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OF THE INTERNATIONAL CONFERENCE ON LOGISTICS AND TRANSPORT

Next Generation Supply Chains: The Future of Supply Chain Management

6th - 8th of September 2016
Grand Copthorne Waterfront Hotel, Singapore

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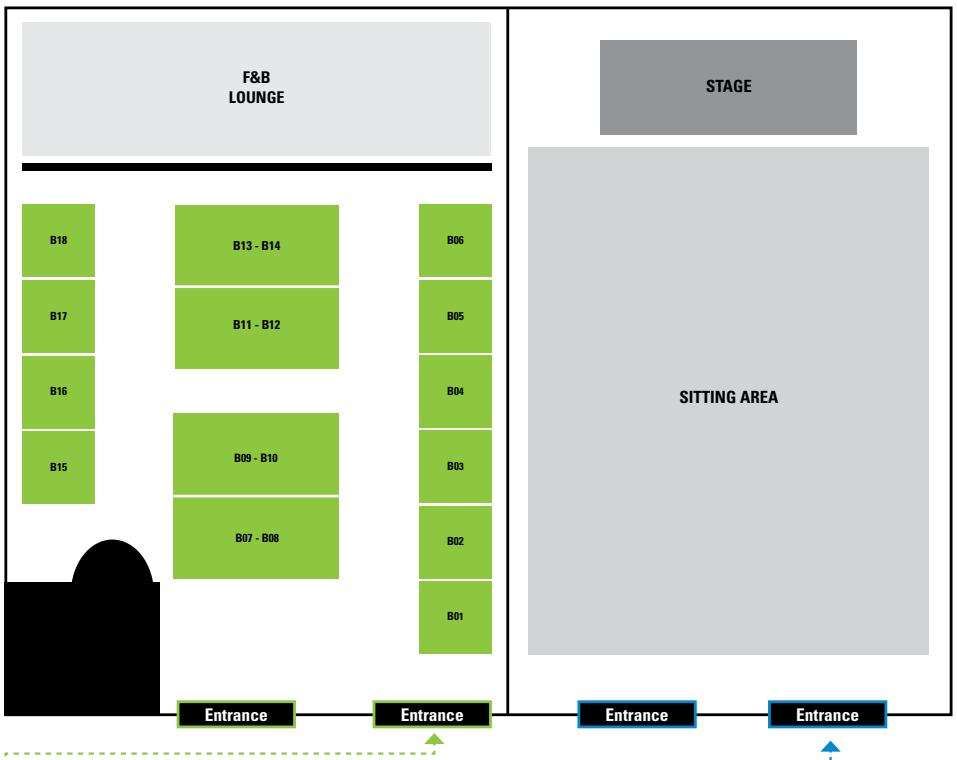
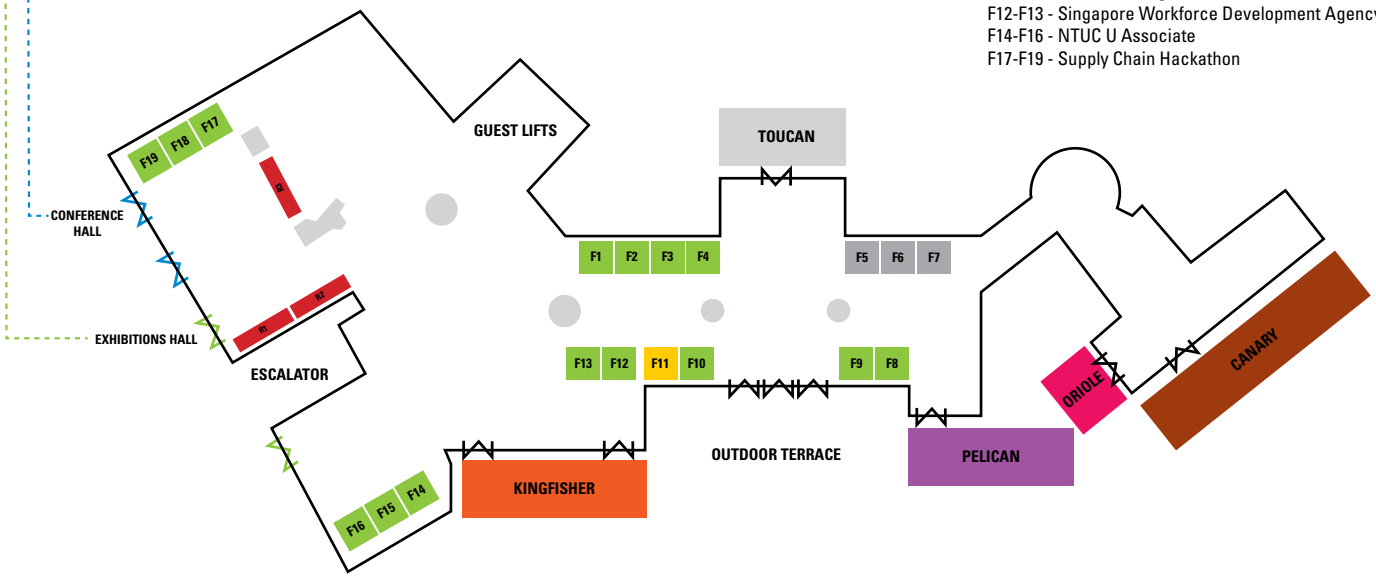
International Conference on Logistics & Transport (ICLT) is organised by the Centre for Logistics Research at Thammasat Business School, Thammasat University and Excellence Centre in Logistics and Supply Chain Management, Chiang Mai University. The 2016 event will be held in Singapore, hosted by the School of Business at SIM University from 6th till 8th September 2016. This major event for researchers in transport, logistics, supply chain and value-chain management has been chosen after successful conferences in Thailand, New Zealand, Maldives, Japan, Malaysia and France. The conference's best paper will be invited and considered for publication in the International Journal of Logistics: Research and Applications.

Supply Chain Asia Forum Floorplan





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INTRODUCTION

This is the 8th international conference organised by the Centre for Logistics Research at Thammasat Business School, Thammasat University and the Excellence Centre in Logistics and Supply Chain Management, Chiang Mai University. This is major event for researchers in transport, logistics, supply chain and value chain management especially in the Asia Pacific region. This year's event in Singapore, is a continuation of past successful conferences held in ChiangMai (Thailand), 2009; Queenstown (New Zealand), 2010; Male (Maldives), 2011; ChiangMai (Thailand), 2012; Kyoto (Japan), 2013; Kuala Lumpur (Malaysia), 2014 and Lyon (France), 2015. This year's event is held during September 6th to 8th, 2016 and is hosted by SIM University, Singapore. The event this year will be held in conjunction with Supply Chain Asia's annual conference.

Under the theme of "Next Generation Supply Chains: The Future of Supply Chain Management", the following topics were welcomed at the conference:

- Procurement & Supply Management
- Planning & Forecasting
- Relationship & Collaboration
- Production Planning & Operations
- Inventory Fulfilment
- International Logistics
- Humanitarian Logistics
- Maritime Logistics
- Logistics Services Providers
- Logistics Development Policies
- Supply Chain Design/Configuration
- Supply Chain Risk Management
- Sustainable Supply Chain
- Production & Inventory
- Supply Chain Performance
- Global Supply Chain
- Multimodal Transport
- Freight Logistics
- E-Logistics
- Logistics Facilitation

The conference best paper will be invited and considered for publication in the International Journal of Logistics Research and Applications.

WELCOME ADDRESS FROM THE CONFERENCE CHAIRS

On behalf of the organizing committee, we would like to welcome all participants to the 8th International Conference on Logistics and Transport (ICLT2016). It has been 8 years since the first conference was hosted in Chiang Mai (Thailand). This ICLT conference is expected to continue on an annual basis in order to facilitate the sharing of ideas, research findings, and teaching directions related to logistics and supply chain from an academic perspective. We are also striving to make our next event in 2017 included in the SCOPUS database.

The theme for this year's event is "Next Generation Supply Chains: The Future of Supply Chain Management". Due to constant changes and evolution in technologies and management practices, traditional supply chain practices of moving a product from point A to point B has become more complex with considerable effort in planning and co-ordination required.

However, due to the current market situation, the search for innovation is one of the key topic in differentiating the firm itself with its competitors but without careful planning, this might hinder a firm's future business performance.

"Next Generation Supply Chains" is an important concept. It can be used as a guiding principle to help improve firms' resources, capabilities and operational efficiencies through sustainability across the entire supply chain continuum. The challenge to harmonise these subtle changes between supply chain members remains an elusive challenge.

Nonetheless this concept does lead to greater opportunities in reviewing and revisiting processes, operations, and production activities that can comply with this given paradigm. Other potential advantages of "Next Generation Supply Chain" is continuous cost reduction, waste minimisation, rapid cycle time response, risk mitigation, and asset utilisation.

We would like to sincerely thank all presenters, reviewers, our scientific committees, and keynote speakers for their appreciated contribution. We cannot forget the important contribution of our sponsors, SeaOil (Public) Co. Ltd, Wice Logistics (Public) Co. Ltd., and SCG Logistics Management Co. Ltd who has supported us through the years.

We also apologise in advance if there are any difficulties you may encounter while participating the conference. Finally, we hope that you will enjoy this conference and we hope that the deliberations will be fruitful and successful.

Ruth Banomyong
ICLT General Chair

Apichat Sopadang
ICLT General Chair

WELCOME ADDRESS FROM THE LOCAL CHAIRS

We welcome all of you to the 8th International Conference on Logistics and Transport (ICLT 2016) in Singapore. SIM University is privileged to host the ICLT conference this year.

We live in a globalised business world where materials and components are sourced worldwide, products are manufactured offshore and distributed to different countries after local customisation. The flexibility to respond to changes in market conditions and the ability to strategise appropriate measures in response to these changes are vital because the customer in today's marketplace has become more demanding, not just of the quality of the product, but also that of customer service.

Rapid urbanisation and the rise of the affluent middle class in Asia have led to greater demand for logistics services in the region. Intra-Asian trade is set to increase significantly as Asian countries evolve to become major consumer markets. Increasing economic integration among Asian countries through the ASEAN Economic Community (AEC), Trans-Pacific Partnership (TPP) and China's "One Belt, One Road" will further spur demand for logistics services.

Emerging trends in the past few years have presented the logistics and transport industry with exciting challenges and opportunities to be better, faster, leaner and more productive. Trends such as big data, 3D printing, automated guided vehicle (or mobile robot), unmanned aerial vehicle (or drone) and augmented reality can pave the way for game-changing solutions.

The theme of this conference is indeed timely as the next generation supply chains dawn upon us. We trust this conference will provide you with the platform for a meaningful exchange of ideas and findings, as well as facilitate education and research efforts in the field of logistics and supply chain management. And to our friends from overseas, we hope that you will be able to take some time off to enjoy the sights, sounds and culinary delights that Singapore has to offer.

We wish you a memorable experience at ICLT 2016.

Tan Yan Weng
ICLT Local Chair

Tay Huay Ling
ICLT Local Chair

CONTENTS

A FRAMEWORK FOR ANALYSIS THE IMPACTS OF RFID ON REVERSE SUPPLY CHAIN PERFORMANCE MEASURED BY HIERARCHICAL REGRESSION ANALYSIS

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Introduction

The success of supply chain depends on good management and good communication, as well as reverse supply chain. Reverse supply chain is the returning flow of goods and information from consumers back to manufacturers for the purpose of recapture, recreate value or disposal. In recent years, many industries have been increasing attention in reverse supply chain because they concern about the effects of environments, socials and economics (Sustainable Development). This concerned has influenced around the globe. For example, Switzerland have legislation for used products called Advance Recycle fee, Thailand established the Ministry of Natural Resources and Environment (MNRE) to support organizations and industries to effectively use energy and preserve the environment. Some industries such as computers and battery industries have reused obsolete products from consumers to reduce production cost. The main activities of reverse supply chain are getting products back from consumers and including support activities such as managing, inspecting, monitoring information and communication. Therefore, application of information technologies, such as RFID, the technology which used to identify the information of products and tracking location of the products. It will provide convenience for any related tasks, process improvement and inventory control. However, due to the cost in investment, alternatives technology such as barcode, which are arguably less powerful than RFID in manufacturing durability, usability and field application. This paper presents the framework for analysis the impact of RFID practices on reverse supply chain performance measured by Hierarchical Regression Analysis. We focused on three major industries in Thailand; automobiles, electrics and electronics industries as a result of being the top 3 ranking export industries in Thailand in 2015. (Custom Report, 2015) The results of this analysis help to decide which process should develop RFID by choosing the process that get high impact on performance from RFID practices.

