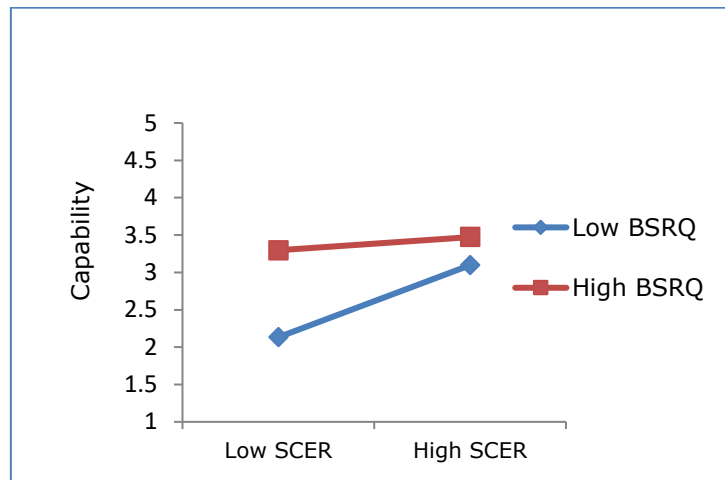


Figure 3: Moderating effect buyer-supplier relationship quality

DISCUSSION AND THEORETICAL IMPLICATION

The result from statistical analysis support the assumption that if the environmental requirements become more stringent it is more likely that supplier firms will put more effort to develop their environmental capability in response to the requirements. This is because firm's internal capability is a mechanism through which they achieve their performance requirements (Simpson et.al, 2012) and meeting performance requirements from customer is the key to sustain in business. As the environmental requirements from buyers change frequently, suppliers need to adjust their capabilities in response to those changes. Suppliers may need to hire expertise from overseas, require special training to incorporate contemporary environmental requirements, need to modify their process and system, and in some instances need to implement a new system. Therefore, it can be said that suppliers will develop their environmental capability to improve their environmental performance in accordance with the requirements from their buyers. This finding also matches with the evidence of recent increase in developing environmental capabilities of the companies in Bangladesh ready-made garment industry. To date, there are 54 companies in Bangladesh took the certification of LEED (leadership in energy and environmental design) and many of them are in process of acquiring it. Considering the context where local environmental regulation is less strict, the most prominent reason would be to satisfy the environmental requirements of customers around the world.

Further analysis revealed that there is a positive direct impact of stringent environmental requirements on supplier environmental performance. Moreover, it also has an indirect impact on environmental performance through environmental capability development. Both of these two relationship paths are statistically significant. Therefore, it can be concluded that, supplier environmental capability partially mediates the relationship between stringent customer environmental requirements and environmental performance.

In this research we have hypothesized that buyer-supplier relationship quality will have a positive impact on supplier's capability development. This is also supported by the result found in statistical analysis.. It can be explained as; if the buyer and supplier have high quality relationship it will motivate suppliers firms to develop their environmental capability. For example, providing experts from buyer end to understand the difficulties of new environmental requirements, help supplier firms to implement the changes in their system, monitoring their progress regularly, the supplier may think that the

relationship will continue for long so that they will get consistent sales order, these all will impact the actions of suppliers towards developing their capability.

The interaction effect shown in Figure 2 indicates that when the relationship quality between buyers and suppliers is high, the strength of relationship between stringent environmental requirements and capability is actually diminishes. We assume this might be because of the nature of moderator variable here. Buyer supplier relationship quality is a quasi-moderator in our model which has direct impact on supplier environmental capability development (which is supported: H1) and also influences the relationship between buyer stringent environmental requirements and supplier environmental capability. When the relationship quality is high, supplier's main motivation or driving force for environmental capability development is the relationship because it might increase their chance to get more order in future, buyers also share the responsibility rather than focusing on how stringent the requirement is. Still, the stringent environmental requirements will impact supplier's capability however the strength will be less as the relationship plays a positive role in capability development too. Similar to our findings that joint effort on environmental activities will help suppliers to develop capabilities which eventually positively impact their environmental performance, Gimenez and Sierra (2013) also found that supplier assessment and collaboration has a significant impact on environmental performance. The result also demonstrates that supplier environmental capability positively impact firm's environmental performance. This is supported by the previous studies such as Vachon and Klassen (2008) found a positive relation between environmental collaboration of training, joint efforts, with environmental performance of reduction in wastes and air emissions.

CONCLUSION

The objective of this research is to explore and understand the concept of stringent customer environmental requirements in the context of sustainable supply chain. It has investigated the critical factors around this concept and analysed quantitatively how they are related to each other by developing a framework. Result indicates that stringent customer environmental requirements positively impact the environmental performance of supplier firms both directly and indirectly through environmental capability development. It can also be seen from result that buyer-supplier relationship quality significantly influences the relation between stringent environmental requirements and environmental capability development.

A unique theoretical framework from this research (that describes relation between stringent customer environmental requirements and environmental performance) may facilitate better understanding of the dynamics of environmental requirements from customers and its impact on supplier environmental performance. It also demonstrates the applicability of TCE theory in a new situation. In reality, factory managers may get valuable insight about dealing with unpredictable changes in environmental demands from their customers. It also may help buyer and supplier firms to work out their inter-firm relationship (transactional/ relational) among them.

Environmental regulations are different in different countries and industries, so data may not reflect all the possible variations in environmental requirements. We consider the theoretical framework will still be valid in other situations however need to be tested other places for generalisation.

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Session 12: Supply Chain Skills, Training and Education

AN ASSESSMENT OF THE SKILL GAP OF THE LOGISTICS PROFESSIONALS – A CASE OF BANGLADESH

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ABSTRACT

Aim/Purpose:

The objective of this study is to identify the relevant skills and their relative importance that logistics professionals in Bangladesh required and to investigate areas for further improvement.

Design/methodology/approach:

A total of fifty skill items were identified through extensive literature review. Using a survey questionnaire, data were collected from fifty one managers who participated at the day-long industry round table against fifty skill items. Using expert opinions these skill items were grouped to create two higher-level logistics skill categories: a soft skill category and a hard skill category. Then, an importance-competence matrix analysis was conducted on these higher-level skill categories to assess the strengths and weaknesses of these skills.

Findings:

The analysis revealed that in order to prepare logistics professionals to face future challenges, they need to further develop their competency in skills such as demand forecasting, inventory management, customer service, people skill, understanding of the supply chain orientation, and ability to manage risk.

Originality/Value:

To the best of our knowledge this is the first attempt to assess the skill gap in the context of logistics professionals in Bangladesh. The proposed recommendations could provide guidelines for the academic and training institutions to develop more targeted programs for efficient and effective delivery of logistics services.

Research limitations/Implications:

This study is based on a relatively small sample size and, hence, the results should be considered exploratory. Future research should consider a large sample size.

Practical implications:

From the practical perspective, the results could be used by firms as a guideline for recruiting right professionals and areas for further skill development in Bangladesh.

Keywords:

Logistics skills, Importance-competence matrix, Logistics professionals, Bangladesh

1. INTRODUCTION

Today's supply chains are highly multifaceted with characteristics such as product and process complexity, heterogeneity, and uncertainty. As a result, there is a greater need for appropriate skills to manage supply chain systems efficiently and effectively. Van Hoek et al. (2002) argued that selecting the right people for pivotal supply chain responsibilities is essential to realize supply chain objectives. Carter and Carter (2007) emphasized that success in supply management will depend on whether organizations "can attract, develop, and retain individuals with the right

skills and capabilities to excel in the future" (p. 40). They must be multi-talented across a range of management and people skills as well as possess in-depth supply chain knowledge and capabilities (Mangan and Christopher, 2005; Murphy and Poist, 2007; Rahman and Yang, 2012). Therefore, successful logistics and supply chain professionals must have the expertise to manage logistics functions as well as to manage and lead people in complex business environments (Tate et al., 2010). The objective of this study is to identify the skills required by logistics/supply chain professionals in Bangladesh and suggest the key skill areas that require improvement.

The rest of the paper is organized as follows. Section 2 presents a brief review of previous relevant literature and identifies a list of key skills in logistics and supply chain management. Section 3 discusses the research methodology and section 4 presents the results of the survey. Sections 5 and 6 provide the results of the analysis and discussion of the results, respectively. Conclusions are drawn in the section 7 of the paper.

2. LITERATURE REVIEW

Since supply chain management is the management of upstream and downstream relationships with customers and suppliers logistics professionals require a broad knowledge and know-how to manage interrelated functions of logistics and supply chain systems. Recognizing managers as the critical dimension in supply chain management van Hoek et al. (2002) argued that selecting the right people for pivotal supply chain responsibilities is essential to realize supply chain objectives. This was also echoed in other studies. For example, Russell and Hoag (2004) suggested that senior management must adopt specific strategies to develop overall supply chain competency, namely, adopting a holistic approach, managing perceptions, building and maintaining strong networks, balancing centralized management with local input, and building leadership at all levels.

To ascertain skills required by the senior logistics executives Murphy and Poist (1991) conducted a survey using three sets of skill: business skills, logistics skills, and management skills. Myers et al. (2004) found that various skills such as decision making and problem solving appear to be good predictors of employee performance in supply chain management. A study by Mangan and Christopher (2005) suggested a general agreement that leadership and interpersonal skills were critical for developing progressive supply chain managers. In a study Kovacs and Tatham (2010) investigated the impact of logistics skills on performance in a humanitarian logistics context and found that generally functional logistics skill category were less relevant for logistics performance than problem-solving and interpersonal skill categories. Executives with experience and knowledge to operate in a global context will bring to their organizations a broader understanding of how to work in different cultural settings (Carter and Carter, 2007).

From the literature review, it is evident that a wide range of skills is required for logistics professionals and may fall into two broad categories: technical skills and generalist management skills. It is essential to find an appropriate blend of technical and management skills for logistics professionals (Myers et al., 2004; Shub and Stonebraker, 2009).

3. RESEARCH METHODOLOGY

3.1 Skill Selection and Categorization

Through extensive literature review we identified a total of sixty-four logistics and supply chain skills. These skills were thoroughly scrutinized to exclude from the list the aspects of management that are recognized as strategies rather than skills in supply chain management. This resulted in the deletion of fourteen skill items and rewording of four items. A total of fifty skills were considered for this study. We then grouped these skills into two skill categories of soft and hard skills. A total of

twenty skill items were chosen in the soft skill category and 30 skills were chosen for the hard skill category.

3.2. Sample and questionnaire

To investigate the logistics and supply chain skills required by the logistics professionals an industry round table was organized by the Faculty of Business, North South University under the title: Supply Chain Skills and Competency – An Industry Round Table. The day-long Round Table was organized in Dhaka in October 2017 where 51 managers participated. A two-part questionnaire was employed for data collection. Part one contained general questions about the company and respondents' background, whereas part two contained questions designed to capture respondents' opinions on importance and competency of the fifty skill items. The respondents were asked to rate the importance and expertise of items on a scale from 0 (none) to 7 (very high). In this study, the word *importance* refers to how important the skills are to perform logistics and supply chain functions efficiently as perceived by the respondents, whereas *competence* refers to how competent they are in these skills.

3.3. Importance-Competence Matrix Analysis

One of the more widely known gap-based methods is the importance-performance matrix analysis proposed by Martilla and James (1977). It is relatively simple to use, easy to understand and interpret, and a highly flexible technique (Skok et al., 2001). In recent times the method in various forms has been applied widely in service operations (Lai and To, 2010; Pezeshki et al., 2009; Rahman and Nie, 2011). We adapted this method in the form of an importance-competence matrix analysis. In this study *importance* means level of importance assigned to each skill by the responding logistics professional, whereas *competence* means level of expertise the respondent believes to possess in these skills. The analysis uses a 2 X 2 format. The horizontal axis represents the perceived importance of the attributes from low to high and the vertical axis represents the perceived competence of the attributes from low to high. Thus, it generates four quadrants such as low priority, free up, keep up, and high priority. The interpretation of the quadrants is given in Table 1.

Quadrant	Levels of importance and competence	Interpretation
Low priority	Low-low	Both importance and competence levels of the measures are perceived to be low. This suggests that the skills which fall into this quadrant should get low priority for improvement.
Free up	Low-high	Importance level is perceived to be relatively low, however, competency level is perceived to be relatively high. This suggests that resources need to be freed up and allocated at the right areas.
High priority	High-low	Importance levels of the measures are perceived to be high, whereas, competency measures are perceived to be relatively low. This means that management must concentrate their attention on these measures.
Keep up	High-high	Both importance and competence measures are perceived to be high. This suggests that the organisation must keep up the good work.

Table 1: Interpretation of the four quadrants of the Important-Competence Matrix

4. RESULTS OF THE STUDY

4.1. Demographic Profile

Of the managers who participated in the study, 21% were senior logistics managers, 16% were logistics managers, 14% logistics executives and 6% were head of logistics. The average work experience of the respondents in the area of logistics was over six years. A summary of the demographic profile of the respondents and responding firms is shown in Figure 1, Figure 2 and Table 2.

Among the respondents, approximately 70% of the firms were in operations for more than fifteen years. A large proportion of the firms (62.8%) had more than 200 employees. Approximately 9% of the firms had fewer than 50 employees. This shows that a vast majority of the firms who participated in this study are relative large firms.

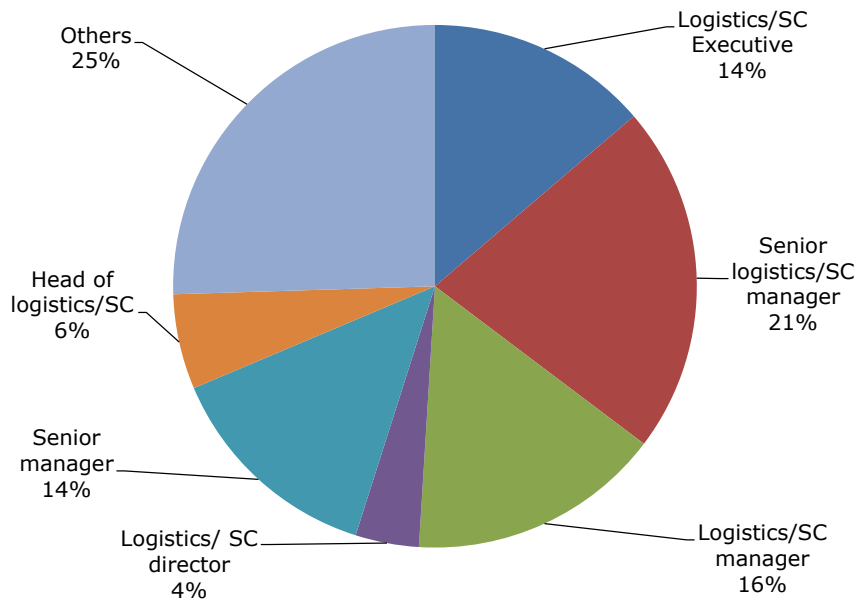


Figure 1: Respondents titles within their organisations

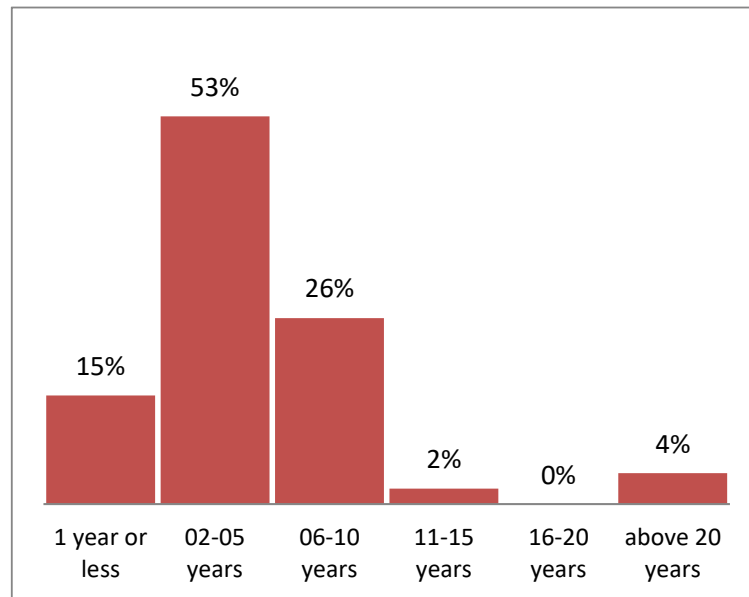


Figure 2: Years the responding firms are in operations

Approximately 57% of the firms belonged to the local private category and 37.3% belonged to the multinational firm category. Only about 6% of firms belonged to the government ownership category.

Employee	Number	Per cent
	1 _50	9.8
	51-100	15.7
	101-200	11.8
	201-500	31.4
	> 500	31.4
Operating years	Year	Per cent
	< 3	8.7
	3-5 years	4.3
	6-10 years	8.7
	11-15 years	8.7
	16-20 years	17.4
	21-30 years	8.7
	> 30 years	43.5
Organisation type	Type	Per cent
	Govt owned	5.9
	Local private	56.9
	Multinational	37.3

Table 2: Sample profile

4.2. Ten Most Important Skills and Level of Competency

The most important ten skills are inventory management, knowledge of the industry, negotiating skill, ability to see the 'Big Picture', information system management, demand forecasting, customer service, database management, understanding of supply chain orientation, quality management and supply chain

cost management. The ratings are generally high varying between 6.32 (supply chain cost management) and 6.59 (inventory management). It is also clear that the respondents rated highly soft skills, such as negotiating skill, the ability to see the big picture, and customer service, and hard skills, such as inventory management, demand forecasting, and supply chain cost management. Figure 2 shows the top ten skills including the competency level. Figure 2 also shows that the level of competence in the top ten skills is lower, varying between 5.50 (inventory management) and knowledge of the industry (6.16). The gap in level of competence versus importance is particularly critical for the skills of inventory management, and customer service. These results are shown in Figure 3.

4.3. Ten Least Important Skills and the Level of Competency

Figure 4 shows the ten least important skills as perceived by the respondents. Some of these skills are benchmarking ability, knowledge of cultural difference, reverse supply chain, corporate social responsibility, quantitative modeling skill. The importance ratings vary between 4.94 (24-hour manifest rules) and 5.47 (benchmarking ability). The competence ratings for these skills vary between 4.50 (CTPAT) and 5.25 (knowledge of the cultural difference). It is worth noting that three out of the ten least important skills are related to the environmental issues of logistics and supply chain management.

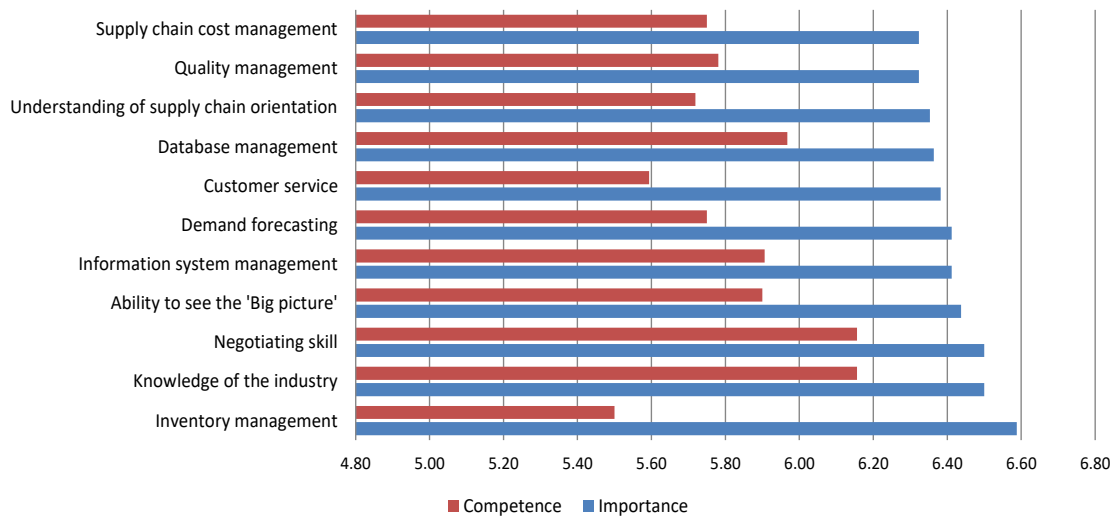


Figure 3: Ten most important skills and corresponding competence ratings

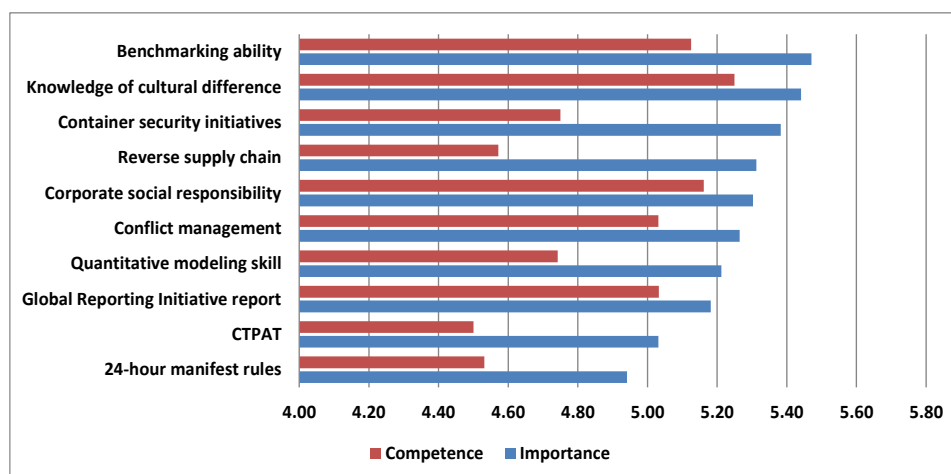


Figure 4: Ten least important skills and corresponding competence ratings

5. IMPORTANCE-COMPETENCE MATRIX ANALYSIS RESULTS

We categorized fifty skills into two categories - hard and soft skill. We then analysed both categories of skills using matrix analysis. There are twenty skills in the soft skill category and thirty skills in the soft skill category. The overall mean ratings of importance are higher compared to competence ratings for both soft skill and hard skill categories and the differences are found to be statistically significant.

5.1. Assessment of the Soft Skill Category

By using a measure of central tendency (i.e., mean), the skill importance and competence scores are ordered and classified into high or low categories; then by pairing these two sets of scores, each skill is placed into one of the four quadrants of the matrix. Mean importance and competence scores are used as coordinates for plotting individual skills on the 2 X 2 matrix as shown in Figure 5. The analysis indicates that seven skills within the soft skill category fell into the 'keep up' quadrant; eight skills fell into the competence in 'low priority' quadrant; and five skills fell into 'high priority' skill quadrant (LGM2 – customer service, LGM4 – understanding of supply chain orientation, LGM12 – ability to see 'Big picture', LGM17 – people skill, and LIS1 – knowledge of the latest technology (Figure 5).

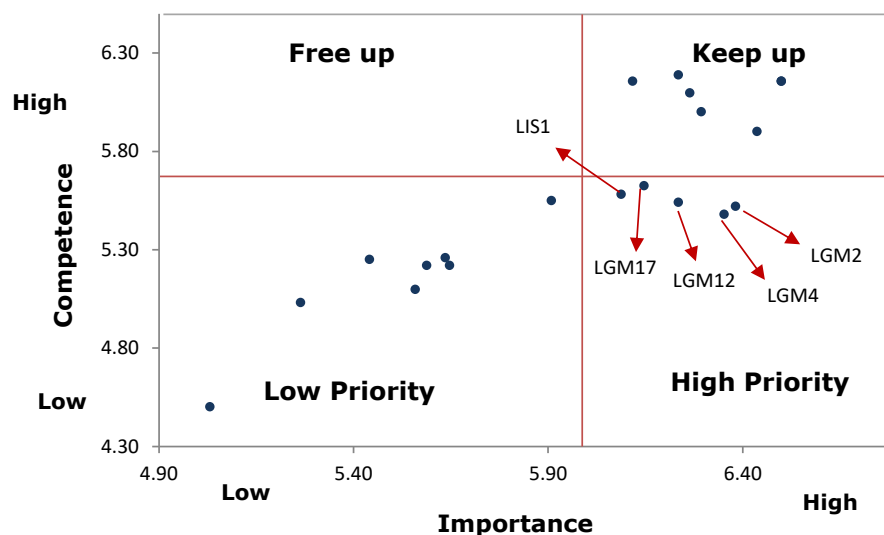


Figure 5: Importance-competence matrix for the soft skill category

5.2. Assessment of the Hard Skill Category

Similar to the soft skill category, the mean importance score of all the skills within the hard skill category is above the midpoint of 3.5 on the 7-point scale. Respondents perceive that the level of their current competence in a hard skill category is below the importance levels in all the skills. The difference between the means of importance and expertise is significant for all skills ($p < 0.05$). The matrix for the hard skill category was designed and the individual skills were plotted into one of the four quadrants of the importance-competence matrix. The analysis shows that ten skills fell into the 'keep up' quadrant; two skills (LA10 – warehousing management; LA17 – material handling) fell into the 'free up' quadrant; fourteen skills fell into the 'low priority' quadrant and four skills (LA7 – ability to manage risk, LA8 – distribution planning, LA9 – demand forecasting, and LS8 – waste management) belonged to the high priority quadrant (Figure 5).