Literature Review

Radio Frequency Identification

RFID (Radio Frequency Identification) is the technology which provides ability to identify and locate information of matter by using radio frequency. This technology functions mainly by using electronic tags which registered information within the tag. This information includes, for example products identification code, production date or expire date. (Hunt, et al. 2007). The tag used altogether with Reader instrument which used to read any information stored within the tag. This process operates by middleware that send the feedback to user to evaluate or calculate information provided by the tag. The information received normally used further to support any operation which related to planning operation or Enterprise Requirement Planning (ERP) (Wang, et al. 2010). Nowadays, the RFID technology is the key of many significant activities in industrial organization such as inventory control, warehouse management, Job scheduling and production execution. (Jedermann,

et al. 2006; Chow, et al. 2006; Huang, et al. 2007). Frequently, many industrial companies have interested and adopted RFID to help increase their proficiency and capability. Many academic researches (Bagchi, et al. 2007) have forecast the demand and growth rate of RFID from 1 billion dollars in 2003 to 4 billion dollars in 2008 and 20 billion dollars in 2013.

The adaptation of RFID is the descendent of barcode technology which it meant to be replaced. Both RFID and barcode technology functionally execute by the same method. The different of both technologies is the ability to store information, range of identifying, and size of information, obstacle and cost. Although acquisition of RFID is more expensive than barcode technology, RFID prove to be far more advantage in every way mentioned. (Lee, et al. 2011 cited in InLogic, 2008) RFID offers the real time information which enhance the traceability of product or information dramatically without line of sight (Non-line of sight). Additionally, RFID is simple to apply and endure to harmful environment which extend the length of used. (Garcia, et al. 2007; Gaukler, 2005; Vlachos, 2014; Lee, et al. 2011; Ramanathan, et al. 2014). The best practice in adopting RFID technology is Wal-mart. Wal-mart gets benefit from enhancing its inventory control and management by using RFID technology, Wall-mart significantly able to decrease inventory level, lower counting time, increase the capacity and efficiency of the warehouse. (Chow et al., 2006). Other than Wal-mart, Federal express, Dell computer, Procter and gamble, United state department of defense (Lin and Ho, 2009). Any airliner and transported are benefit from RFID technology.

Reverse Supply Chain

The research concerned reverse supply chain can be traced back to 1993 when Lund studied about the idea of remanufacturing. Later in 1995, Thierry analyzed the subject which included the management of retrieving products and renews into additional value. Rogers and Tibben-Lembke (1999) defined the meaning of reverse logistic is that the strategy that control, evaluate and plan the flow of information and product since the end of supply chain back to the origin of production process. This chain meant to be renew, add additional value or effectively eliminate any remaining wastes form production line Especially, renewing or recycling prove to be key of success in many organization (Fuente, et al. 2010). Forward logistic indicate the process and value chain since the beginning of creating production's good into the hand of customer, which is the ordinary. In the other hand, the reverse logistic concerns about following method which provided additional value to the goods (Lee and Chan, 2009; Rahman and Subramanian, 2012)

- Reuse : The renew of product or material
- Recycle : Transforming used goods by adaptation or remedy material by cleansing, re-fabrication of re-assembly into different product.
- Disposal : Endanger waste must be handle with care and appropriate way in disposal.

Moreover, the exceed inventory and variety of product are also the main reason of producing the bullwhip effect. Even more, the uncertainly of quality and quantity is also one of the major threat to the financial crisis to every organization. To solve these problems and effectively enhance the value of supply chain, many companies have adopted the technology of RFID to solve their supply chain problem.

The advantage of reverse supply chain is not also just providing additional value to the customer, it creates the opportunity to acquire additional resource or appropriately get rid of any remaining waste. The effectiveness of reverse logistic relied heavily on the accurate information in collecting and precision of data. Many organizations have realized and adopting RFID Technology to take advantage of this tool to enhances the effectiveness of reverse logistic. This research is to focus on adapting RFID technology to provide effectiveness which leads to increase profit or added additional value in to any firm organizations.

Methodology

Research Design

This research applied the theory of Hierarchical Regression Analysis by using SPSS program to synchronize and evaluate the impact of RFID practices on reverse supply chain. The results generated by applying Hierarchical Regression would present the significant values. The R square is the anticipate factor since it indicates significant of variance prediction interested in outcome.

In order to evaluate the impact of RFID practices on reverse supply chain, we focused on automobile industries, electric industries and electronic industries. By using structured questionnaire with Likert scale from 1-5 (Strongly disagree to strongly agree) and distribute to managers in the company. The samples are from list of companies in the Ministry of Natural Resources and Environment website via an online methodology (i.e. google survey or survey monkey)

RFID Factor or independent variable were collected from review papers with high impact factors (shown in Table 1) that related with reverse supply chain and RFID. There're transportation, distribution center inventory, collection point, retailer's warehouse, landfill, application system, stock level, recovery facility, store, manufacturer, supplier's warehouse and manufacture's warehouse. Moreover, the reverse supply chain performance variables were derived from the SCOR model. All of dependent and independent variables will use in analysis the impact of RFID practices in Hierarchical Regression Model.

Hierarchical Regression Analysis

Hierarchical Regression is use to analysis to understand the impact of RFID practices on reverse supply chain performances. The model of Hierarchical was shown in Figure.1. We will employ a Hierarchical Regression procedure in 3 steps; firstly, control variables (i.e. firm size or number of employees) are considered in regression model. Second, we create independent model by adding the 12 RFID practices into regression model. Third, enter interactions of 12 independent variables into regression analysis to create interaction model. The interaction term shows the significant and statistical power results. Additional the significant change in R^2 indicates that when RFID apply in reverse supply chain, it shows how much will improve the performance of each activity.

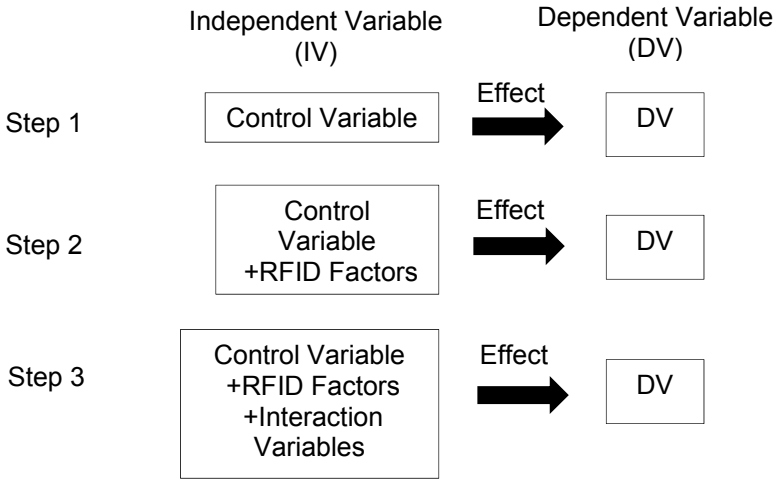

Figure.1 Hierarchical Regression Model

Authors	Tsoulfas et al. (2002)	Daniel et al. (2003)	Hou and Huang (2006)	Prahinski and Kocabasoglu (2006)	Ngai et al. (2007)	Amaro and Barbosa-Povoa (2008)	Skinner (2008)	Kumar et al. (2008)	Gou et al. (2008)	Lee et al, (2009)	Becker et al. (2009)	Poon et al. (2009)	Lee and Chan (2009)	Trappey et al. (2010)	Zhang et al. (2011)	Lee et al. (2011)	Turrisi et al. (2013)	Bogataj and Grubbstrom (2013)	Govindan et al. (2015)	Zhong et al. (2015)	**Frequency**
Transportation	/	/		/		/			/	/	/		/		/		/	/	/	/	13
Distribution Center Inventory			/	/		/		/	/	/			/	/	/	/	/		/		12
Collection Point		/	/			/					/	/	/		/		/	/	/		10
Retailer's warehouse	/	/		/				/	/	/							/		/	/	10
Landfill		/				/	/						/	/	/		/	/	/		9
Application System			/		/		/	/			/	/		/		/				/	9
Stock Level			/		/			/		/	/				/	/				/	8
Recovery Facility	/			/			/							/				/	/		6
Store	/	/	/	/				/		/											6
Manufacturer			/	/				/		/										/	5
Supplier's warehouse				/		/													/	/	4
Manufacturer's warehouse								/			/	/									3

Table 2: Independent Variable Analysis

Anticipated Results

The results from Hierarchical Regression analysis presented the impact of RFID practices on reverse supply chain performances indicated in the value of change in R^2. So, it means percent of improving performance. According to Vlachos (2014), the different percentage of R^2 indicate the significant value of variable. For example, in table 2, if the value of change in R^2 of Dependent Variable 1 is 0.338, we can define that if we apply RFID on Dependent Variable 1 the reverse performance of this activity will improve 33.8 percent and performance of dependent variable 2 is improve 26.8 percent.

		Step 1	Step 2	Step 3
Dependent Variable 1	Change in R square	3.604	0.134	**0.338**
Dependent Variable 2	Change in R square	0.006	0.109	**0.268**

Table 2 : Example of HReg Results (Vlachos, 2014)

After we analysis all of activities (Independent variable), the percent of improvement will have presented. The Results from this analysis is the information for companies to make a decision in adopting RFID in reverse supply chain activities. Moreover, we can make a priority of applying RFID by adopting RFID on activity that gets high impact on performances first.

Conclusions and future work

In this paper presents the framework that guide how to analysis the impacts of RFID on reverse supply chain performance. The contribution of this paper included the details and model of Hierarchical regression analysis for evaluating, the variables; dependent and independent that used to analysis was presented. In the future, we will use this framework to evaluate the impact of RFID on reverse supply chain performance.

Acknowledgement

The authors would like to gratefully acknowledge the Excellence Center in Logistics and Supply Chain Management (E-LSCM), Chiang Mai University for the supporting of this research work

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A SYSTEMATIC REVIEW OF THE HUMANITARIAN LOGISTICS AND SUPPLY CHAIN PERFORMANCE MEASUREMENT LITERATURE

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Introduction

Humanitarian performance should be defined in terms of both its effects on those affected by crisis and according to core humanitarian principles. A more integrated approach to performance bringing together different levels, functions and initiatives within the system, could help to overcome many of the perceived failures of humanitarian assistance (Ramalingam *et. al*, 2009). There are many existing projects, initiatives and approaches for monitoring and reporting on performance within the humanitarian system. However, these have been established for a range of different purposes and different focuses and address aspects of performance. Many operate in parallel, and some overlap. Most efforts do not involve regular collection and analysis of data. Those that do are often fragmented in their approach.

The purpose of this paper is to provide a systematic literature review of the humanitarian logistics and supply chain performance measurement literature combined with a citation network analysis approach. This will enable the identification of the main research clusters in the field of humanitarian logistics and supply chain performance measurement.

This paper is separated into 2 main sections. The first section will discuss the systematic review methodology while the 2nd section will focus on the findings of the review. The findings of the review will be presented through the use of the Pajek software and conclusions will be derived.

The systematic review methodology

This manuscript follows the guideline provided by Hemingway and Brereton (2009). Figure 1 describes how the articles were selected, evaluated, analysed and interpreted. The objective of this systematic review methodology will help identify the research streams related to performance measurement in the humanitarian logistics and supply chain context. The first stage of the review process involved the identification of papers and research reports that were concerned with humanitarian logistics and supply chain performance measurement. The authors identified electronic databases and websites that could provide potentially relevant articles. The following databases were searched: Emerald, Science Direct, Taylor & Francis, Springer, ABI/Inform, Scopus and Wiley Online Library. However, some journals are available in more than 1 database, such as IJPDLM which is published in Emerald but available in ABI/Inform. To ensure that there has no duplicated journals, ABI/Inform and Scopus were selected as the main database in this systematic review.