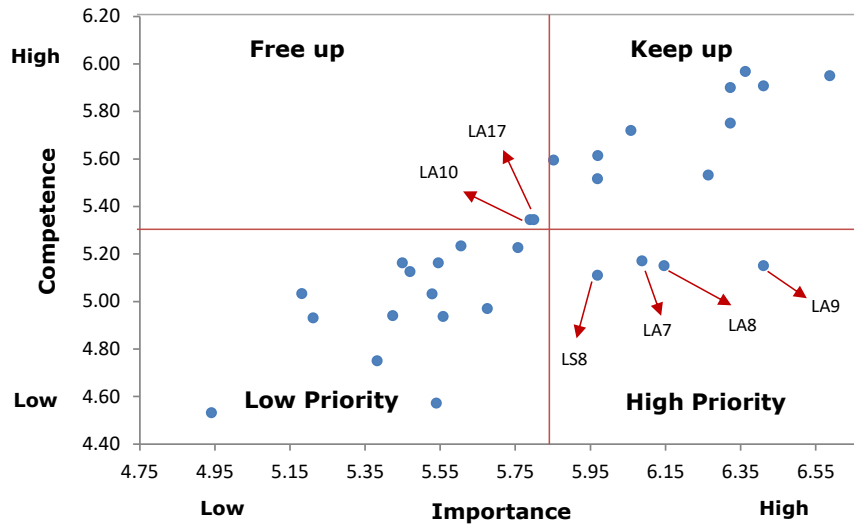


Figure 6: Importance-competence matrix for the hard skill category

6. DISCUSSION

This study provides an assessment of skills required by logistics professionals in Bangladesh. The results indicate that all individual skills are highly rated with regards to importance of these skills in the workplace. However, the level of current competence of all logistics professionals who participated in the study is lower than the importance they assigned to these skill items. The gap between importance and competence of a specific skill indicates its strength or weakness. The top five largest gaps identified are for skills of inventory management, demand forecasting, supply chain cost management (hard skill category) and customer service, understanding of supply chain orientation (soft skill category). This suggests that both categories of skills need improvement. A total of nine (five soft skills and four hard skills; out of fifty skills) fell in the 'high priority' quadrant. It is critical that the management concentrate on these skills for further improvement.

Given the fact that environmental issues are less emphasized in the current business systems in Bangladesh, it is not surprising to see majority of environmentally related skills falling into the 'low priority' quadrant. However, environmental issues are becoming challenging areas for companies because the environmental-related laws and legislation are gradually being enforced by the buyers to be responsible for their wastes.

7. CONCLUSION

This study aimed to identify the critical skills required by successful logistics professionals in Bangladesh. A literature search identified a set of skills that were grouped into two broad categories of hard and soft skills. An importance-competence analysis was then conducted to assess the strengths and weaknesses of skills as perceived by the Bangladeshi logistics professionals. This study revealed that the logistics professionals in Bangladesh are required to develop further their expertise in skills such as inventory management, demand forecasting, customer service, understanding of supply chain orientation, ability to prioritise, people skills in order to prepare to face future challenges. However, because not all skill areas are critical for all levels of professionals, training in specific areas must be targeted to the specific level of logistics professional. This study is based on a relatively small sample size and, hence, the results should be considered exploratory. Future research should consider a large sample size.

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A NOVEL APPROACH FOR SAFETY AND PRODUCTIVITY ON HUMAN MACHINE COOPERATION

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Abstract

In view of this, this study proposes a man-machine Internet approach to instantaneously capture human and machine signals at work and to design a safety and productivity assessment mechanism that meets each process through deep learning big data analysis. Surrogate-assisted mechanisms that blend into real-time operations without any sense of danger prevent all potential safety hazards from occurring and monitor production performance immediately.

The effectiveness of the proposed method is evaluated by an actual safety ensurance mechanism for a shaping operation of hydraulic machine in precision casting production process. The approach can monitor the state of operators' attention instantly and disconnect the power when workers are unable to meet the standard operation requirement. In addition, through the real-time human-machine action signal acquisition and big data analysis, the proposed method can evaluate the production efficiency and production quantity accurately.

Keywords: Safety, Productivity, IoT, Big Data, Deep Learning and Surrogate-Assist

1. Introduction

Facing advent of Industry 4.0 era, enterprises must improve product efficiency, cost and quality to maintain competitiveness. Among them, a small number of different orders need a variety of tools and methods and in order to take into account flexibility and cost-effective coordination of human operations gradually increased demand, operational safety requirements have become harsh. Work safety research is quite general, and can be divided into machine design [1], training and management. From the viewpoint of machine design, using the special machine or jig is the highest efficiency and safest but most expensive. Therefore, it is difficult to apply to a small number of different or short delivery process.

From the viewpoint of training, Wu [3] studied on using training to improve quality, safety and efficiency. Experienced a complete and continuous training, staffs can meet the job requirements

safely, but the cost of training materials, teachers, and time is increased inevitably. Especially, considering the memory and habits of staffs, it is also difficult to cope with a small number of urgent orders at the same time. Finally, from the viewpoint of management, Zhang [2] showed that management should meet the requirements of safety, efficiency and quality. However, management requires additional inspection, inspection, auditing, counseling and management and the effectiveness varies from person to person.

The way of survival of the traditional industry is to meet customer needs flexibly, rapidly, efficiently under cost considerations. Therefore, man-machine collaboration is often used, and the work safety problem has become a major issue in manufacturing. Government departments have specified machine operation safety standards and the enterprises themselves have relevant operating rules, but still can not finish the accident prevention.

The reason is due to frequent product changes, staff turnover and urgent delivery. Special jigs or automatic folder fixtures are high cost and take a long period before production. The working type is not suitable for use in pressing and diversified modes of production. Consequentially, human intervention is an inevitable trend [1]. On the other hand, the professional skills of operators can enhance the flexibility, quality and effectiveness of production. Therefore, various staff training, on-site management and auditing systems are often used by enterprises. However, in the age of Global Village, many people with different languages, cultures and educational backgrounds in the same jobsite work simultaneously, raising the cost of education and the difficulty of management greatly.

In view of this, this paper proposes a novel approach for safety and productivity on human machine practical cooperation by combination of management, ICT and AI technology. An experiment is conducted in a small amount of a variety or short or urgent short deliver time order casting precision casting process. The experiment results proved the validity of the proposed method. Further, the content of this paper consisted of the first chapter introduction, the second chapter literature review, the third chapter problem description, the fourth chapter proposal method, the fifth chapter experiment design and conduct, and the last chapter results and discussions.

2. Intelligent Mechanical Safety

Intelligent mechanical safety has become an international trend. In recent years, Taiwan's machine tools companies have moved towards the trillion-dollar industry, mainly for export sales [1]. Therefore, they must comply with the requirements of international safety norms, especially the safety supervision and management of mechanical products in the European Common Market. The most stringent, standard-setting organizations based on the current technological development proposed an updated security design. The original circuit architecture requirements to join the concept of reliability, mechanical intrinsically safe. Mechanical safety control system in the future will be based on the functional safety level and reliability-based.

The topic has attracted international heated discussion due to the European CE mark for the implementation of the harmonization of mechanical safety standards [2] and the international ISO 9000 and ISO 14000 series of international standards of certification, together with the British

Standards Organization in 1996 to complete the BS 8800 (Safety and Health Management System Pointer) standards. Quality, environmental protection must be combined with safety and health and become a complete standard system indispensably. According to statistical data on labor disability accidents over the years, workers have suffered from "crippled, crushed and wound" handicapped cases [3], which are mostly caused by power punching machines. Due to the various dangers of punching machinery, safety protection, safety of equipment, safety protection, control circuit and safety warning information can be used to protect workers' safety.

There are basically three ways in which countries can respond to accidents related to machinery. The first classification (applicable to all European countries): Machinery manufacturers have relevant legal responsibilities, and require that machinery circulated in the market must have a safe design, if the violation of this law has a considerable degree of penalties for manufacturers. The second classification (applicable to the United States): Machinery manufacturers do not have related legal responsibilities, but the accident will be strictly recognized under the Manufacturers Liability Act (PL Law), so there will be a considerable degree of safety design before manufacturing. The third category (Japan): There is no legal liability for machinery manufacturers, there are quite a few cases applicable to the PL method, so mechanical manufacturers do not design the so-called safety design. In the event of an accident, although the manufacturer will be held accountable for the accident. It is actually regarded as a considerable number of accidents caused by the improper operation of the victim. As a result, the legal manufacturer is not responsible for the crime and the victim is the victim of the state labor disaster insurance to compensate [4].

3. Problem Description

This chapter describes the problems faced by the man-machine coordination of the plastic manufacturing process. In a small number of different production modes, the number of early products made by case study enterprises is up to thousands. The size of the orders varies from several thousands to tens per month. Therefore, the problems facing the shaping process are more diverse and random. With the addition of multi-national workers, the design, education, training and management of the shaping operation become very complicated.

Traditional raster grating switch or two-hand button switch method can not meet the operational requirements. For example, the operations of sculpture, pottery and other manual works need to manually adjust the workpiece angle and position, the operator's hand will inevitably enter the work area shown in Fig. 1 and 2. Further, the design requirements and operation constraints are listed in Table I.



Fig. 1 The hydraulic shaping machine



Fig. 2 The operation of hydraulic shaping machine.

TABLE I. DESIGN REQUIREMENTS AND OPERATION CONSTRAINTS

Design Requirements	Operation constraints
(1) Quality requirements. (2) Speed requirements. (3) Safety requirements. (4) Workability requirements. (5) Diversity requirements. (6) Analyze job status through big data.	(1) The safety system should not affect the original operations. (2) Stopping operations when there are safety concerns. (3) The safety system should not affect the operation before its failure repaired. (4) Power supply and network connection is needed.

4. System Infrastructure

This study identifies the key factors that affect work safety by studying machine movements and observing the operator's work patterns. Reusing ICT technology, we design a mechanism that ensures safety without affecting working efficiency. The infrastructure showed in Fig. 3 is to develop the monitoring system of production effectiveness and safety. The structure consists of machines (hydraulic shaping machine), on-off type proximity switches, signal process box, computer processing and cloud storage. The proximity switches installed in hydraulic shaping machines are utilized to obtain the times of shaping process. Then, the times of shaping process are transferred to computer processing by a signal process box. In addition, more information are obtained by scanning the barcode in every production order. Eventually, whole information are delivered to cloud storages and integrated into the monitoring system.

The unsorted raw data gained from proximity switches and barcode include with employee information, machine producing information, order number and so on. It is essential to extract the valuable information from the raw data stored in the monitoring system, which is shown in Fig. 4. To deal with the data extracting, this study firstly proposed an approach to calculate the production of shaping machine by treating the sensing data from proximity switches. Process and safety design of shaping machine were the major task of this study. Figure 5 presents the operating process of the shaping machine, and Fig. 6 shows the shaping process for users. To ensure the safety for users, the safety strategy is designed as Fig. 7. Further, the electrical signal of safety strategy is illustrated in Fig. 8, and Fig. 9 shows the practical implementation.

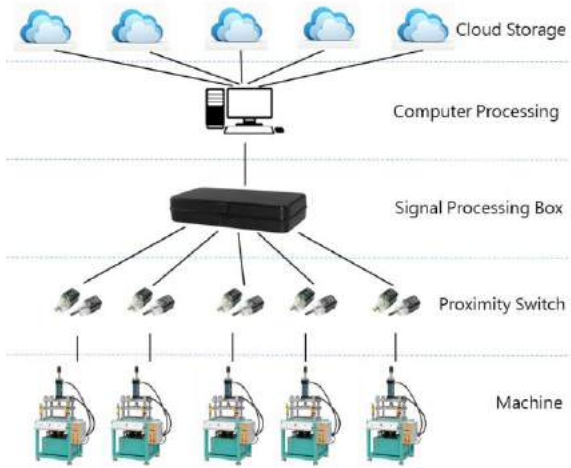


Fig. 3 Infrastructure of the monitoring system.

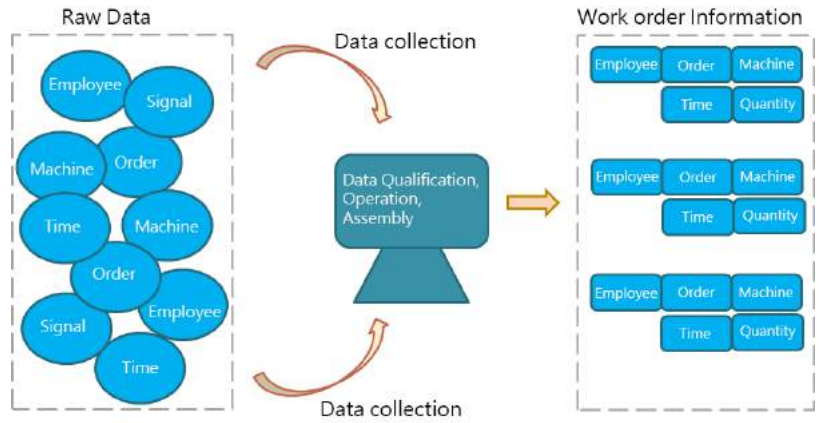


Fig. 4. Extracting the valuable information from raw data.

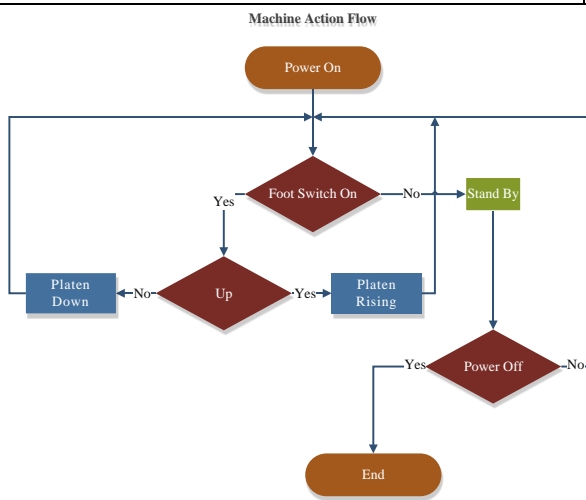


Fig. 5. Operating process of shaping machine

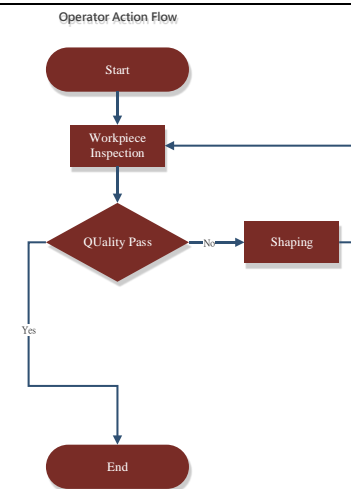


Fig. 6. Operating process of shaping machine user

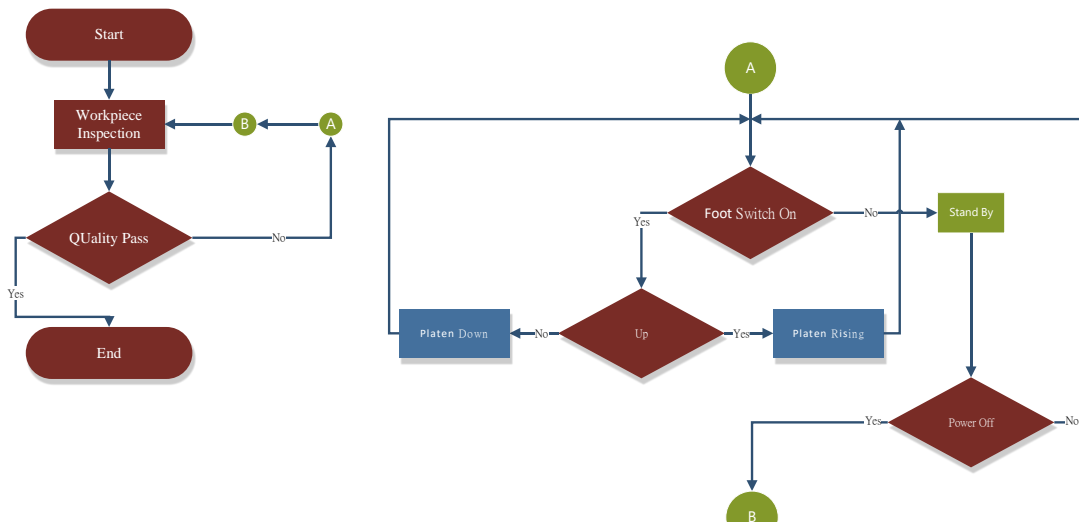


Fig. 7 Safety design

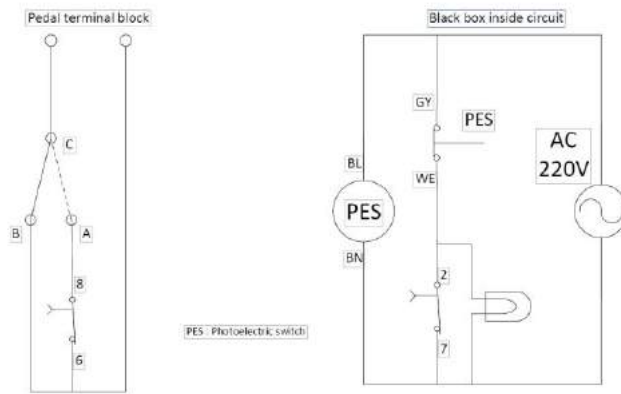


Fig. 8 Electrical diagram of safety strategy design implementation



Fig. 9 Practical implementation

5. Experimental Design and Implementation

Delivering products to customers on time is an important issue in manufacturing industries. In other words, a well production scheduling is essential. In the previous study, intelligent genetic algorithms (GA) had been effectively certified for optimizing production schedule [5]. Therefore, the production scheduling designed by GA has been applied for the shaping injection process in this study.

Assume that there are five workpieces which should be manufactured by five processes with the different sequence, such as Table II. Generate a one dimension array, this array contains each work piece's process, e.g. [1, 1, 1, 1, 1, 2, 2, 2, 2, 2, 3, 3, 3, 3, 3, 4, 4, 4, 4, 4, 5, 5, 5, 5, 5], the third element in array is the process 3 of the work piece 1, the sixth element in array is the process 1 of the work piece 2 and so on. Shuffle the array we can obtain an array, e.g. [1, 4, 3, 4, 4, 5, 5, 1, 1, 2, 2, 3, 2, 4, 3, 2, 2, 1, 5, 4, 3, 1, 3, 5], this array is the initial chromosome. Figure 12 shows the one-point crossover. Choosing a cut point and split into two parts randomly. The left part is preserved and the right part exchange the all genes. In this case, this method cause the genes to lost the information, the total quantity of genes in each chromosome is different, such as Fig. 13.

TABLE II. WORK PIECE & PROCESS

Process's Machine	Process1	Process2	Process3	Process4	Process5
Work Piece 1	3	1	2	4	5
Work Piece 2	2	4	5	1	3
Work Piece 3	1	3	5	4	2
Work Piece 4	4	2	1	3	5
Work Piece 5	2	5	4	1	3

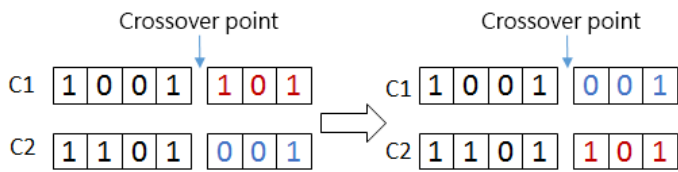


Fig. 10. One-point crossover demo.

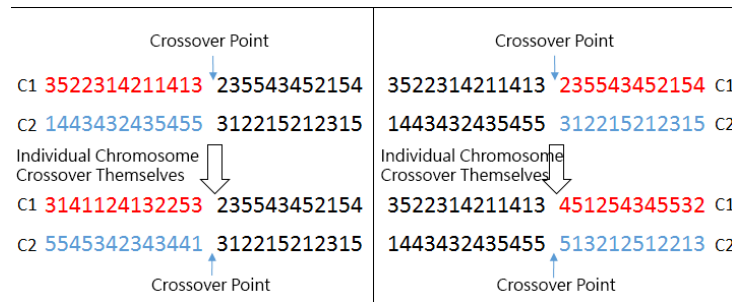


Fig. 11. One-point crossover example

Partition Crossover shown in Fig. 14 can be randomly chose two chromosomes and divide into two group. The first gene of Parent A compare with Group U1, The first gene of Parent B compares with Group U2 ... and so on. **Error! Reference source not found.**4 shows Parent A's first gene "3" is equal to Group U1, this gene put into the new chromosome (New C), Parent B's first gene "2" is equal to Group U2, this gene put into the new chromosome... and so on. The Parent B's second gene "1" is not equal to Group U2, and this gene don't put into the new chromosome. Also the Parent A's third gene "2" is not equal to Group U1, this gene don't put in to the new chromosome.

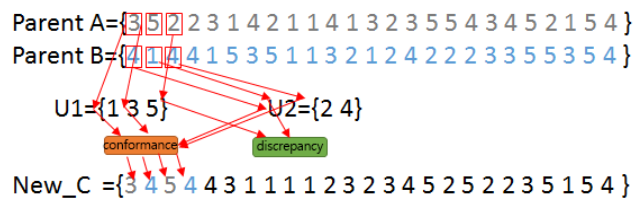


Fig. 12 Partition Crossover example

Mutation is necessary process in Partition Crossover, which avoiding chromosome becomes the same one, this method can help develop the new search space. Each one gene in chromosome assign a randomly generate number from 0 ~ 1 . If the number is less than mutation rate. Common GA problem is exchange gene state e.g. 0 to 1 or 1 to 0. Assign a random number to chromosome, if the number is less than mutation rate, randomly exchange two gene in chromosome. Elimination the better chromosome as parent of next according to their fitness values. The most favourable result will be displayed. This result is checked with the shaping machine to verify its reliability. Figure 15 and 16 show the process of implementation.

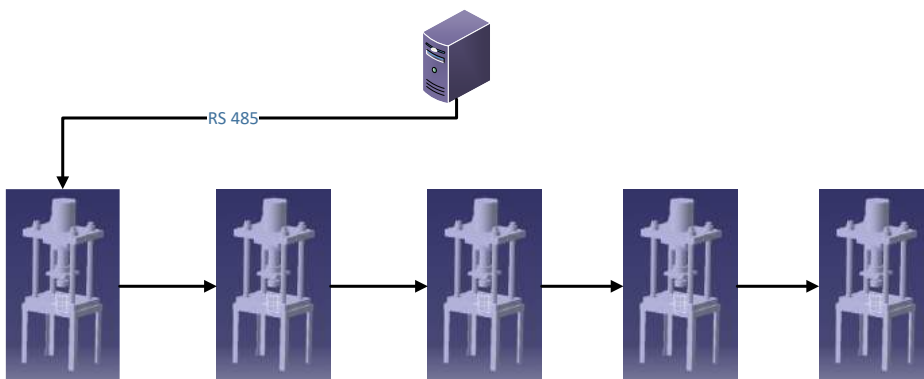


Fig. 13. Operation process.

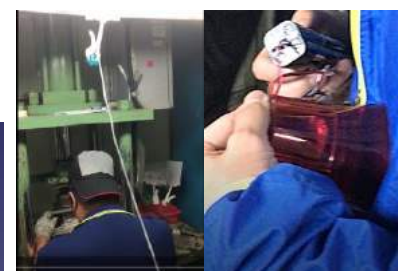


Fig. 14. Experimental Implementation

Implementation

6. Result and Discussion

In the past, the quality, environmental protection combined with safety and health to the shaping machine had been presented. Not only the software design, but also the electrical implementation is developed, in practically, the safety performance is increased for operator during shaping process. The information integrated into monitoring system should be conducted in the future work.