The period of publication of the journal articles is from 1990 to 2016. 1992 was chosen as the anchor point for the review because it was the year that had the highest number of hits when keywords such as “Humanitarian” or “Logistics” or “Supply Chain” or “Performance Measurement” were selected. Nonetheless, earlier literature was also included. This figure also presents the decline by more than 9 percent of humanitarian, logistics, supply chain and performance measurement articles in the year 2015. Moreover, the numbers of articles went down by 62 percent by mid-year 2016 and this particular aspect of humanitarian logistics may have reach its saturation point. The evidence from

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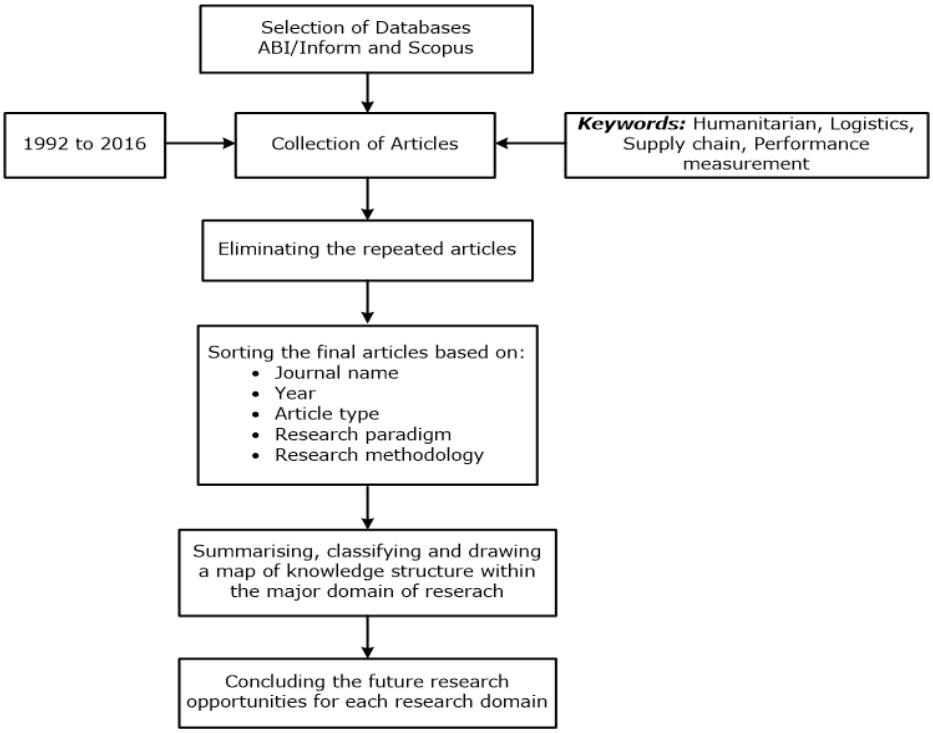
ABI/Inform and Scopus database show that researchers have interest in other humanitarian logistics and supply chain facets; such as knowledge transfer and management humanitarian supply chains; information and communication technology for humanitarian logistics; supply chain co-operation, integration and collaboration in the humanitarian setting; or the role of donors and volunteers in humanitarian logistics, etc.



Source: adapted from Hemingway and Brereton (2009)
Figure 1: Review methodology

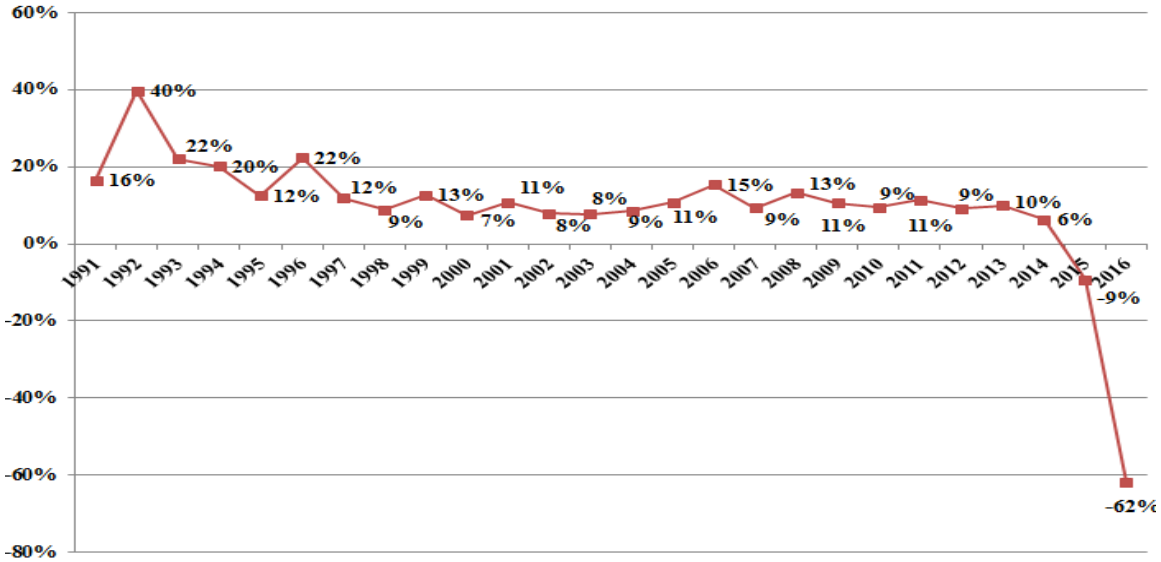


Figure 2: percentage change Y-O-Y of humanitarian logistics and supply chain performance measurement

There are four main keywords used in this review “logistics performance measurement”, “supply chain performance measurement”, “logistics and supply chain performance measurement”, “humanitarian logistics and supply chain performance measurement” and equivalent keywords are also used for

covering all the potential relevant papers. Table 1 summarises the keywords and the search results. This table shows the number of article identified.

Keywords	Equivalent keywords and search strings	Number of articles	
		ABI/Inform	Scopus
Logistics Performance Measurement	Logistics Performance Assessment; Logistics Performance Evaluation	39,208	8,196
Supply Chain Performance Measurement	Supply Chain Logistics Performance Assessment; Supply Chain Logistics Performance Evaluation	41,988	2,016
Logistics and Supply Chain Performance Measurement	Logistics and Supply Chain Performance Assessment; Logistics and Supply Chain Performance Evaluation	15,160	310
Humanitarian Logistics and Supply Chain Performance Measurement	Humanitarian Logistics and Supply Chain Performance Assessment; Humanitarian Logistics and Supply Chain Performance Evaluation	495	195

Table 1: Search keywords and results (1992-2016)

In total 323 articles published in 127 journals were discovered. In order to reduce the number of potential papers related to humanitarian logistics and supply chain performance measurement, the 323 abstracts were screened and 63 abstracts were determined based on the keywords and their suitability for inclusion in the systematic literature review.

The next step was the analysis and interpretation of the selected articles by focusing on the authors, year of publication, research context (country and industry), objective, methodology, article type, data collection method, data analysis method, contributions and classification dimension according to Di Fan *et al*. (2014). The last step was focused on understanding the structure of the research domains by following the guideline of Main Path Analysis (MPA) (Colicchia and Strozzi, 2012) with the Pajek software 4.01 (De Nooy *et al*., 2005).

Classification of research domains

According to the authors' initial finding, humanitarian logistics and supply chain performance can be divided into four categories: (1) mitigation phase, (2) preparedness phase, (3) response phase and (4) recovery phase. It was observed that there were 22 articles related to preparedness phase while 17 and 11 articles focused on preparedness and response phase respectively, then 13 papers on the recovery phase were presented in figure 2 to 5.

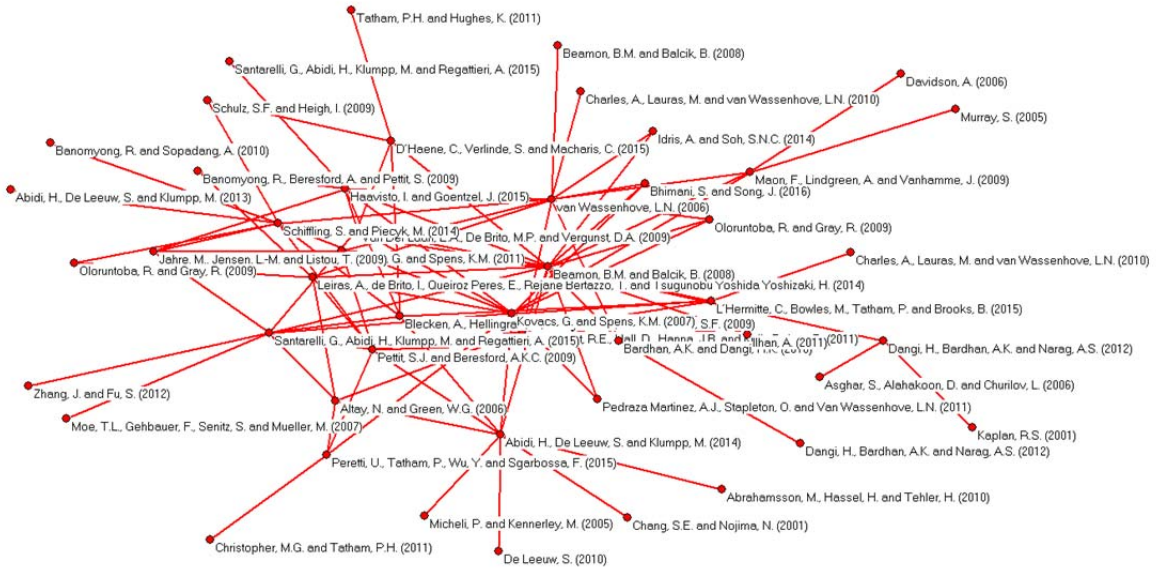


Figure 2: Citation network of the articles in mitigation perspective

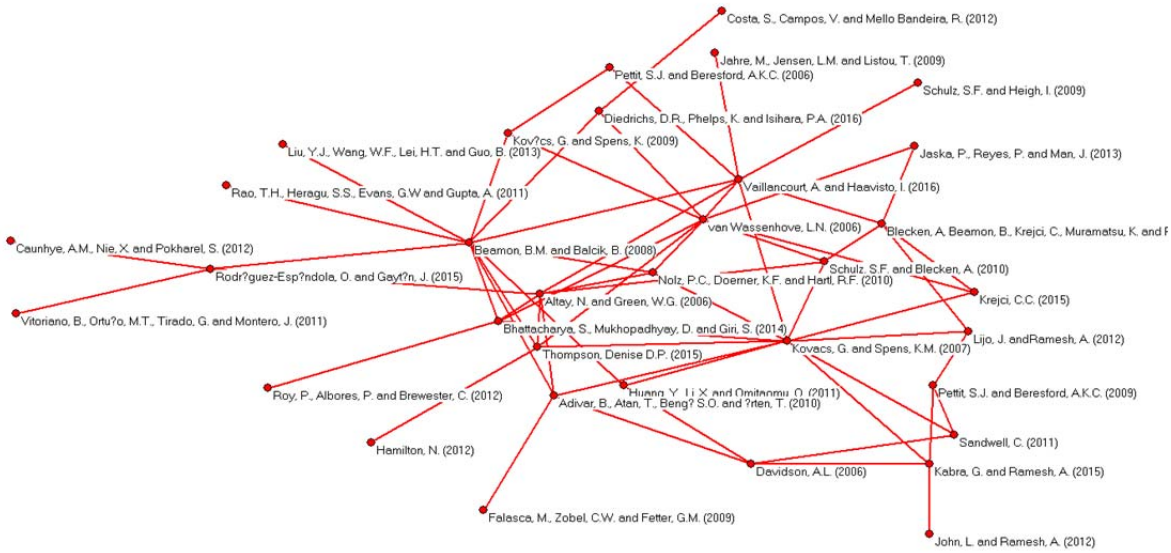


Figure 3: Citation network of the articles in preparedness perspective

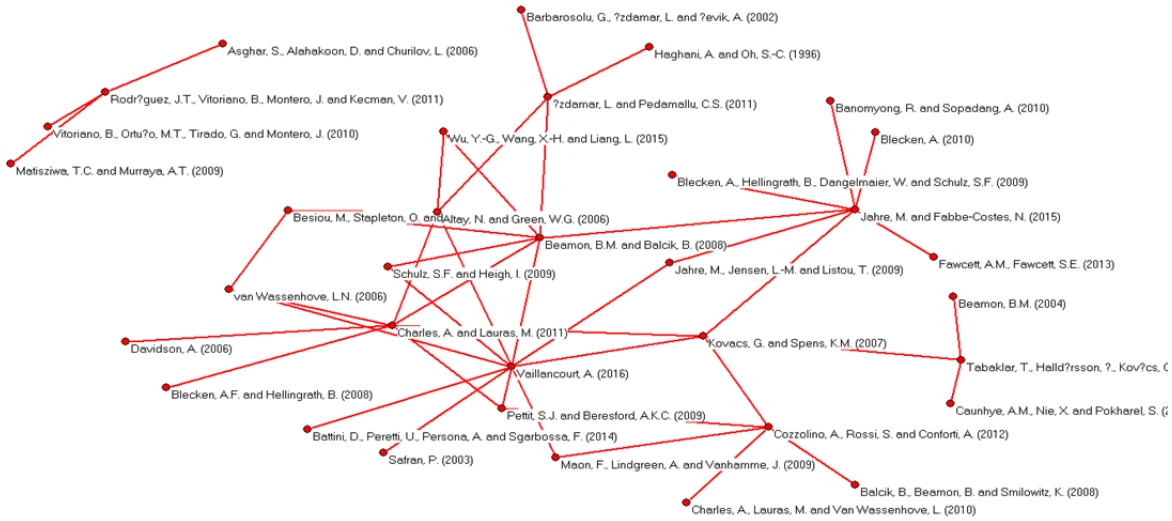


Figure 4: Citation network in response perspective.

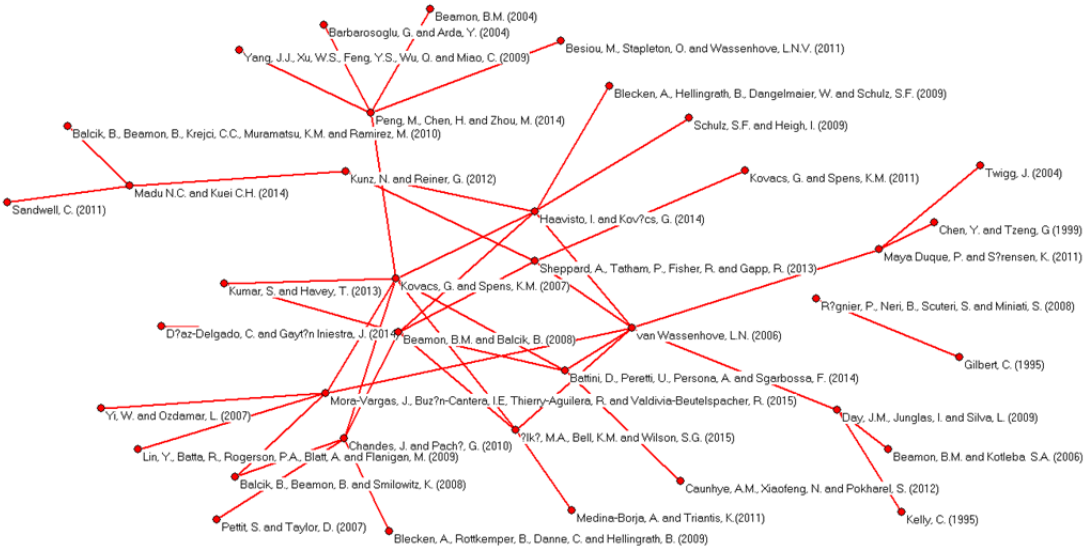


Figure 5: Citation network in recovery perspective.

Research streams path analysis

Figure 2 to 5 illustrated the structure of four research domains which are mitigation, preparedness, response and recovery phase by following Main Path Analysis (MPA) approach (Colicchia and Strozzi, 2012), the authors used the citation network as the key to link each article with Pajek software 4.01 (De Nooye *et al*., 2005).

Reviewing the "mitigation" phase

The first domain is the mitigation perspective as started in 2006 by Altay and Green, also van Wassenhove. After that in 2007, Kovacs and Spens identified a conceptual model that serves as a basis to identify these preparedness challenges. Beamon and Balcik considered facility location decisions for a humanitarian relief chain responding to quick-onset disasters in 2008. Last but not the least, there were two articles published in 2009. The first article is about the critical success factors in Humanitarian Logistics by Pettit and Beresford and the other's aim to discuss three dimensions identified in logistics and organization theories and how they relate to three different cases of humanitarian logistics operations by Jahre, Jensen and Listou. Finally, Blecken *et al*. (2010) identified

the practice of supply chain coordination mechanisms and evaluated their adaptability to the unique relief environment.

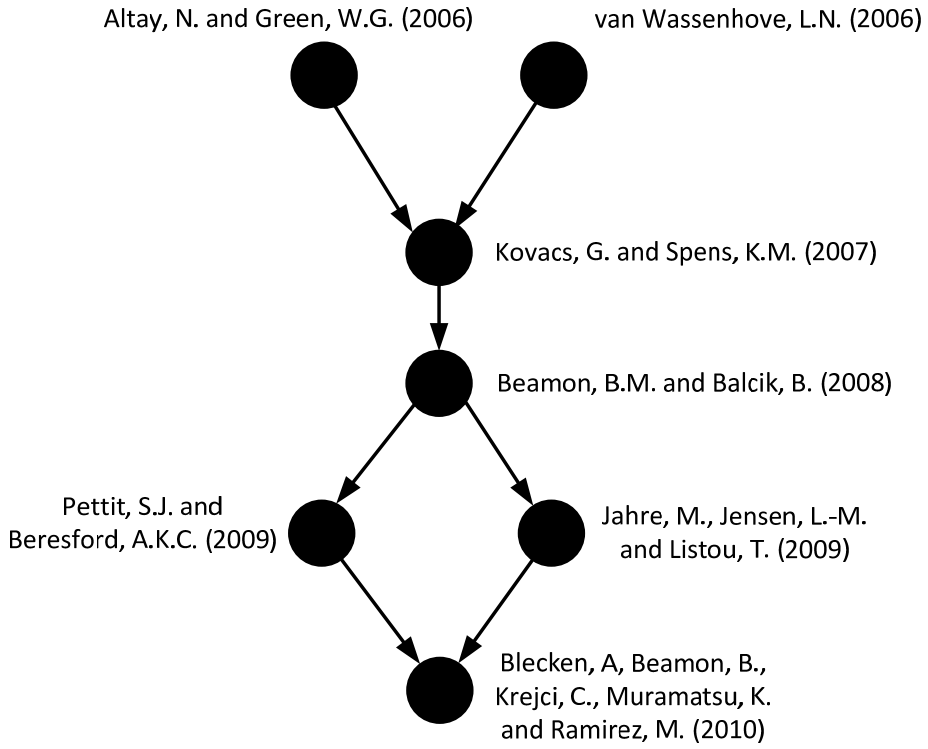


Figure 9: Mitigation path

Reviewing "preparedness" phase

This research domain presents only one cluster with six articles that have the most citations. The starting point is in the year 2006 with three seminal papers by Altay and Green which discussed about OR/MS research in disaster operations management. The second paper is proposed by Pettit and Beresford, they proposed a refined model for logistics requirements in emergency conditions. The last paper introduced by van Wassenhove was built on the idea that private sector logistics can and should be applied to improve the performance of disaster logistics.

In 2007, Kovacs and Spens proposed a conceptual model for disaster's preparedness while Beamon and Balcik identified a model for facility location decisions in 2008. In 2010, Blecken *et al*. reviewed the challenges in coordinating humanitarian relief chains and described current and emerging coordination practices in disaster relief.

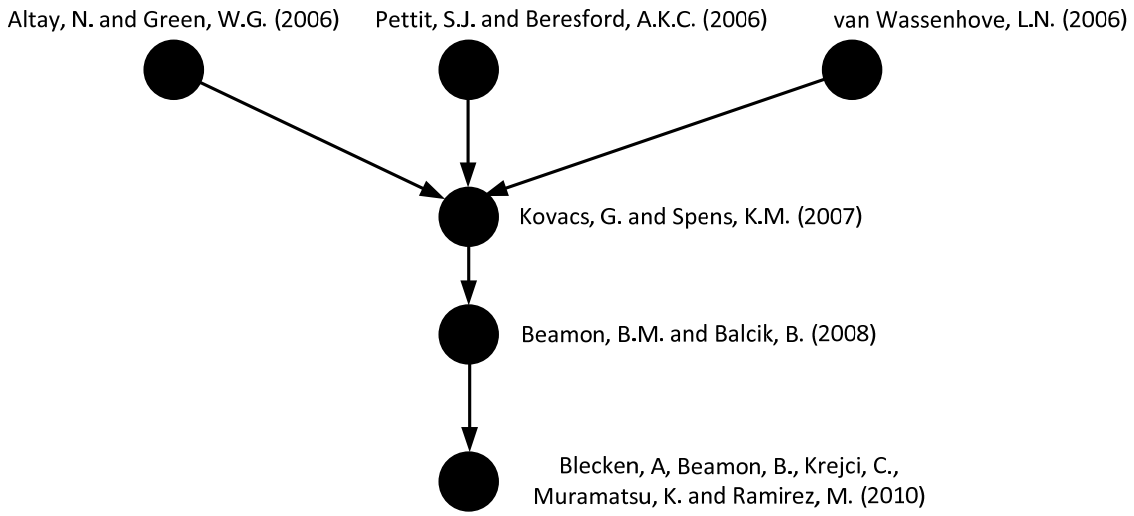


Figure 6: Preparedness path

Reviewing "response" phase

The second domain is focused on the response phase which was classified into 2 research streams. The first stream is similar to the preparedness phase with only two seminal papers by Altay and Green, also van Wassenhove in 2006. After that Kovacs and Spens (2007) and Beamon and Balcik (2008) was linked. The last paper connected to this domain was published in 2009 by Pettit and Beresford related to the critical success factors (CSFs) in the context of humanitarian aid.

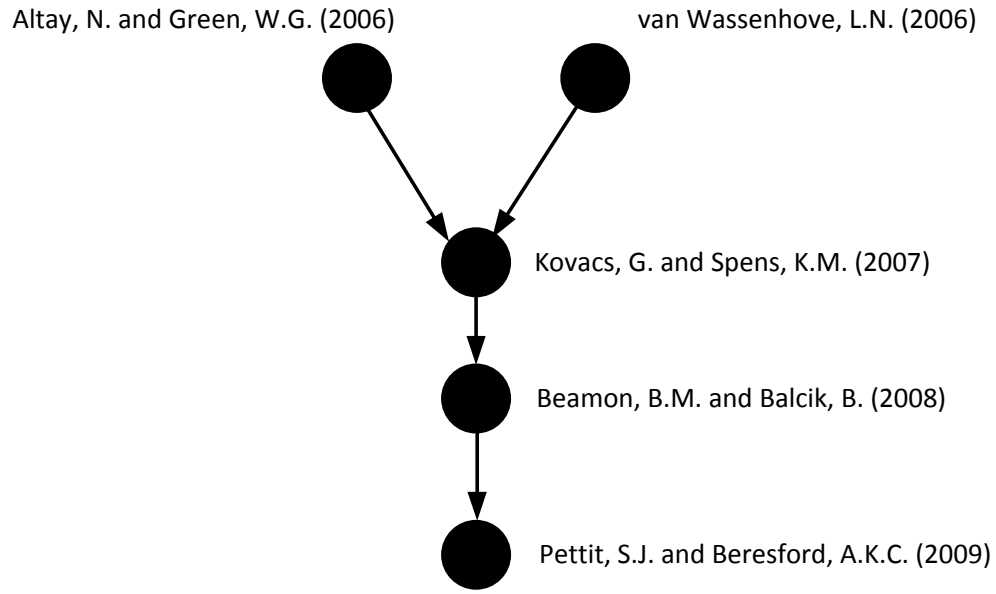


Figure 7: Response path I

There is a second research stream in the response phases which was started by Asghar, Alahakoon and Churilov in 2006, they proposed an integrated model to be used as a solution to reduce the complexity and inefficiency of dealing with multiple Decision Support System (DSS) models for disaster management. After that in 2009, Matisziwa and Murraya proposed an alternative model for constraint structure over existing models. In 2010, Vitoriano *et al*. proposed several criteria for an aid distribution problem. In 2011, Rodríguez *et al*. developed a decision support system (DSS) for the assessment of the severity of natural disasters. It can be noticed that this stream is very focused on how to improve decision-making during a humanitarian event through the use of a DSS model.