7. Acknowledgement

The authors gratefully acknowledge the support provided by Ministry of Science and Technology in Taiwan with 105-2221-E-327-030, 106-2221-E-327-012, 106-2221-E-327-005, 106-2221-E-037-001 and 106-2622-E-037-005-CC3, and by the "Intelligent Manufacturing Research Center" (iMRC) from the Featured Areas Research Center Program within the framework of the Higher Education Sprout Project by the Ministry of Education (MOE) in Taiwan.

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ATTRACTING THE BEST STUDENTS TO STUDY LOGISTICS AND SUPPLY CHAIN MANAGEMENT – THE GUARANTEED JOB APPROACH

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Abstract

Purpose:

Industrial practitioners in logistics and supply chain management across the globe often lament the quality of graduates choosing to enter their workplace. This paper will report on a recent initiative at a university in the United Kingdom where students commencing logistics and supply chain management undergraduate courses are guaranteed jobs upon graduation in order to attract better qualified students to work in the sector. Course design, delivery and the resultant graduate skill set will be analysed from the perspectives of both employer and graduate to identify whether the guaranteed job offer is having the right effect.

Design:

The study adopts a mixed methods approach incorporating both questionnaires and interviews with practitioners, students and graduates.

Findings:

Preliminary findings suggest that the lure of a guaranteed job is important in attracting students onto a logistics and supply chain management course and that these may override other considerations, such as what and where students study. Practitioners are keen to be involved in both curriculum and skills development and see this as a way of ensuring a pipeline of quality graduates who will progress to senior positions in industry within a shorter timeframe than their existing graduate pool. However, tensions exist between academic content, industrial relevance and perceived student need.

Value:

This work adds to the skills and competences literature in logistics and supply chain management through analysing the motivations of both students and practitioners when a guaranteed employment position is at stake.

Research and practical Impact:

This research will identify whether or not the job guarantee approach can be successful in attracting higher quality students into logistics and supply chain management programmes and hence add to the existing recruitment practices undertaken by companies in this field.

INTRODUCTION

There is little doubt that there are difficulties in attracting and retaining talented personnel in the logistics and supply chain sector. The World Bank (2017) study on logistics competencies, skills and training acknowledged that there is a short supply of qualified logistics-related labour across the world in both developing and developed countries. Industry-led bodies (e.g.:www.think-logistics.co.uk) and professional associations (e.g.:www.ciltuk.org.uk) in the United Kingdom also have been extremely active in the lobbying and promotion of the importance of the sector and the need to attract personnel at all occupational levels, from truck drivers to senior supply chain management positions (World Bank, 2017). This study reports on a relatively new initiative at a UK University to attract and educate the senior supply chain professionals of the future. The key feature of the course offering is that upon successful completion of the course, the graduate is guaranteed a graduate level job with one of the UK's leading third party logistics providers,

manufacturers or retailers. A survey of 86 current students on undergraduate courses in logistics and supply chain management (LSCM) was undertaken to ascertain the reasons why they took the course and whether or not this feature was the key to successful recruitment. The effect on entry grades of students was also investigated and comments from a small number of interviews undertaken with personnel working in the LSCM sector.

LITERATURE REVIEW

Student choice of course and University

The range of options open for a young person leaving full-time education in most developed countries is wide. The decision to attend university can be affected by both influencers and other motivational factors, the understanding of which plays a major role in the marketing and promotional activities of universities (Johnston, 2010). These factors range from the rational and predictable to illogical and disastrous with respect to the fit of the individual making that decision. Helmsley-Brown and Optlaka (2014) reviewed the literature on higher education choice and categorised according to the following thematic headings: Demographic and academic factors; Institution factors- *quality, outcomes and benefits, facilities and characteristics of institutions*; and Institutional and student characteristics' factors- *price and sensitivity, information and information sources, and travel and geographical factors*.

The weighting of these influencing factors will vary according to the determinants and motivations of the individual's reason and purpose of study. Both intrinsic and extrinsic motivations may be exhibited by applicants according to their basic psychological human innate needs of autonomy, competence and relatedness and reflected in the degree of self-determination in their decision making (Deci and Ryan, 1985). Johnston (2010), in a study of students attending a university in the USA concluded that the most important source of influential information regarding choice of university was parents and other family members and friends, but that a visit to the campus also strongly influenced the final decision to attend that university. Wong et al. (2017), in a study of the use of the online environment by potential university applicants in Hong Kong, identified four constructs of university information perceived by students to be important in their search behaviour, namely: university reputation; eligibility and affordability; teaching and learning; and university tangibility (location and campus facilities).

Universities' marketing activities and employability

In many higher education markets, both public and private universities are now operated as businesses. In certain countries, such as England, universities compete to become the institution of choice for both domestic and international applicants, their reputations being massaged or blighted by unofficial league tables (e.g. thecompleteuniversityguide.co.uk), albeit based on official statistics. These reputations may strongly influence the decision of where to apply to study, often overriding course-related intrinsic motivations, and affordability and graduate employment extrinsic motivations of the potential applicant. Branding is becoming increasingly important to universities (Joseph, 2012), although its relationship to reputation is a complex one (Temple, 2011).

Employability has become an important element of the make-up of many university courses reflected in graduate employment rates gathered in an annual survey (Destination of Leavers from Higher Education), which in itself is a constituent element of the unofficial league tables. DLHE information is displayed on the website entries of all undergraduate courses in the United Kingdom enabling a snapshot of graduate employability for prospective applicants. The view of graduate employers has been shown to value soft skills in preference to other employability factors (Finch et al., 2013) whilst the media is always keen to suggest that graduates are not being equipped with the appropriate skills' sets the employers demand. Simon Jenkins even suggested that universities are "extraordinarily conservative enclaves", and that students expect a "rate of return" on their investment (The Guardian, 23rd October 2013).

Naturally, such inflammatory comments have not been welcomed by institutions which have more of a research than vocational emphasis in their education provision. Boden and Nedeva (2010) approach this employability discourse by suggesting that it adversely affects pedagogies and curricula to the dis-benefit of stakeholders and society. Moreau and Leathwood (2006) suggested that there may be damaging consequences faced by “non-traditional” graduates through the discourse of employability, which tends to focus on individual responsibility and neglect of social inequalities. McCowan (2015) suggests that social institutions other than universities may be better equipped to promote employability.

The need for logistics and supply chain professionals and the response of Educational Institutions

The current shortfall in the number of appropriately qualified and skilled logistics and supply chain professionals globally is a growing concern. Cottrill (2010) (cited in Sinha et al., 2016) suggested that we are facing a supply chain talent crisis whilst Joyner (2012) identified a shortage of professional supply chain management talent in the USA. Addressing this need is a constant challenge for both industry and educators as they both look to widen the appeal of the sector to school leavers and university graduates. The World Bank (2017) study suggested that there are certain characteristics of a career in logistics which may work to attract more entrants, namely: “internationality, working in intercultural teams, stimulating working environments, mobility, key contribution to the economy and general welfare, and involvement in technological innovation” (p.19). However, it also suggested that the logistics sector has a poor image and should work more effectively to promote professional opportunities, especially to younger professionals.

LSCM higher education provision has attempted to respond to this challenge by creating a wide range of engaging and relevant courses at both undergraduate and postgraduate level. In some ways an entirely coherent and consistent approach to course development and marketing has been hindered by LSCM being located in a myriad of faculties - within business, engineering, applied sciences and social sciences faculties in the UK alone. Education providers are sometimes criticised for the content, delivery and scope of their LSCM offerings. Fawcett and Rutner (2014) suggest that there is a growing split between practitioners and academics as to what is relevant and call upon logistics and supply chain ‘thought leaders’ to come together to enhance education provision. Sinha et al. (2016) suggest a mismatch between industry supply chain management talent requirements and the knowledge and skills developed in business schools in the USA. Wong et al. (2014) identify an imbalance between the undergraduate curriculum and employer needs in a study of undergraduate LSCM courses in the United Kingdom. There are similar concerns in maritime courses with a need for greater industrial relevance (Pallis and Ng, 2011), a call for leader firms in port clusters to engage more with educational providers (De Langen, 2008), and in Hong Kong, maritime students considered that studies were too theoretical (Lau and Ng, 2015). Gekara et al. (2009) went so far as to suggest that attrition rates on maritime courses in the UK should be addressed by increased employer involvement.

Therefore the challenges to LSCM education providers and employers is to design and develop courses which truly reflect the knowledge and skills’ sets which the sector desires, whilst at the same time enthusing a new breed of entrants onto these courses through interesting, relevant and possibly enhanced offerings. The identification of these knowledge and skills’ sets is a complex and difficult task. Jordan and Bak (2016) identified skills’ gaps reported by academics, practitioners and graduates in relation to a supply chain management course at a UK university. Bazaras et al. (2013) identified a lack of personal and professional competences being developed in students on transport and logistics courses in the Baltic countries whilst Myers et al. (2004) emphasised the need to develop logistics managers’ human capital. Wong et al. (2014) highlighted that LSCM recruiters in the UK tend to prioritise professional skills and general management knowledge above specific LSCM subject knowledge. Lutz and Birou (2013) specify a need for problem analysis and tools after surveying logistics syllabi at 118 US and international providers. They also recommended greater focus to be placed on people skills.

Attracting the best students to choose LSCM courses as their preferred route through university is a tremendous challenge in many higher education markets. As previously discussed, the literature relating to student choice of higher education subject and institution and the factors associated with that choice indicate that it is a complex process (Hemsley-Brown and Optlaka, 2014). Applied and non-traditional subjects, not studied at high school, face many hurdles in galvanising interest among prospective students. For LSCM undergraduate courses, this is especially acute as the general public's understanding of the wealth and breadth of graduate opportunities is minimal and both logistics and supply chain are terms that are commonly misunderstood. The marketing and promotional efforts of university's central marketing units require support from LSCM educators to get the message across to both potential applicants and influencers. Gardner (2013) reports on a pilot study in the US which involved running two-week long workshops with middle and high school teachers and guidance counsellors to advise them of the opportunities in SCM and for them to adopt SCM practices in their teaching. Constantinidis and Zinck Stagno (2011) in a Netherlands study suggest that the potential of social media as a marketing tool has yet to be fully harnessed by higher education institutions.

DESCRIPTION OF THE PROBLEM

We are faced with a skills and talent deficit in the LSCM sector, partly fuelled by a lack of knowledge and understanding of the subjects themselves and ignorance of the wealth of opportunities which exist. There is also concern that many higher education courses are not equipping graduates with the knowledge and skills which the LSCM employers demand. Overcoming these challenges is not straight-forward and this paper reflects on a unique approach adopted at a UK university where the focus has been upon designing a course in line with industry advice and needs and providing a guaranteed job upon graduation. The key question being asked in this paper is "Has the guaranteed job approach resulted in an improvement in the quality of students applying to an undergraduate logistics and supply chain management course?"

DEVELOPING THE OFFERING

The initiative developed from discussions amongst like-minded logistics and supply chain directors of major UK-based manufacturers, retailers, third party logistics providers and recruitment professionals who were lamenting the relative paucity of supply chain managerial talent emerging in the sector. They engaged with a small number of university providers of LSCM undergraduate education to see if there was an appetite for the development of a bachelor degree level course which would be underpinned by a number of specific features, namely: salaried summer placements for students between Year One and Year Two, guaranteed salaried twelve month placement in Year Three, guaranteed graduate level job upon graduation, and mentoring by a LSCM manager throughout the course. The decision was made to entrust the University of Huddersfield to roll-out the programme as they had a history of strong graduate employment and industry engagement in LSCM. Novus (www.novus.org.uk) was born and the steering committee was entrusted with approaching companies in the LSCM sector to join the scheme and within a short period of time, more than twenty companies had signed up.

In the meantime, academic staff at the university engaged with industry contacts to design a four year degree course which provides a balance between academic rigour, industry relevance and development of the personal and transferable skills often lacking in undergraduate courses. Employability would be further developed through the offering of work placements. The course curriculum was then discussed with key logistics and human resource representatives of the member companies. After several iterations, it was decided that there was a need for a second course offering on which a student was able to further hone in on their managerial knowledge and skill development. The courses were then validated through the usual university validation process and added to the list of courses

available for applicants to apply to through the UK's Universities and Colleges Admissions Service (UCAS). The courses offered are BSc (Hons) Logistics and Supply Chain Management and BA (Hons) Business with Supply Chain Management (Table 1).

	BSc (Hons) Logistics and Supply Chain Management	BA (Hons) Business with Supply Chain Management
Year One	Business Skills Commercial Management Organisations & People Marketing & Innovation Economics Principles of Logistics	Professional Aspects of Business Markets & Marketing Responsible Business Enterprise Organisational Behaviour Principles of Logistics
Year Two	Human Resource Management Planning Techniques for Logistics & Transport Operations Purchasing & Supply Physical Logistics Management Manufacturing & Operations Mgt. Project & Quality Management	Human Resource Management Planning Techniques for Logistics & Transport Operations Purchasing & Supply Physical Logistics Management Management Research Methods & Decision Making
Year Three	PLACEMENT	PLACEMENT
Year Four	Strategic Supply Chain Mgt. Strategy & Leadership Retail & Manufacturing Logistics Supply Chain Systems & Modelling Industrial Project	Strategic Supply Chain Mgt. Management of Work & Society Retail & Manufacturing Logistics Managing Organisational Design & Change Industrial Project

Table 1: Course structures and module titles

COURSE PROMOTION AND APPLICANT SELECTION

Whilst the university had been successfully recruiting students onto LSCM undergraduate courses for three decades, this new venture was designed to attract a different and better qualified set of entrants that had not previously considered undertaking a LSCM qualification. Therefore, Novus companies each donated a small amount of money to a marketing budget to facilitate generation of a website, promotional literature and video material, and to participate in UCAS Fairs and other related exhibitions. The university engaged in additional schools and colleges activities including taster days and workshops.

The course entry educational requirements were set as slightly higher than other LSCM courses in the university and the application process was more rigorous. Upon receipt of an application, the university would decide, according to educational merit and supporting statements provided by the applicant, whether or not an applicant would be invited to attend an Assessment centre held at the university. The assessment was performed by Novus company representatives, often from human resources, and applicants were required to give a formal presentation on a supply chain topic, have a personal interview and undertake various desktop and group activities of the type often used at graduate assessment centres. If successful, the applicant would be offered a place on the course conditional upon satisfying the educational requirements. Once high school results become available in the summer, then the applicants place on the course is confirmed if they have acquired the required grades. They are now confident in the knowledge that if they perform well on the course (upper second class honours or above) and receive a good reference from their placement year company, then they have a guaranteed job with one of the Novus companies on the scheme at that time (see Figure 1 for Novus scheme companies in 2018).



Figure 1: Novus sponsor companies 2018

RESULT/ANALYSIS

In order to address the key research question, a brief on-line questionnaire survey was distributed to 86 students currently studying in all four years of the course. This was supported by three informal interviews with graduate employment and placement-providing representatives from Novus companies. 48 students responded to the survey representing a response rate of 56%, although five students did not complete the questionnaire fully. The survey was undertaken over a brief three day period shortly before the main examination period and this may have contributed to the response rate. Year groups are all evenly represented with the exception of students on their Year Three placement. It is quite typical of students on placement not to check their university email addresses on a daily basis and hence this under-representation was to be expected.

Students were asked to provide three reasons in order of priority (with no prompting) as to why they decided to take the Novus course. 61% of respondents mentioned the guaranteed job upon graduation as the primary reason and this rises to 80% if the second reason is included. Other factors mentioned across all three reasons in order of prevalence included industrial relevance, mentor support, interest in the subject, work experience and placement opportunities and site visits. Interestingly, only 80% of the respondents were able to provide three reasons, whilst location and reputation were mentioned by only four respondents and campus facilities did not feature at all. Students were then asked to assign the degree of importance that pre-specified key features of the courses had on influencing their decision to apply (Figure 2). In this instance, the guarantee of a placement (77% ranked extremely important) and guarantee of a job (70%) were by far the most important influencing factors.

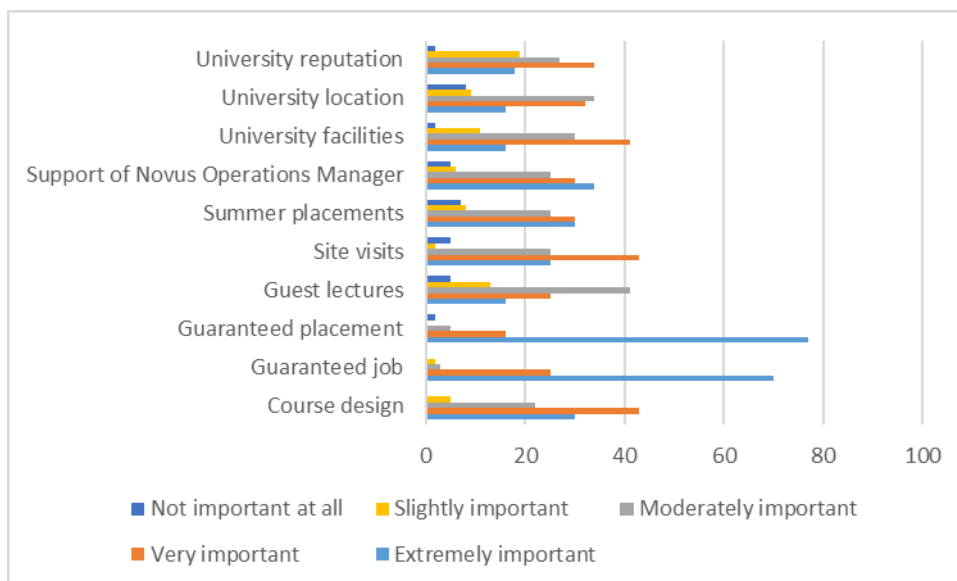


Figure 2: Importance of Novus course features to decision study

Students were then asked to rank the importance of the ten pre-identified course features from most important to least important. The results showed that 64% ranked the Guaranteed job as most important and 19% the Guaranteed placement. Together, these two features accounted for 82% of the first and second place rankings, clearly reinforcing the importance of these influential factors. The least important factors (more or less equal rankings) were the University’s location and facilities and guest lectures and site visits.

The final question reported here was an open question where the students were asked what they would have done if they had not studied one of the Novus courses. The results are presented in Table 2.

Business related degree (unspecified university)	45%
Supply Chain or Transport degree at University of Huddersfield	18%
Straight into employment	14%
Business related degree at a Russell Group university	11%
Apprenticeship	9%
Gap Year	2%

Table 2: What would you have done if you had not taken a Novus course?

DISCUSSION

Initial results clearly show that the main influencing factors affecting student choice for the Novus courses is the guarantee of both a job and a twelve month salaried placement. Many students commence their LSCM education journey with minimal knowledge and understanding of the sector and very few regret their choice of university course. Analysis of the grades attained by Novus students prior to commencing their studies indicates a slightly higher attainment level compared to students on other LSCM undergraduate courses, though such comparisons do not lend themselves to statistical corroboration at present. As an institution keen to encourage more students to study LSCM, and to support a pipeline of talent eagerly anticipated by the sector, the responses in Table 2 are encouraging. It seems that the current offering is successfully tapping into the motivations of potential applicants whom have growing concerns over the accumulation of debt associated with studying at universities in the UK and wish to know that their investment is sound. Indeed, one respondent commented “the best £47,000 I ever spent!” It is especially encouraging that the Novus courses are able to attract applicants away from business-related courses at Russell Group universities whose reputation and league table positions are generally considerably higher.

Interviews held with personnel working in the sector support the perceived need for this type of course and intervention. A logistics director of a major multinational food manufacturer stated that his company was 100% behind the scheme and that the students have contributed massively to the various LSCM functions within the business through summer and year-long placements, and more recently through graduates taking full-time employment. The human resource manager responsible for talent acquisition at a major UK supermarket retailer commented that the introduction of these talented and motivated students at all levels is having a positive impact on both their business performance and existing staff. Comments from a human resources manager for a major multi-national third party logistics provider included "please send us more students and graduates". Further analysis of industry views of the scheme will be presented at a later date as part of a longitudinal study of how the scheme has been progressing.

CONCLUSIONS

Murphy and Poist (2007) in their study of the skills' requirements of senior level logisticians conclude that "logisticians should be managers first and logisticians second". For LSCM undergraduate education, a key concern has been how to attract young people to subjects which they have not come across at high school but which have excellent graduate employment and career prospects. This study is part of an ongoing project to address a shortfall in supply chain talent in the sector by attracting students onto undergraduate courses with the promise of a guaranteed job upon graduation. It would appear, that the offer is fulfilling its purpose as it is influencing student choice and that a slightly better qualified student is being attracted to the courses. Feedback from employers is that the scheme is successful in addressing some of their needs but further research is required to ensure that graduate skills' sets are appropriate for the future needs of logistics and supply chain employers. The scheme is currently being rolled out to a small number of other universities in England.

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COMPETENCY REQUIREMENTS FOR LOGISTICS AND SUPPLY CHAIN PROFESSIONALS: AN ANALYSIS OF MARKET DEMAND

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ABSTRACT

Purpose of this paper: Analysing the market signals of sought after logistics and supply chain (LSC) management jobs, this study explores the current market demand and evaluates the competency requirements for the supply chain/logistics professionals in terms of knowledge, skills and abilities (KSA).

Design/methodology/approach: Based on the APICS (American Production and Inventory Control Society) and CILT (Chartered Institute of Logistics and Transport) competency frameworks, a conceptual competency model with a set of 42 unique knowledge, abilities, and skills (KSA) is developed and which has been rationalised by the resource-based theory. A total of 836 job advertisements in the supply chain/logistics sector is collected from the widely used job site "Seek Jobs" over the period between October and November 2017. The content analysis technique is employed to search relevant contents from selected job advertisements to identify the sought after KSA against the proposed conceptual competency model.

Findings: Results indicate that the supply chain manager, operations manager, procurement coordinator, warehouse manager, supply planner are the most demanded jobs in the market and most of the jobs required both soft and job specific hard KSA. The top five sought after soft KSAs are related to communication skill, teamwork, leadership, customer focus, interpersonal skills; whereas, the top five job specific hard KSAs are managing inventory, computer literacy, data collection and analysis, analytical and mathematical, and ERP systems implementation.

Originality/Value: The study suggests a unique LSC management conceptual competency model which can be employed by human resource departments as a reference guide to devise strategies for recruitment and development of right talent in the field of supply chain and logistics management.

Practical implications: Research findings can be used by the educational institutions to benchmark their current offerings against the current market demand and if required can redesign their supply chain programs.

Research Limitations: Competency requirements for LSC professionals could be different in different nations and economic regions. This research studied job advertisements in Australia and New Zealand, and therefore the findings may not be generalizable for other economies.

Keywords: Australia, Competency, Competency model, Market demand, Supply chain and logistics professionals,

INTRODUCTION

In the current global business environment, with the increased complexity in logistics and supply chain (LSC) systems, the demand for the right talent (employees) has increased (Ellinger and Ellinger 2014; Kiessling and Harvey 2014). The scarcity of talented personnel in LSC is a result of labour market shortages and economic crises as well as a lack of knowledge, skills, and talent (Hartmann et al. 2010). The competition for high-potential employees has also ramped up, and that has become a global LSC challenge for companies in terms of recruiting, retaining, and developing their human resources (Cottrill 2010).

In Australia, supply chain / transport logistics industry represents 8.6% of Australia's GDP, and adds more than \$135 billion to the economy. The industry employs over 1.2 million people (ABS 2017) and is predicted to grow by 4.5 percent through to 2022 (AIS 2017). From November 2017 to January 2018, the job advertisement in this sector have grown by 18% compared to 12 months ago (SEEK 2018). Furthermore, IRC Skills Forecast Survey predicted a possible skills shortage in this industry. The main reasons for such shortages include a lack of qualified workers and an ageing workforce, combined with high rates of retirement (AIS 2017). This could lead to a loss of business and economic growth if succession planning is not implemented. This has motivated to conduct this research.

Considering the significance of LSC talent requirements,, this study aims to identify the current market demand and assesses the competency requirements in terms of knowledge, skills and abilities (KSA).