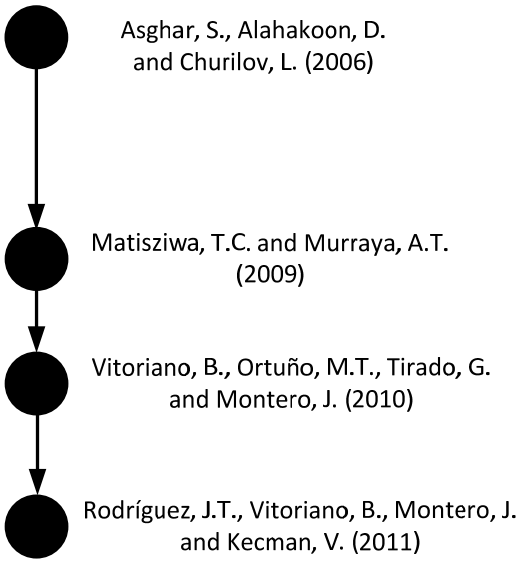


Figure 8: Response path II

Reviewing "recovery" phase

The next research domain is the recovery perspective as proposed by van Wassenhove in 2006, Kovacs and Spens (2007) and Beamon and Balcik (2008) respectively. They provided models to identify and improve the performance of humanitarian logistics such as facility location selection.

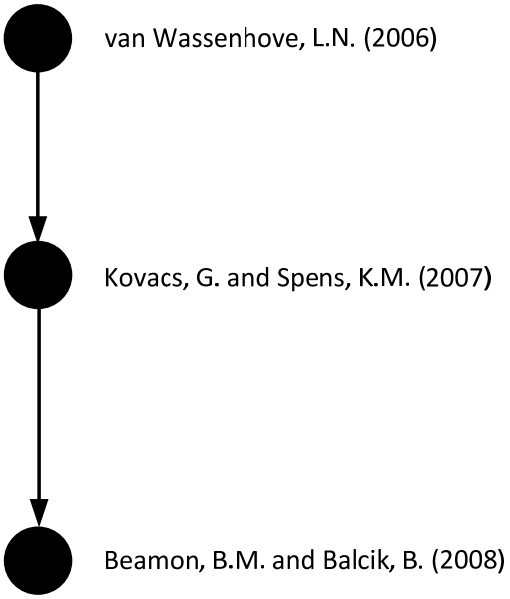


Figure 9: Recovery path

Summary

This study aimed to describe the state of the art literature related to performance measurement in humanitarian logistics and supply chains by using a systematic review. The authors aimed to define the gaps and the challenges in this field and provide insights for future research in this domain. For this performance measurement was based on the classification of the phases of emergency management in four phases developed by Federal Emergency Management Agency (FEMA) in 1978. In doing so, it found that four seminal papers by Altay and Green (2006), van Wassenhove (2006), Kovacs and Spens (2007) and Beamon and Balcik (2008) must be referred to when reviewing humanitarian logistics and supply chain performance measurement as they are at the centre of all research related to performance in the humanitarian logistics and supply chain literature.

The following insights were derived from the systematic literature review: the total number of research articles in this specific field of performance measurement in humanitarian logistics and supply chains is still low compared to the commercial sector. The authors furthermore observed that the topic has gained more attention among European researchers than among US or Asian researchers. There are many valuable contributions based on theory and models, but the number of contributions that deal with actual application in humanitarian sector is limited (too theoretical). Further work is needed on the application of theory and models, particularly in the area of mathematical and stochastic programming as well as decision theory.

A limitation of this study therefore relates to the general validity and reliability of qualitative literature research. Further research in the area of performance measurement is pivotal to not only advance theory but more importantly help improve the logistics and supply chains in the humanitarian context. The success of humanitarian organisations these days relies heavily on excellence in logistics and supply chain as a core competence and functionality of their missions and that requires appropriate performance measurement. Another limitation of this systematic review is based on the restricted scope of material used as the focus has been exclusively on published research papers in academic journals. This narrow scope does not provide insights into the possible direction of each path that may be found in white and policy papers or even conference papers.

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CENTRALIZED PURCHASING OF MANAGEMENT CONSULTING SERVICES. BEYOND INVOLVEMENT, TOWARDS OUTSOURCING.

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Introduction

Purchasing of management consulting services is a challenging and complex task (Mitchell, 1994; Smelzer and Ogden, 2002; Werr and Pemer, 2007; Pemer *et al*., 2014) that has received increasing attention in research and practice. As other professional services they are abstract, built on intangible qualities and dependent on the buyer-supplier interaction which make them difficult to specify, compare and evaluate. But management consulting services (MCS) normally have high strategic stakes, including high prices for the services and giving advice concerning critical situations (Mitchell, 1994). Siewke *et al* (2012) find two main approaches for purchasing MCS: a decentralized where the functional high-level manager decides whether to use consultancies, which, and how much to spend; and a more centralized where e.g. the purchasing department is more involved in selection and contract negotiation phases. Werr and Pemer (2007) add a hybrid approach with some stages in the purchasing approach centralized while other still run by the functional manager. Traditionally, and still in many companies, MCS have been purchased without the involvement of purchasing professionals (Smelzer and Ogden, 2002; Ellram *et al*., 2004; Schiele, 2005; Werr and Pemer; 2007), as the managers instead personally handle the purchase themselves, leading to a situation where the personal relationships between high-level managers and consultants play a central role (Clark, 1995; Smelzer and Ogden, 2002). Although recent studies argue that purchasing professionals could contribute in the purchase of MCS (Ellram *et al*., 2004; Schiele, 2005; Werr and Pemer, 2007; Siewke *et al*, 2012; Pemer *et al*, 2014) to make it more professional (Höner and Mohe, 2009), they also indicate that MCS are among the most difficult for professional purchasers to get involved in.

While researchers argue that there is now a shift ongoing to the more centralized approach (Werr and Pemer, 2007; Siewke *et al*, 2012) there have been little research really exploring the structure and the process of centralized purchasing of MCS. Werr and Pemer (2005) studied 6 companies that used, or discussed to introduce, more professional procedures for purchasing MCS. But they characterized only one of those 6 as centralized, while two were coordinated decentralized, and the final three were decentralized when it came to the purchasing of MCS. The hybrid approach (coordinated decentralization) meant that the purchasing department had taken initiatives to select preferred suppliers, establish master service agreements, developing procedures and templates for dealing with different challenges in the purchasing process.

This explorative study intends to increase the understanding of both the structure and the process of the purchasing function after that purchasing of MCS has been centralized. This is done based on case studies of four large companies that all have centralized their purchasing of MCS and where purchasing professionals are more than just slightly involved. This study extends current research by discussing how the centralization evolves over time; by finding that service definition and supplier selection are done twice; by finding that the cases with longest experience of centralized purchasing of consultancy services even outsources certain steps of the purchasing process to an external middleman that does parts of both tactical and operative purchasing. All of this challenges the traditional perspective that the functional manager must be as a key person in the purchasing process.

This article is structured as follows. First a framework regarding the organization structure and the purchasing process of management consultant services is given before the methodology of the study is described. A cross case analysis follows, before conclusions are spelled out in the final section.

Structure and process of purchasing management consulting service

Organizational Structure

Organization of purchasing is highly dependent on the characteristics of the company, the type of industry, and the characteristics of the products purchased (van Weele, 2010). Traditionally the discussion has been between the decentralized and centralized structure, but Johnson *et al*. (2006, 2012) showed that different kind of hybrid structures summed up to be the most popular organizational mode for purchasing in general. But while around 65% in their studies leaned towards centralization (centralized and centralized hybrid) only 25% leaned against decentralization. van Weele (2010) points in his purchasing development model out centralized and co-ordinated purchasing as an important dimension for more developed practices. In a centralized purchasing structure, a purchasing department can be found where corporate contracting specialists operate at the strategic and tactical level, while operational purchasing still can be done locally (van Weele 2010). Main advantages are that through co-ordination can better conditions in terms of price, cost, service and quality from suppliers be achieved, it facilitates efforts towards production and supplier standardization, better control and compliance (van Weele 2010; Karjalainen 2011). One result of centralized purchasing are often framework agreements, and Karjalainen (2011) describes their results in three main categories of synergies: economies of scale, economies of process, and economies of information and learning. A decentralized structure is characterized of that the management of a business unit is fully responsible for all its purchasing activities (van Weele, 2010). Negative consequences of more relationship-oriented (decentralized) approach to purchasing MCS has been argued to be e.g. uncertain/mis-estimation of consulting demands, unsystematic selection of consultants, the reinterpretation of aim and scope to suit the consultants in consulting projects, assignment of inexperienced consultants in projects, no utilization of synergy potentials, and no evaluation of consulting projects (Ellram *et al*, 2004; Mohe, 2005; Werr and Pemer, 2007).

Purchasing Process

Purchasing activities are often outlined in a purchasing process to get the work more rational, structured and formalized. Contemporary studies of purchasing of professional services in general (van der Valk and Rozemeijer, 2009), and management consulting services in particular (Werr and Pemer, 2007; Pemer *et al* 2014), take van Weele's six-step process for goods as a starting point. This purchasing process (e.g. van Weele 2010) is divided into steps for determining specification, selecting suppliers, contracting (that together forms tactical purchasing), ordering, expediting & evaluation, and follow-up & evaluation (that together form operational purchasing). Although the major steps is argued to work well both for goods and services, different activities in the separate steps get more complicated (or different) when buying services (Axelsson and Wynstra, 2002), due to e.g. the intangible nature of services, the use of personal contacts and experience, and co-production between consultant and client (see e.g. Werr and Pemer 2007 for deeper discussion). A tension was observed between this kind of rational and effective purchasing process and managers' actual purchasing of MCS that was more relationship-oriented. Van der Valk and Rozemeijer (2009) argue that the success of the service purchase is primarily determined during the first step of the purchasing process, and they add two substep after determining specification: request for information, and detailed specification. The information requested from the suppliers should help to further jointly develop and improve the service specification. In essence, they argue for a pre-selection step where the initial specification can be detailed in close collaboration with the pre-selected suppliers.

Centralization vs. decentralization depends on who is performing the different steps in the process. In a centralized structure, strategic activities but also the tactical steps of the purchasing process are driven by purchasing professionals from a central department while the ordering steps can be performed either decentralized (by buying from framework agreements) or by the central function. In a decentralized structure, the central purchasing professionals are very limited and ad hoc involved, and the non-purchasing managers or local purchasers carry out most of the entire process themselves (Werr and Pemer, 2007).

Methodology

This research was part of an explorative project aiming to build knowledge for company X planning to centralize their purchasing of MCS. The study should inform how other companies were doing this and what challenges they have faced, something we argue also is of a general and academic interest. Easton (2007) suggests that if the aim is to advance theory, a comparative case study on elements of that theory is a suitable methodology. Hence, a multiple-case embedded design (Yin 2003) was applied for two reasons. Firstly, case studies are suitable for building in-depth understanding and developing theory when little is known about the studied phenomenon (Voss *et al*., 2002). These cases allowed us to explore and get deep insights into centralized processes for purchasing MCS. Secondly, the embedded case design allowed capturing both insights of the centralized structure, the process, particular activities in different purchasing process steps, and how this evolved over time. So in addition to the focus on the centralized purchasing process (primary unit of analysis), the study also explores the centralization process. For those looking for statistical generalization an often stressed limitation with case study research is its aim to arrive at analytical/theoretical generalization (Yin, 2003). But cases are chosen because of their literal and theoretical relevance, while "generalizability to the sampling population is not of main concern" (Barratt *et al*, 2011, p. 332). Our case selection followed literal replication logic (Yin, 2003) and the research questions informed the selection of four cases of companies that centralized their purchasing of MCS. Other criteria were that they should be large and provide access. (The cases are referred to as InfoCom, FinanceCom, MachineCom, and RetailCom based on their industry). The cases are summarized in table 1. (Page restrictions make us not being able to describe the cases in more details, but short case descriptions could be received by the corresponding author).

	InfoCom	FinanceCom	MachineCom	RetailCom
Year starting to centralize purchase of MCS	1993	2004 (coordination of strategic purchasing; 2007 Framework Agreements; 2011 coordination of oper. purchasing + broker).	2012 (only techn mgmt consulting) (2000 temporary labor services).	2011
Organizational structure for purchasing before centralization of MCS	*Indirect material:* decentralized and unstructured. *Direct material:* decentralized.	*Indirect material:* decentralized and unstructured. *Direct material:* centralized.	*Indirect material:* decentralized. *Direct material:* decentralized.	*Indirect material:* decentralized. *Direct material:* centralized.
Type of MCS centralized	Business services, financial, marketing, management, IT etc.	IT (70%), management, accountants.	Technology mgmt consulting.	IT, management, finance, insurance, marketing, technology.
Type of MCS NOT centralized yet	None.	Some strategic MCS doesn't follow similar process as others, but are dealt with centrally.	IT, general management, accountant, project, quality, environment, law, HR, recruitment.	Confidential.
Differences in purchasing process.	All follow the same purchasing process.	Most follow the same purchasing process. Exception, see above.	Non-centralized MCS are planned to follow the standardized purchasing process later.	All follow the same purchasing process.
Centralized activities	Strategic, tactical, and most of operative purchasing.	Strategic, tactical, and most of operative purchasing.	Strategic and tactical purchasing. A centralized VMS-system will coordinate and control most of oper purchasing.	Strategic and tactical purchasing.
Possibility to buy outside Framework agreements	No.	No (some exceptions).	No.	No.
Number of suppliers	1 Framework agreement with Vendor broker (since many years).	1 Framework agreement with Vendor broker.	Tech mgmt consultants: a few framework agree-ments, one with broker.	15 (including both framework agreements and for separate services).

Table 1: Overview of the cases

InfoCom is a big global company leading its industry, having over 400 000 employees when the centralization process of indirect material and services started 1993. For InfoCom the vendor broker has had a crucial role in the ordering process since 2007 with which the main framework agreement is and with whom they have a close relationship. Employees from the vendor broker sit a few days per week in InfoCom's offices so that information can be shared more easily. FinanceCom is a leading player on the Nordic financial market, with activities in Northern Europe, and about 15 000 employees. It started to centralize purchasing of indirect material and services 2004, when the company had a decentralized structure where each line managers purchased consultants needed themselves. Before the implementation of the vendor broker, FinanceCom used about 150 consultancy providers whereof 10-15 were more strategic and had a framework agreement. Now the vendor broker handles most of the operative purchasing, and this firm is in principle the only provider FinanceCom has a framework agreement with. MachineCom is a big global company (~150 000 employees) leading its industry. Data is collected from the Nordic region (including the Nordic countries, British Island, Baltic states, and Russia), but this purchasing department is part of a global corporate structure. The company has a decentralized purchasing structure for direct material, but for indirect material and services strategic and tactical activities have been centralized for most

categories. Within the category Contracted services, purchasing of e.g. temporary labor (blue and white collar) was centralized already from 2000, but the work to centralize purchasing of consultants (black collar) started 2012. RetailCom is a Swedish retail chain with about 3000 employees. It has two separate purchasing processes for direct vs. indirect material. RetailCom started to centralize the purchasing of indirect material 2011, and part of this was professional services including MCS.

Guiding theory and investigation framework were developed based on current research on centralized purchasing of MCS, purchasing processes in general and professional services in particular, and purchasing organization. The framework served to map where, how and by whom different activities in the purchasing process were performed. A pilot study (a fifth case not explicit reported here) was used for fine tuning the investigation framework, case study protocol and interview guide. An important observation from this, as supplement to previous literature, was the separation of selecting consultancy firm for the framework agreement, and selecting the individual consultant for a specific project. This made us more thoroughly investigate the specification, selection and ordering process. One of the strengths of the case study method is the possibility of carrying out multiple data collection techniques to get a deeper understanding of the phenomenon (Eisenhardt, 1989). Data were collected through nine semi-structured open interviews with strategic purchasers and managers leading the transformation, were the interview guides were send in advance. The interviews covered multiple themes to map current and previous organization and processes, as well as the change management process. The interviews (in average 90 minutes) were both recorded and transcribed. Data were triangulated with other data collection techniques and sources (Yin, 2003; Ellram, 1996; Marshall and Rossman, 1999). Interviews were complemented by collection and analysis of annual reports as well as company internal documents (organization charts, process descriptions). Finally the cases were sent to respondents for validation and confirmation.

The analysis was conducted in two rounds: first for cases individually, and then across cases. In line with qualitative data analysis guidelines (Miles and Huberman, 1994), the raw data were progressively reduced and organized. After all individual case descriptions were finalized, a number of tables were devised for each case (as suggested by Miles and Huberman, 1994). A pattern matching approach (Yin, 2003) was followed using manually constructed cross-case tables and processes (see table 1, figures 1 and 2). These helped to reduce and make sense of the data (Miles and Huberman, 1994) and identify theoretically important similarities and differences (Yin, 2003) across the cases. The understanding gained from this analysis was compared with suggestions from theory to refine the conceptual model and further our understanding of the topic.

Cross case analysis and discussion

Centralized purchasing process for MCS

The purchasing process for management consulting services (MCS) follows similar patterns for the four studied cases. It is handled by a central function for purchasing of Indirect Material and Services, and as is often treated as a sub-category to the category Professional services. The cases have all centralized their strategic and tactical purchasing activities (policy and process development, spend analysis, defining specification, supplier selection, and contracting) that lead to a framework agreement with a consultancy firm. The operative steps (ordering, evaluation & follow up) had more decentralized and local involvement, but were still within standardized processes and getting support from central purchasing, automatic support system, or external vendor brokers. The operative steps resulted in a call off of an individual consultant coming from one of the few providing companies having a framework agreement. This observation can be noted as a clear distinction from the view of authors like Gummesson (1977) stating "..buyers purchase the services of individuals in whom they have confidence, not those of consulting companies"; and Edvardsson (1990) stating "buyers is less interested in the service itself and more in the individual service provider/consultant". In the systematic purchasing processes developed by professional purchasers, seen in our cases, the focus is instead first on selecting the providing firms based on the needed and specified services. In comparison to previous discussed processes in literature, the four cases had then established a

specific sub-ordering process for calling off individual consultants based on a previously centrally negotiated framework agreement. In the latter steps the functional manager/user had a larger role and could make interviews with individual consultants, based on selected CV's. This indicates a movement of roles and responsibilities. In comparison with Werr and Pemer (2007), the degree and scope of centralized activities in the purchasing process observed in our cases were much larger, and suggest that the trend of more specialized purchasing professionals involved in purchasing of MCS has continued.

For most of our cases the operative purchasing steps were decentralized and done locally, but three of the four cases had also involved a neutral external middleman, vendor broker, for these steps. (Examples of such vendor brokers on the market are ZeroChaos and eWork). This use of an external middleman for purchasing MCS is something we have not seen discussed before in research literature. To move the involvement and execution of buying activities from the functional managers first to centralized purchasing professionals – and then further beyond this to external companies, is from our perspective an interesting observation. This might indicate that when the purchasing of MCS can be demystified and separated from functional managers, purchasers might be able to better define the services and make them so "tangible" that parts of the purchasing processes can be more automated and even outsourced.

A purchasing process for MCS, developed based on the four cases and van Weele's (2010) classical process, is outlined in figure 1. This process clearly divides between the more tactical sourcing activities (leading to framework agreements with providers) and the more operative ordering processes (starting from the framework agreement and leading to a purchase order) of an individual consultant. For all companies spend analysis was stressed as an important and initial step, and hence it has been added not only as a part within "selecting supplier" but as an initial step before specification of the service. A reason for the importance of spend analysis related to purchasing of MCS might be its history of decentralized purchasing, and that companies in their transformation to centralized purchasing really have to understand what were bought, from whom and by whom.

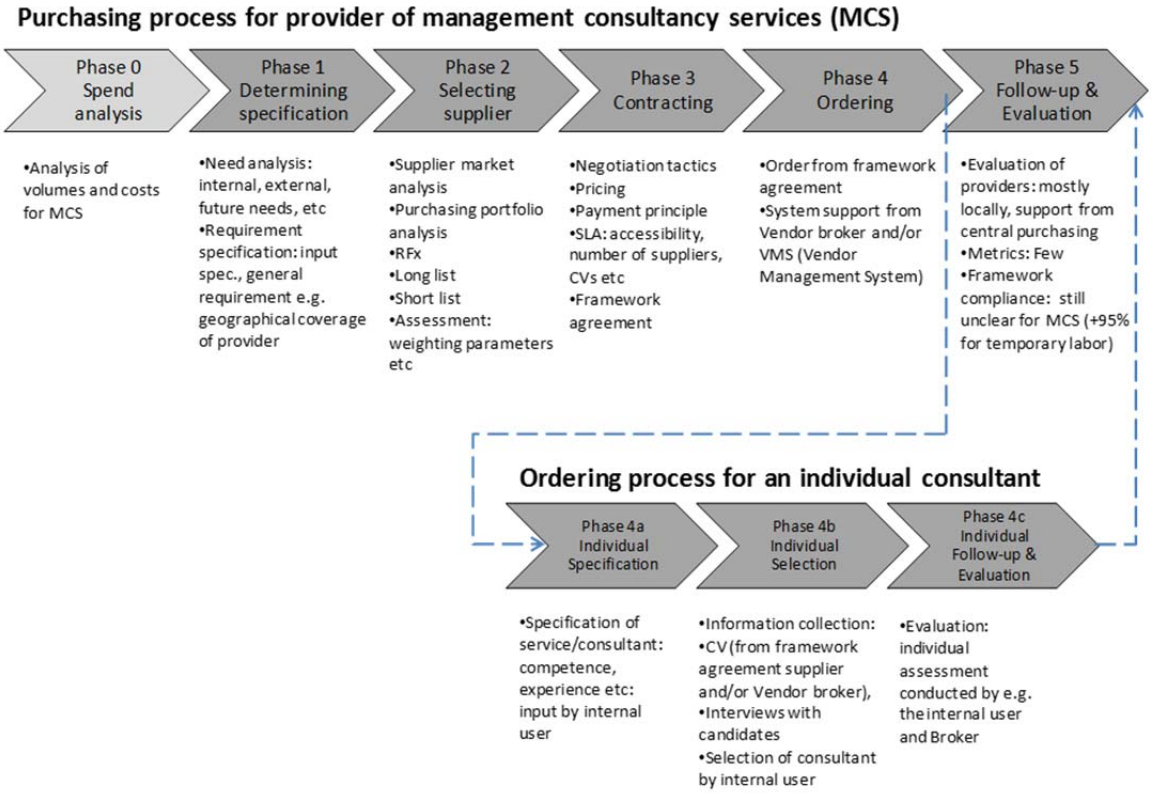

Figure 1: Process for purchasing management consulting services

While the tactical steps (until phase 3) are well aligned with the classic and rational process normally used for goods, we see some differences in the ordering process that are needed to handle some of the particularities of MCS. Some more steps are taken when an individual consultant should be hired. First a specification of the individual service/consultant needed is further detailed by purchasing professionals and functional managers/users working together. In some cases the user is filling in templates previously defined by central purchasing. Based on this specification, the central purchasing (sometimes with help from a system or an external vendor broker) collects different individual consultant's CVs, and gives the functional manager a selection of those that meet the specification. The CVs come from different companies that either have a framework agreement with the company, or are part of the vendor broker's supply base (in case only the vendor broker has a framework agreement). Then, if needed, the functional manager/user interviews some of the selected candidates, and the user makes this final selection. Assessment of the individual consultant is done later by the user, following a process and using templates developed centrally. Evaluation of the providing firms is done by the professional purchaser, and sometimes supported by the external vendor broker.
Our observation of the second round of specification and selection in the ordering process was a distinction to previous theory (van der Valk and Rozemeiher, 2009). They suggested a second round of specification to take place already in the tactical process before contracting.