We organize the paper as follows. Next section provides a review of literature highlighting the competency in terms of knowledge, skill and ability (KSA) and develops a competency frame to assess the current market demand. The following section discusses the research methodology adapted in this study. Then the results of the analysis is provided and discussed. The paper ends with a conclusion in the last section of the paper.

LITERATURE REVIEW

Competency theory

A competency is the capability to apply or use a set of skills, related knowledge, and abilities that allow an individual to successfully perform a task or an activity within a defined work setting (APICS 2014). Hence it's a complex combination of knowledge, skills, and abilities, frequently referred to as KSAs (Soosay 2005). According to Collins English dictionary, knowledge is "the state of knowing" or "specific information about subject". In other words, knowledge means a body of information that can be applied to do some specific type of job. It includes theoretical knowledge (e.g. knowledge of lean principles, economic order quantity) and procedural knowledge specific to a job or industry (e.g. knowing the procedure for assembling a product). Skill is an observable competence which include know-how (e.g. the application of working procedures), and empirical know-how (e.g. tricks, talents), or developed or learned behaviour or tools and techniques (Pagell et al. 2000). Generally, skills are learned and repeatable (Pinto 2010). Ability means aptitude and quality to perform a desirable output which is proven and already established. Abilities are harder to quantify during the job interview; however, it can be learned from reference of previous work or significance for future career development.

These KSAs are important determinants of hiring supply chain talent. When an organisation is hiring a new person, competencies of professionals are sought from their set of relevant attributes such as KSA, as well as their educational qualifications (Wu et al. 2013).

Human resource research in supply chain area

The resource-based view (RBV) states that firms can enhance their competitive advantage by acquiring valuable, rare and inimitable resources and capabilities (Barney 1991). The human resource systems can support RBV through contributing to sustained

competitive advantage by facilitating hiring right people (Wright and McMahan 1992) at the right time for the right job. Through proper utilisation of human resources, organizations can lower operating/business costs, and enforce service and product differentiation (Schuler and Jackson 1987). It is widely acknowledged that human resource management can impact organizational performance through the strategic management of people's KSA (Pfeffer 1994).

The Human resource management (HRM) literature in supply chain management (SCM) has identified talent management as a source of competitive advantage for emergent firms (van Hoek and Wagner 2013). Recently, Hohenstein et al. (2014) identified hiring of talents or resources as one of the seven research areas of HRM/SCM. The hiring of talents focuses on competencies that a professional possesses in the LSC context to carry out tasks in a competent manner to add value for competitive advantage (Ellinger and Ellinger 2014).

HRM/SCM research focusing on KSA are rare. Previous HRM/SCM research focused on specific skills issues or on particular supply chain professionals (Murphy and Poist 2007; Wu et al. 2013) to identify either skills (Sohal 2013; Wu et al. 2013; Ellinger and Ellinger 2014; Rahman and Qing 2014) or skill and knowledge (Yew Wong et al. 2014). Moreover, there are lack of research which investigates KSA based competencies from market signals or job advertisement.

Recruitment job advertisements and demand signal

Recruitment performs the essential role of bringing in the requisite human capital into the organization and can have significant impact on organizational performance (Schulz et al. 2008). Organizations who fail to recruit effectively are unable to compete with competitors that do (Chen et al. 2004). Johnson et al. (2008) suggests that one of the most critical recruitment activities that organizations use to gain competitive advantage is the use of the job advertisement. Usually, job advertisements provide signals on employer expectations and demanded skill set (Youngok and Rasmussen 2009). Employers are thus, able to utilize the job advertisements as signals for the market or organizational requirements not only for the job but the organization. Considering the importance of job advertisements as market signals of KSAs, this research considers examining sought after KSA competencies and observes how organizations signal their required need through job advertisements.

Supply chain competency model

Competency based models have focused on identifying the necessary characteristics for the successful performance and behavioral indicators (Jackson et al. 2009). The competency model guides individuals considering careers in LSC management, seeking to advance their positions, and human resource managers who are closely involved in hiring in this fast-growing field (APICS 2014). Over the years, supply chain professional bodies have developed several competency models which are widely used by various industries. Among these models, APICS (American Production and Inventory Control Society) Operations Management Body of Knowledge (OMBOK) Framework is notable. Based on the OMBOK framework, APICS developed a competency model for LSC professionals based on KSA and covers competencies for different levels such as occupation, profession, and foundational. CILT (Chartered Institute of Logistics and Transport) is another professional body, which has suggested a knowledge-based competency model known as CILT competency model (CILT 2018). Based on APICS and CILT competency models, we have developed a new framework of KSA competencies which is used to analyse LSC job advertisement in this study (Table 1). The new KSA framework is consisted of forty two different competencies which are grouped under five higher level competency-categories such as academic, workplace, personal effectiveness, professional related, and other occupation.

Table 1: A framework of KSA competencies for LSC professionals

Academic	Workplace	Personal effectiveness	Professional related	Others	
<ul style="list-style-type: none"> • Supply chain fundamentals • Math, statistics and analytical thinking • Operations and enterprise economics • Data collection, monitoring and analysis • Costing and finance • Computer literacy 	<ul style="list-style-type: none"> • KPI setting • Strategy development and application • Problem solving and decision making • Leadership • Teamwork and collaboration • Customer focus • Negotiation and conflict management • Organizing and planning • Accountability • Sustainability 	<ul style="list-style-type: none"> • Communication • Interpersonal management • Awareness of the needs of others • Adopt with change 	<ul style="list-style-type: none"> • Warehouse management • Transportation and distribution management • Process improvement and six sigma • Project management • Continuous improvement and lean management • Planning and scheduling • S&OP • Forecasting 	<ul style="list-style-type: none"> • Risk management • Strategic sourcing and supplier relationship • Customer relationship management (CRM) • International and local regulations • Location facilities • Inventory management • Safety management • ERP systems 	<ul style="list-style-type: none"> • Salary • Job location • Degree • Industry membership • Position title • Years of experience

RESEARCH METHODOLOGY

This study employs content analysis as the main research tool to analyse the collected LSC related job advertisements. Content analysis is a research technique that enables inferences to be made based on a text considering the context in which it was written (Holzmann and Spiegler 2010). The method includes both qualitative and quantitative content analysis (Krippendorff 2004). Qualitative content analysis demands meticulously reading each document, understanding and interpreting the text in its relevant context, and finally coding and classifying each of the text units. On the other hand quantitative content analysis summarizes the inferences and insights derived from the qualitative phase in the form of numerical examinations of the interpreted text units and the related categorized codes (Holzmann and Spiegler 2010). This study utilises both qualitative and quantitative content analysis techniques in an integrated manner and use the following three steps proposed by Ahsan et al. (2013): (i) create LSC job related key competencies from the professional bodies, (ii) identify job advertisement websites and collect sample data, (iii) scrutinise job advertisement contents and code frequency of relevant items. These steps are briefly discussed below.

(i) Create LSC competency variables: The first step of the research is to create KSA dictionaries which are considered the basis for data collection. The proposed competency framework is consisted of forty two different competencies which are grouped under five higher level competency-categories such as academic, workplace, personal effectiveness, professional related, and other occupation (shown in Table 1).

(ii) Identify job advertisements: Since online sources are generally easy to navigate and finding the intended advertisement is manageable and accessible, we have used only online job boards. Job advertisements from online sources are categorized based on country, industry, position roles and responsibilities. When contemplating which job sites to use as sources for advertisements, we find the 'Seek Jobs' website a potential, comprehensive, and dedicated source of job advertisements (Ahsan, et al. 2013). Seek jobs is by far the largest job board in the Australasian region in terms of both job advertisement and jobseeker numbers. In a given month, over 4 million job advertisements are posted on SEEK and so far 450 million people visited this website (SEEK, 2018). We use advertisements from seek jobs sites Australia (sekjobs.com.au) and New Zealand (seekjobs.co.nz). To avoid duplications, we do not consider any other job board since recruiters quite often post the same advertisements simultaneously in

multiple websites. Moreover, such an approach would require considerable time including visiting different websites and potentially overlooking smaller and lesser known companies (Sodhi and Son 2010).

(iii) Scrutinise job advertisement contents and code frequency of relevant items: Job advertisements from 'seek jobs' were collected over a period of one month starting from October 17, 2017. We used the key words "supply chain management", "logistics", "procurement", and "operations". As inclusion criteria, we restricted the job advertisements which were related to full time job, and key words. Under exclusion criteria we used part time jobs, positions such as sales manager, admin coordinator, supply chain administrator, supply chain associate, project manager, retail stock analyst, warehouse assistant, accountant-transport and logistics, forklift operator, warehouse administrator, administration support officer, warehouse assistant. In first search, considering exclusions criteria we obtained 510 jobs from Australia and 110 jobs for New Zealand. In the second search, following the similar process, we obtained 140 jobs from Australian site and 125 from New Zealand site. Job advertisements were saved as pdf with the job title as file name, afterwards each job is numbered, and further screening were conducted to remove any duplicated job advertisements. This process resulted in 836 useable advertisements (621 jobs from Australia and 215 jobs from New Zealand). Using Nvivo® V11, contents of the advertisement were scrutinised and coded under each of the KSA competencies of proposed KSA framework.

RESULTS AND ANALYSIS

The results of the content analysis of 836 job advertisements reveal that majority of the jobs (71%) are attached to the major cities in Australia and New Zealand regions such as Sydney (29.3%), Melbourne (26.2%), and Auckland (15.7%). In total 22 job positions are identified and most frequently advertised jobs are found to be for supply chain manager, operations manager, procurement coordinator, warehouse manager, and supply planner. Furthermore, based on commonality of position, the majority of the jobs are with the title manager (46.3%), coordinator (25.2%), planner and controller (20.2%). About 25% of the jobs (202) required tertiary degree in the areas of supply chain (66), logistics (38), operations (32), procurement (22), and business (24).

Critical KSA competencies for LSC profession

Figure 1 shows the frequency distribution of KSA competencies for 836 jobs. The figure demonstrates that the top five sought after competencies are communication, teamwork and collaboration, inventory management, computer literacy, data collection and analysis. Within the top ten competencies, four are related to the soft competency category (such as communication, teamwork and collaboration, leadership and customer focus) and six are related to the hard competency category (such as inventory management, computer literacy, data collection and analysis, analytical and mathematical, problem solving and decision making, and ERP systems implementation). Approximately 46% job advertisements mentioned 'communication' as a required competency for LSC jobs. Nearly 33% job mentioned 'inventory management' as a competency for LSC jobs.

We further analyse the job advertisements for top KSAs. For each competency we investigated knowledge, skills and abilities. It appears that most job advertisements are looking for skill-based competencies. Top 10 KSAs are listed on Table 2. It was identified that top sought after knowledge areas are related to supply chain fundamental, ERP, warehouse management, safety management, and continuous improvement (CI) and lean management. Top five skills are related to communication, data collection and analysis, inventory management, teamwork and collaboration, and leadership. Furthermore, top five abilities are found to be teamwork and collaboration, leadership, inventory, analytical capability, and problem solving.