Outsourcing of purchasing activities to middlemen
As mentioned, a surprising observation was the use of a neutral external middleman. The explanation might be that the demystification of the purchasing of MCS in three of the cases had gone so far that an external middleman could take over activities in the tactical sourcing steps. In the two most mature cases (InfoCom and FinanceCom) most of the activities in the ordering process were also moved to the vendor broker. In fact those two companies only had framework agreements with the vendor brokers and not directly with consultant firms. The third case, MachineCom, had a Vendor Management System (VMS) supporting internal local buyers for most of the operative purchasing, but used the vendor broker to handle the "tail of suppliers". From a supply risk and a government perspective, it has to be reflected on whether the use of a vendor broker creates more of a neutral and transparent market place for the purchaser, or it instead leads to a monopoly situation.

Sequential development of the centralized purchasing of MCS
Werr and Pemer (2007) ask for longitudinal studies for finding evolutionary paths of purchasing's functional role in purchasing professional services. The design of this study is not longitudinal, but our observations of the companies' development over time can be seen through such a lens.
A pattern of different sequential stages of the centralization process can be outlined, where the two most centralized cases (InfoCom and FinanceCom) also are the ones that started to implement it first, while the newer cases (MachineCom and RetailCom) not are as centralized. It seems hence that the degree of centralization develops over time (see figure 2). All cases first centralized the more strategic/tactical steps, while InfoCom and FinanceCom then centralized also more operational activities. To do this, they leveraged information systems and an outsourced partner (the vendor broker). For InfoCom we also observe a more centralized process for monitoring and evaluation, while FinanceCom so far only is planning for this. The power of the functional managers/user has in general decreased, and their role are more to first give input to the specification, and then, if needed, to be part of the individual assessments of proposed consultants. Another observation is that more activities get automated over time, by the use of different systems (such as VMS).

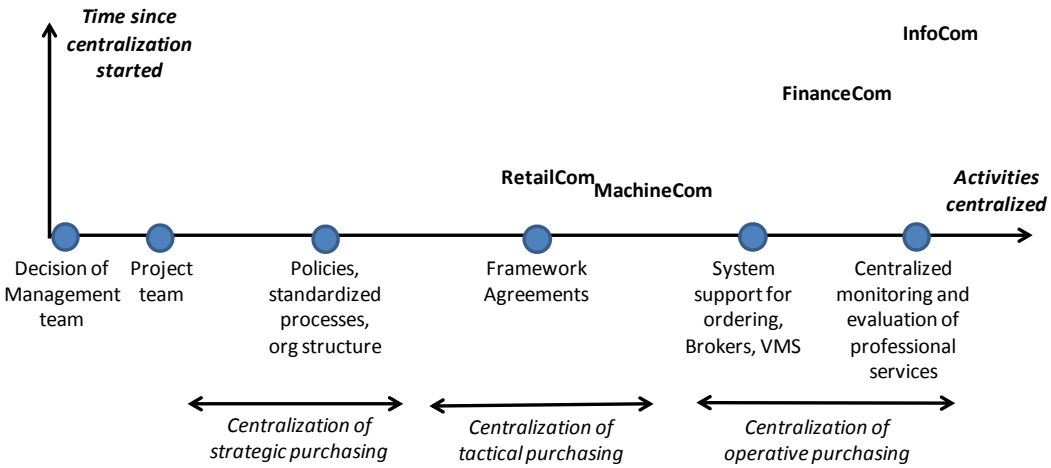

Figure 2: Development for centralization of purchasing of management consulting services

The least developed cases, MachineCom and RetailCom, both have reached the stage where the tactical purchasing is centralized with framework agreements as output. MachineCom has then continued, and developed a plan for their centralization of operative purchasing, e.g. the implementation of the VMS and the use of a vendor broker for "the tail" of their suppliers. In much, their plans are aligned with the pattern observed for InfoCom and FinanceCom.

Conclusions

Contributions

In general purchasing develops toward centerled organizations (centralized and centralized hybrids), while purchasing of management consulting services often have been purchased directly of the functional managers/users (decentralized). Previous research has lately argued for a movement also for this category towards centralization and more involvement from professional purchasers, but there has been a lack of deeper empirical studies into it. This study has focused on to understand the centralized purchasing of MCS, and confirms that companies can go in this centralized direction of implementing more rational purchasing process where functional managers get separated from controlling the strategic and tactical purchasing process. The functional manager/users are often still involved by giving input for the specification of the general services needed, and in particular involved in the operative ordering process of individual consultants. This study contributes with descriptions, discussions and insights from cases that have gone further in their implementation of centralization (really done it) than we have found in previous reported research. In doing this, we have contributed by outlining an adapted purchasing process based on findings from the cases.

It seems possible to implement a centralized purchasing process, although the power position functional managers/users historically have had. Traditionally, the view was that consulting services were not purchased from providing firms, but individual managers bought individual consultants (compare Gummesson (1977) and Edvardsson (1990)). We have now observed a clear pattern of clients' professional purchasers selecting consultancy firms that gets framework agreements, and then the selection of individual consultants is a step in the ordering process where the functional managers might be involved for further service specification and direct interviews. As previous studies in this area, we used van Weele's (2010) classic purchasing process as a starting point. This study confirms that it seems to work well in general also for centralized purchasing of MCS. However we observe, in comparison both to van Weele's processes and the suggested process from van der Valk and Rozemeijer (2009) a difference. We suggest the sub-specification and sub-selection of individual consultants to take place in the operative ordering process. Demystification of services seems to be critical for being able to implement a more centralized and rational purchasing process. This is for MCS done by approaching their intangible nature with 2 stages of specification (first for the providing service/firm, later for the specific service/consultant), the personal contact by involving more

professional and central purchasers or external middlemen on the tactical level, and letting the user evaluate only a proposed limited number of individuals first in the ordering process.
Another contribution is the observation and discussion of the use of an external middleman both in the tactical sourcing process and in the operative ordering process of MCS. This contradicts the previous argued importance of the functional manager. It indicates not only involvement of central purchasers, but also that after centralization, demystification and structuring of the purchasing process of MCS could certain activities also be outsourced. Further we point out a sequential development process of the centralized purchasing organization, where first strategic purchasing activities are centralized, then the tactical sourcing process. Finally companies, that have been working long time with centralization, also could centralize some of the operative ordering activities, e.g. by automating or outsourcing some of them. Measurement and follow up are finally approached from the centralized function, but involve functional managers/users to get their assessments as input regarding individual consultants.

Limitations and further research

The study is limited to the general boundaries of case study research, e.g. the inherent boundaries of the range and size of the sample. Four large companies from four different industries have been studied, and this research could be extended by more companies – especially from other industries and sizes. Although some of the companies have been global, the data collection has been done mainly in Sweden, a country that from a cultural perspective is characterized as a feminine and low level uncertainty avoidance culture. Our observations of processes that have increased their formalization and created a larger distance between functional user and provider are not fully in line with the current research of Pemer *et al* (2014a). The cultural aspects of the centralization issue, especially when it should be implemented in global companies, is hence a research area worthwhile continuing in. Our findings should be seen as early indicators and propositions, and must be further evaluated and tested. Especially the question of where in the process specification of the service should be done could be further researched, as our observations differ from van Valk and Rozemeijer's (2009) suggestion. Research could for example investigate if the positioning is dependent of different situations and contingencies. Our proposition regarding the sequential centralization process must also be further tested.
Finally, the potential role and long term impact of middlemen's (vendor brokers) involvement in the purchasing process of services would be interesting to increase knowledge about. Issues here could be the development of middlemen's power position, and the functional user's acceptance for those new players. Of interest would also be how problems in the service delivery are handled when the client's contract is with the vendor broker, and how risk and gain sharing looks like in this extended service supply chain. Another research topic is the middlemen's role in the service triad, e.g. the vendor broker's relation to their suppliers (the consultancy forms) and how it works with communication and feedback. In this direction follows also issues connected with if the client would like to transfer more of consultancy projects into performance based contracting.

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CHARACTERIZATION OF FOOD PROCESSING MANUFACTURERS WITHIN THE CHAOPRAYA WATERSHED

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Introduction

Food industry is, economically, one of the most important manufacturing sector of Thailand. Possessing the rich of natural resources, the country's food processing industry is relied on agricultural products, within related supply chains. There are plenty of agricultural products, which are used as raw materials in the food industry. Moreover, Thailand also exploits modern production technology for adding value to agricultural products. This mechanism strengthens the food security of the country. Although most processed food products target the international market, domestic consumption continues to grow due to lifestyle changes that have resulted in increased demand for greater convenience concerning food. Processed food products are available in a wide variety of local retail outlets, most major Thai supermarkets such as Tesco Lotus, Makro, Gourmet Market, Big C, Foodland, and Tops. The boost by a government policy, namely, "Kitchen of the World", is a driving force for Thailand's food industry has expanded in recent years. The policy bas focused, tactically, on the field of food production in the region and expand investment channels to an increasingly global market. Thailand, recently, become an important production-base in the region, and a major food exporter in the world market. In 2014, Thailand exported about US$ 30 billion in the amount of food to the major countries, such as Japan, USA, China, UK and ASEAN. Thailand's food exports are evenly distributed across major geographical regions. National Institute for Food (NIF) states that Japan was Thailand's biggest market for food products, taking 14% of the total the export values, followed by the US at 11.1%, China at 7.6%, and Indonesia 3.8%. NIF, in addition, forecasts that Thailand's food industry will increase by 17% in 2015. Important Thai food exports in the following areas: fishery products, meat products, cereal products, fruit products, and vegetable products as shown in table 1 Thailand's exported food products, 2011 – 2014.

In the year 2011, Thailand's worst flooding in half a century, is severely impaired the economies of the industry and society. Floodwaters inundated 90 billion square kilometres of land, more than two-thirds of the country, ranking as the costliest natural disaster. Flood crisis affected a total of 4,039,459 households and 13,425,869 people; 2,329 houses were completely destroyed, while 96,833 houses were partially damaged; the death toll has reached 657 people and 3 were missing. As of December 2011, World Bank estimates the damage to have reached THB 1,440 billion. Because of the effects on the major industrial sector, unemployment repressed due to the closure of several factories. The economy continues to be in an awkward position that the impact of flooding has reduced the confidence of investors and insurance, which will lead to an increase in unemployment and poor economy. The water has cut off areas north of Bangkok, including a significant number of key industrial centers located in the Chao Phraya watershed, and the output is stopped. Food processing industry, another substantial income in the economy has suffered a loss of THB 1.2 billion.

These types of natural disasters do not fundamentally change the current structure of food processing supply chains as the companies concerned will pay more attention to planning for emergencies, business continuity risk management of suppliers and management of its operations. The logic of this argument is based on the fact that the relevant place of production selected for economic reasons, and which might not easily be changed due to natural disasters. We now consider the characterization of food industry supply chain network for business continuity which may disrupt flood disaster, looking at the case of a manufactures in the Chaopraya watershed area. Effective food supply chain network (FSCN) is explored dynamic behaviours for Thai food manufacturers a

competitive advantage and improve the flexibility of the organization very devastative flood disaster today.