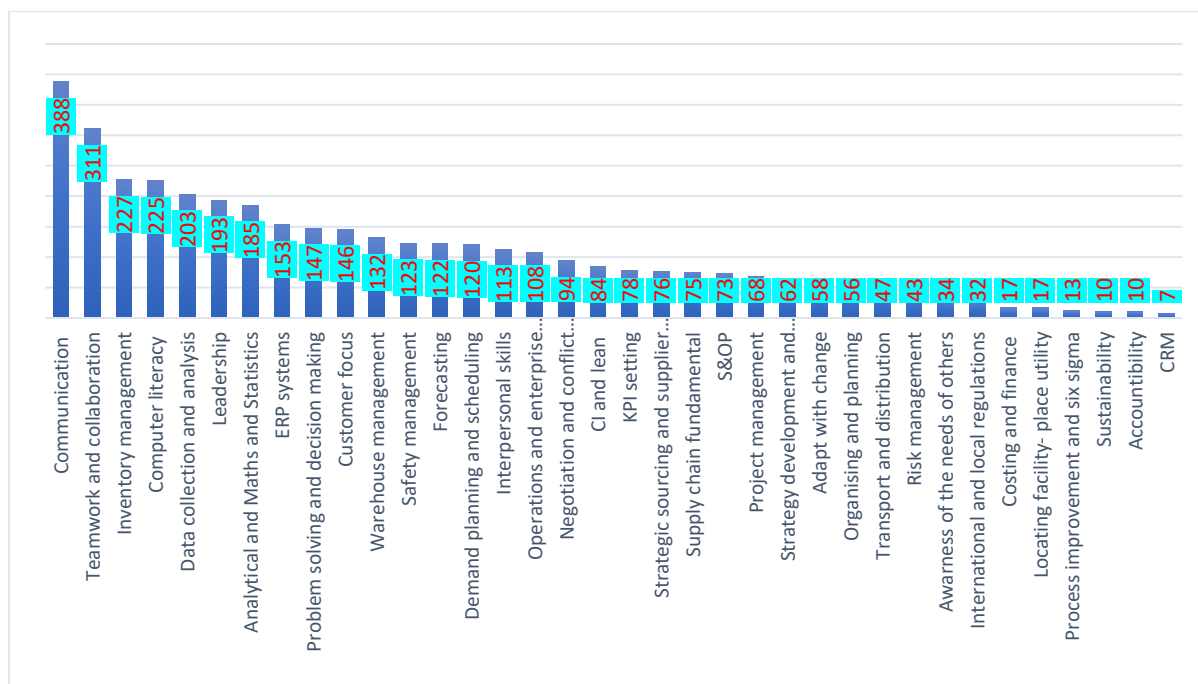


Figure 1: Frequency of KSAs from Job advertisements (without others category)

Table 2: Top ten KSAs from job advertisement

Knowledge (frequency)	Skills (frequency)	Ability (frequency)
Supply chain fundamental (55)	Effective communication (382)	Teamwork and collaboration (110)
ERP systems (33)	Data collection, monitoring and analysis (189)	Leadership (57)
Safety management (25)	Inventory management (187)	Inventory management (30)
CI & Lean management (16)	Teamwork and collaboration (187)	Math, statistics, and analytical thinking (29)
Inventory management (13)	Leadership (150)	Problem solving and decision making (25)
International and local regulations (12)	Analytical and Math and Statistics (150)	Safety management (25)
Warehouse management (11)	Problem solving and decision making (123)	Strategic sourcing and relationship (23)
Project management (7)	ERP systems (122)	Customer focus (22)
S&OP (7)	Customer focus (122)	Data collection and analysis (21)
Analytical and Math and Statistics (6)	Forecasting (115)	Demand planning (15)

We further analyse whether the KSAs requirements are different for different levels of LSC positions. In total we identify 22 number of positions, these positions are grouped under the categories of manager, coordinator, planner and analyst. Rank orders of KSA competencies for each group are shown in Table 3. Overall, among the positions communication is common. In total 387 (46% of the total sample) job advertisements were for managerial positions. Manager position jobs require mostly soft competencies such as communication, leadership and abilities, teamwork and collaboration, strong operations and enterprise economics knowledge. For coordinator position (25% of the total sample) and sought after major KSAs are mostly technical or hard competencies (e.g., computer literacy, inventory management, data collection and analysis). For the planner position (20% of total sample) required competencies are mostly related to hard competencies (e.g., planning and scheduling, inventory management, forecasting, data collection and analysis). Lastly, for the analyst jobs (6% of total sample) it appears that hard skills are dominant similar to the planner position.

Table 3: Top five KSAs for different position levels

Role/rank order of competencies (no. of jobs)	1st	2nd	3rd	4th	5th
Managers (387)	Communication skill	Leadership-skill, ability	Teamwork and collaboration-skill, ability	Operations and enterprise economics-skill	Analytical and Maths and Statistics skill
Coordinator (211)	Communication skill	Teamwork and collaboration skill, ability	Computer literacy skill	Inventory management skill, ability	Data collection and analysis - skill
Planner (169)	Communication skill	Planning and scheduling skill	Inventory management skill, ability	Forecasting skill	Data collection and analysis-skill
Analyst (53)	Data collection and analysis skill	Analytical and Maths and Statistics skill	Communication skill	Inventory management skill, ability	Computer literacy skill

In Table 4 we show the breakdown data for a particular position such as 'manager'. Managerial position titles of job are comprising of operations managers, supply chain manager, procurement manager, warehouse manager, logistics manager and sales and operations (S&OP) manager. For all the managerial positions, communication skills are common as one of the top five KSAs. These positions require mostly soft competencies with some professional competencies. Some of these managerial positions require to have professional related competency. For example, operations manager need to have strong competency on operations and enterprise economics, procurement manager on strategic sourcing and supplier management, warehouse manager on warehouse management, supply chain manager on inventory management, S&OP managers on S&OP skills.

Table 4: Top five KSAs for different managerial positions

Role/rank order of manager's competencies	1st	2nd	3rd	4th	5th
Operation manager (95)	Operations and enterprise economics skill	Leadership skill, ability	Teamwork and collaboration skill, ability	Safety Management KSA	Communication skill
Supply chain manager (95)	Communication skill	Leadership skill, ability	Teamwork and collaboration-skill, ability	Computer literacy skill	Inventory management skill, ability
Procurement manager (84)	Strategic sourcing and supplier relationship skill and ability	Communication skill	Teamwork and collaboration skill, ability	Leadership skill, ability	Negotiation and conflict management skill
Warehouse manager (54)	Warehouse management skill	Teamwork and collaboration-skill, ability	Communication skill	Leadership skill, ability	Safety Management KSA
Logistics Manager (53)	Communication skill	Teamwork and collaboration skill and ability	Leadership skill, ability	Analytical and Maths and Statistics skill	Customer focus skill
S&OP manager (6)	S&OP skill	Leadership skill, ability	Teamwork and collaboration-skill, ability	Inventory management skill, ability	Communication skill

We further compare the KSAs for different positions levels for specific areas of jobs. For example, we investigate whether KSAs are different for different supply chain management related positions (managers, planner, coordinator and analysts). From Table 5, it appears that supply managers need to lead and communicate, whereas and analyst needs hands on experience on analytical aspects. Supply chain managers need to lead and manage the teams and that's the reason why more soft skills are required from a manager. On the other hand, an analyst profession requires mostly hard skills such as data analysis, analytical skills, ERP systems knowledge and skills, computer literacy. For the analyst's position, some communication skills are also necessary to work in a team or within an organisation.

Table 5: Top five KSAs for supply chain specific position levels

Supply chain specific jobs	1st	2nd	3rd	4th	5th
Supply chain manager (95)	Communication skill	Leadership skill, ability	Teamwork and collaboration	Computer literacy skill	Inventory management skill, ability
Supply chain coordinator (55)	Communication skill	Computer literacy skill	Teamwork and collaboration	Data collection and analysis skill	ERP systems
Supply planner (53)	Inventory management skill, ability	Analytical and Maths and Statistics skill	Communication skill	Computer literacy skill	Data collection and analysis
Demand planner (43)	Planning and scheduling	S&OP	Forecasting skill	Data collection and analysis-skill	Inventory management skill, ability
Logistics and supply analyst (29)	Data collection and analysis-skill	Analytical and Maths and Statistics	Communication skill	Computer literacy skill	ERP systems

DISCUSSION

This study explores the current market demand and evaluates the competency requirements for the supply chain/logistics professionals in terms of knowledge, skills and abilities (KSA). Irrespective of job locations and positions, this research demonstrates that effective communication, and team work and collaboration are the two top KSA competencies.

According to APICS, communication means receive, attend to, interpret, understand, and respond to verbal messages and other cues; express information to individuals or groups considering the audience and the nature of the information. From job advertisements, we further investigate particular aspect of required communication competency. For effective communication it is expected to have or to be able to conduct communication in the forms such as: strong/excellent/high level of verbal and written communication skills, specifically e-mail and phone communication; it is mostly related to interpersonal communication; communication channels are with customers and other stakeholders; quality of communication should be clear and in timely manner/fashion.

We consolidated specific tasks requirements under teamwork and collaboration competency. Further, details of teamwork and collaboration requirements are: ability to work within a team, should be a team player, contribute in a team, liaise or collaborate and maintain a strong relationship with team, work collaboratively across departments, strong team ethics, can work international or multi-cultural or diverse team. Managing and leading a team also emphasised in job advertisements and under managing and leading team it was expected to develop a high performing team, support and manage team, mentoring and leading junior members, managing the team's workload, mentoring or coaching a team, create a team environment and bringing together a team. In the job advertisements, teams are identified as functional teams such as logistics, marketing, finance, inventory team, sales, supply and replenishment, procurement, supply chain, buyers, planning, and production teams. Most frequently mentioned team sizes are small consisting of size 2-7 personnel.

It is worthy to mention that a high percent of jobs require hard competencies.. Amongst the top five sought after hard competencies are inventory management, computer literacy and data collection and analysis, analytical and mathematical, and ERP systems implementation.

Inventory competencies are required to run manufacturing or business operations smoothly and hence maintaining and controlling accurate inventory level of inventories were emphasized. Moreover, inventory management is not an isolated part of supply chain, rather it was emphasized to integrate inventory of raw materials or semi-finished or finished goods as part of the entire supply chain. Hence, jobs are looking for LSC professionals to align inventory with the sales forecast, predict how much to order, when to order and where to order from. Amongst the competencies required in this area are to

review company inventory system regularly, review inventory levels for all items and make adjustment as required, manage finished goods inventory to minimize obsolescence. Since, inventory holds resources and therefore accuracy of inventory movements is emphasized both in inbound and outbound shipments. To meet customer and business requirements many jobs emphasized on using technology and analytical skills to ensure best-in-class inventory management processes to determine min-max inventory levels, optimal amount of inventory holdings, carrying out stock balances at timely intervals via SAP. Other important aspects of inventory management jobs are related to continuous improvement of inventory process and periodic and accurate reporting of inventory to stakeholders.

Computer literacy is identified as fourth most frequently required competency. Under the computer literacy, majority of the jobs were expected to have ERP and MRP related literacy such as SAP software knowledge. Number of jobs were asking for advanced Excel and Microsoft Office skills, and warehouse management system (WMS) knowledge and skills.

Analysis of LSC job advertisements contents shows that different types of competencies are required at different level of jobs. For example, manager position needs more soft competencies such as communication and leadership. The primary reason for this is that jobs at managerial positions need to deal with supply, distribution and procurement where they need to plan, organise, direct, control and coordinate the supply, storage and distribution of goods, products and services produced and used by organizations (ABS 2009). On the other hand, an analyst needs more hard competencies such as data collection, analytical skills, computer skills, inventory knowledge and skills. In the case of career progression, analyst may acquire more soft skills such as teamwork and collaboration and communication skills to become a coordinator. Furthermore, a coordinator would need additional communication, leadership and teamwork skills to be a manager.

CONCLUSION

This study identifies the current market demand trend of LSC jobs and assesses the competency requirements. Based on the APICS and CILT competency frameworks, we propose a knowledge, abilities, and skills based conceptual competency model which is underpinned by resource-based theory. Through content analysis of 836 LSC job advertisements this study identifies the most demanded KSA competencies. Overall, the number of hard KSAs are dominant within top five competencies. The top five sought after soft KSAs are related to communication, teamwork, leadership, customer focus, interpersonal skills; whereas, the top five hard KSAs are managing inventory, computer literacy, data collection and analysis, analytical and mathematical, and ERP systems implementation. The most demanded jobs in the market are supply chain manager, operations manager, procurement coordinator, warehouse manager, supply planner. The majority of these jobs seek for tertiary qualified supply chain professional with at least an undergraduate degree in business logistics or supply chain, operations and procurement management.

The proposed competency framework can add new perspective to the current HRM/SCM literature which is grounded on knowledge, skill and ability. Furthermore, this research took the unique initiatives to assess competencies based on job advertisement information. Job advertisements are indication of market signals and a true reflection of organisational requirements expected from LSC talents. Identified market-based competencies can help potential job seekers to prepare for job requirements. Moreover, logistics firms can use the competency models and required KSAs for employee assessment and their career progression for different supply chain jobs. Recruitment agencies can also use this model to prepare the job advertisement in line with expected KSAs. Furthermore, the findings may assist educational and training institutions to design and redesign their courses and curricula in line with the market demand and trend. Although the research is conducted with the market demand in Australia and New

Zealand, it can be easily extended to other country environments. Moreover, in the future the research can be extended to compare the supply side of competencies with demand side requirements.

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