This study identifies the behavioural characteristics of dynamic FSCN from the producers of food processing and tests their relationship to organizational performance. The main focus is to explore the characters and behaviours of food processing manufacturers within the Chaopraya watershed. Data were collected from the enterprises of food processing supply chain in the area.– The questionnaire was distributed to organizations in the four food industry supply network i.e. processed meat, processed fruit, packed rice, and sugar. The observed data were analyzed based on collaborative strategy framework. using statistical analysis software package with appropriate descriptive analysis. The finding results will be an underpinning data to formulating of damage evaluation model: modification of existing model flood and drought damage function model. The fundamental limitation of lacking d of data sources.

Related literature

Overview of Thai food processing supply chain

In 2014, GDP agriculture agricultural sector (excluding forestry) accounted for 39.14 billion USD or 10.5 % of nominal GDP of the country. Thai food processing industry's raw materials is relied on production of agricultural supply chain, with complement with of imported agricultural raw materials, partly. The underpinning agricultural sub-sectors are crop production 84 %, livestock 9 %, and fisheries 7%, respectively. The cereal crops mainly comprise of sugarcane, rice, cassava, while fruit corps include mango, pineapple plants. Vegetable corps, majorly, consist of potatoes, garlic, onions, shallots. Livestock groups include chicken meat, and fisheries include shrimp (please see details in table 1). Thailand's agricultural sector utilizes 12.7 million workers, representing 33.4 % of the country's employment.

Food processing production has the highest proportion value of Thai manufacturing sector, accounted for 22 % of GDP in the entire manufacturing sector in 2014. Main players of food processing industry are in small and medium enterprises (SMEs). Production capacity of Thai food processing industry increase continuously to 28.5 million metric tons, which 59% for domestic market, 35% supply to export market, and the rest 6% is reserve as nation food security storage. The food processing products on the domestic market, include condiments, feed package, vegetable oil, animal fats, meat and dairy products, respectively. While the major export food processing product are cassava starch, sugar. aquatic processing, and process fruit and vegetable. The food processing industry have used appropriated innovative technologies, which can add value and achieved the quality and safety standards at the international level.

Export Group	2011		2012		2013		2014	
	Metric Ton	Million US$	Metric Ton	Million US$	Metric Ton	Million US$	Metric Ton	Million US$
Fisheries	1,669,774	7,977	1,632,453	7,958	1,406,824	6,789	1,419,377	6,322
Cereal	11,263,919	6,692	7,028,034	4,857	7,357,086	4,702	11,921,834	5,816
Meat	545,219	2,335	648,676	2,646	640,971	2,689	706,184	2,892
Sugar	6,521,046	3,602	6,853,112	3,929	5,994,946	2,812	6,293,590	2,710
Fruit	2,189,739	2,285	2,290,247	2,123	2,292,276	2,224	2,279,198	2,494
Non-Alcoholic Beverage	962,011	1,197	1,130,606	1,340	1,448,978	1,499	1,886,789	1,719
Tapioca starch*	1,894,194	928	2,237,932	993	2,451,236	1,135	3,019,855	1,268
Vegetable	556,353	645	508,943	612	473,368	601	495,019	629
Condiment & Seasoning	234,648	472	243,659	503	263,270	545	283,137	586
Alcoholic Beverage	306,386	338	816,809	547	382,110	450	316,088	436
Baby food	125,188	359	114,216	357	131,944	366	145,172	391
Palm oil	381,847	394	292,830	305	549,213	427	221,929	199
Confectionery	41,642	161	44,518	191	43,133	179	39,605	138
Other	1,172,670	2,269	1,256,311	2,365	1,417,235	2,615	1,450,116	2,805
Total Food	27,864,636	29,654	25,098,346	28,726	24,852,590	27,033	30,477,893	28,405

Table 1 Thailand's Exported Food Products, 2011 – 2014 Source: Anomynous (2015)

Food Supply Chain Network (FSCN)

The food industry is becoming an interconnected system with a large variety of relationships. This is reflected in the market place by the formation of (virtual) FSC alliances, horizontal and vertical cooperation, and forward and backward integration (Van der Vorst, et al., 2009). An FSCN comprises organizations that are responsible for the production and distribution of vegetable or animal-based products. From a general perspective, there are two main types:

1. FSCN for fresh agricultural products (such as fresh fruit and vegetables). In general, these schemes may be manufacturers, auctions, wholesalers, importers and exporters, retailers and their suppliers, as well as specialized logistics services. Processes are the primary method of treatment (with air conditioning), storage, packaging, transport and distribution of food. Over time the quality of the product may either increase (e.g. fruit ripening) or decrease - if they are harvested at the mature stage.
2. FSCN for food (such as meat, portioned meals, snacks, desserts, canned). Generally, these chains consist of manufacturers, importers, food industry, and retailers and out-of- home segment and logistics service providers. In these chains, agricultural products used as raw material for the production of consumer goods with higher value added. Sometimes consumer goods hardly tenable on savings processes.

Supply Chain Risk Management in food industry

Several articles review of the literature on supply-chain disruption (Ellis et al., 2011; Ivanov et al., 2014; Heckmann et al., 2015). Tan and Musa (2011) show that research in this area has increased dramatically since 2004, Tang (2006) defines supply chain risk management as " the management of supply chain risks through coordination or collaboration among the supply chain partners so as to ensure profitability and continuity." Diabat et al. (2012) organize the risk sources relevant for supply chains into three categories: (1) external to the supply chain; (2) internal to the supply chain; and (3) network-related. Moreover, they classify risks into two categories: (1) supply risks (e.g. capacity limitations, currency fluctuations and supply disruptions); and (2) demand risks (e.g. seasonal imbalances, volatility of fads, new products). Since supply chain disruptions can have long-term negative effects on a firm's supply chain performance, competitiveness, and financial performance, firms need to implement a proactive supply chain risk management toward their vulnerabilities.

The manufacturing process may be designed in different ways. For example, changes in manufacturing activity may be indicated by a comparison output during certain subsequent periods. This method of analysis generally provides acceptable measurement variable success of the manufacturing process, but says little about the production process itself (Kittipanya-ngam et al., 2011). Nothing indicated the relative importance of different types of productive activity or the respective amounts of productive resources are used in the production of different types of property. The results illustrate the significant positive relationships between the eight characteristics of FSCN and organizational performance. This indicates the importance of these behavioural characteristics FSCN dynamics that companies need to develop and implement effectively to maximize organizational performance. The results reveal that the flexibility of the organization has the strongest relationship with performance. Therefore, it should be a top priority of management in the implementation FSCN.

Effect of Natural Disasters to Supply-chain disruption

Contemporaneous with rising climate change, the frequency of natural disasters in the world has been steadily increasing over the years, reaching its highest rate (with an average of 450 natural disasters per year) in the past decade. Flood, one of devastated natural disasters, inflict tremendous social, economic and human costs. It has the potential to affect the economic development not only of a domestic economy, but also the rest of the world, given the extent of interconnected production networks in this globalized era. Several recent flood disasters have been of an extremely large magnitude and have resulted in proportionately large economic and social costs for the affected

domestic economies, and their effects have increasingly extended to many other parts of the world. Flood disasters not only create large economic costs, but also have a direct impact on people in terms of loss of lives and dislocation of families. Thus, it is imperative for us to study these tragic events carefully, to ascertain policy gaps and lessons, and to highlight key economic and social policies to manage such a disaster. Pettit et al. (2011) suggests that the new economic dimension of natural disasters is a fragile supply chains. As policymakers must address the dangers to citizens caused by natural disasters, it is now necessary for economists and business people to find ways to soften. The very real threat of these events on the international economy. Many Japanese companies, have operations in Thailand, play important role in the supply chains. The companies that suffer significant efforts to recover activities quickly. In the latter two cases, serious problems need to be addressed. In addition, assessing how disasters may influence firms' strategic decisions regarding their subsidiary activity and structure, managers may employ an initial risk calculus where the firm's response would be in proportion to the loss of life and the duration and severity of the disaster (Abe and Thangavelu 2012). Chomsri and Sherer (2013) shows the most recent example of a major natural disaster disrupt both domestic production and regional supply chains in Thailand in the fall of 2011, when production was affected by widespread flooding in huge parts of the country. This was the second incident within one year have been severely affected by a major natural disaster, the activities of "Factory Asia", and served to the threat to the global manufacturing and the need for appropriate measures to be taken to further underline. Abe and Thangavelu (2012) study, on Indonesia, the economic and social consequences of the earthquake in Yogyakarta in 2006. The earthquake led to the deaths of more than 5,700 people, and hundreds of thousands lost their homes. The paper examines the determinants of livelihood recovery after this natural disaster and in particular the role of the support that the recovery process. They found that: (a) small businesses are resilient and thus be able to recover faster; (b) an industrial cluster system within a district judge provides the necessary support for the companies to recover; (c) the quality of the village infrastructure can be important; and (d) it is important to support early as possible to minimize the damage caused by natural disasters.

In recovery phase after natural disaster hit, supply chain resiliency is enhanced when the capacity is increased by the alternative sources of supply. A number of documents, to evaluate the benefits of using multiple power sources. Anupindi and Akella (1993) consider the procedure for the assignment between the two providers, one of which is more expensive, and the production process makes it uncertain supply. Development of an optimal ordering policy for three types of contracts. Li et al. (2010), to analyze the situation of a dealer who buys from two suppliers (subject to random failures) and the spot market. The stated results include the characteristic equivalent Librium prices, the impact of pricing strategies violations, as well as the coordination mechanism in order to maximize profits, if the suppliers cooperate.

Collaborative supply chain (CSC)

Collaboration between supply chain partners was widely covered in the strategic management literature (Gilmour 1999, Bowersox et al. 2000). Studies have shown more research, for example, those in the main direction of the supply chain is to improve the inter-enterprises level (Stank et al. 1999). Chen (2001) has examined the theoretical implications of supply chain collaboration and by unilateral policies. Others have used theoretical models to examine the bilateral exchange of information instead of unilateral political incentives (He et al. 2002, Li 2002). Some studies, recently, (Simatupang and Sridharan 2005, Lambert et al. 2004), are interested in a better characterization of the CSC. SC is working often defined as two or more companies working together to create a competitive advantage and more profile that can only be achieved by acting alone. In the paper the term collaboration, is chosen to describe the close cooperation between independent partners in the mutual efforts to effectively meet the needs of the end customer at a lower cost. The advent of supply chain collaboration creates a need, to inter- enterprises level, to pay particular attention to the

understanding of cooperation to prepare the partner for the creation of collaborative e ff orts success (Lambert et al. 2004)

The advent of collaborative supply chain creates the need, multi-level to pay particular attention to the understanding of cooperation to prepare members of the chain to create a successful partnership initiative (Lambert et al., 2004). However, previous research supports the hypothesis that collaboration is a one-way phenomenon that emphasizes collaboration feature such as information sharing or co-managed inventory. Little attention was paid to capture the different features that represent different areas of cooperation. This lack of consideration helps explain why operators find it difficult to address the issue of partnership understanding (Mentzer et al., 2000). Alternatively, a mutual approach is more appropriate to define the collaborative supply chain because explicitly revealed a phenomenon of interaction between key collaboration features (Lee, 2000). Since the objective of improving the overall performance, the mutual approach is to ensure that the main characteristics match or complementary.

Building a framework for characterization of food industry supply chain network

In order to identifies the behavioural characteristics of dynamic FSCN from the food processing producers and tests their relationship to organizational performance, the methodology must be as follow:

1) To explore the typical characteristics exhibited by manufacturers who are in the Chaopraya watershed area. The study data are collected from 151 manufacturing organizations in the Chaopraya watershed region, located on the banks of Chaopraya River, listed from north to south.
2) To identify dynamic behaviours in food processing businesses that have specifically increased the complexity beyond the capability of existing supply risk management approaches.

This article selected the term collaboration to address the close cooperation between strategic partners who are involved in joint efforts to effectively meet describe the needs of customers from the end of less. The emergence of supply chain collaboration creates a need, at the international level companies, to pay particular attention to the concept of collaboration to prepare partners for joint efforts with success (Derrouiche, et al. 2008).

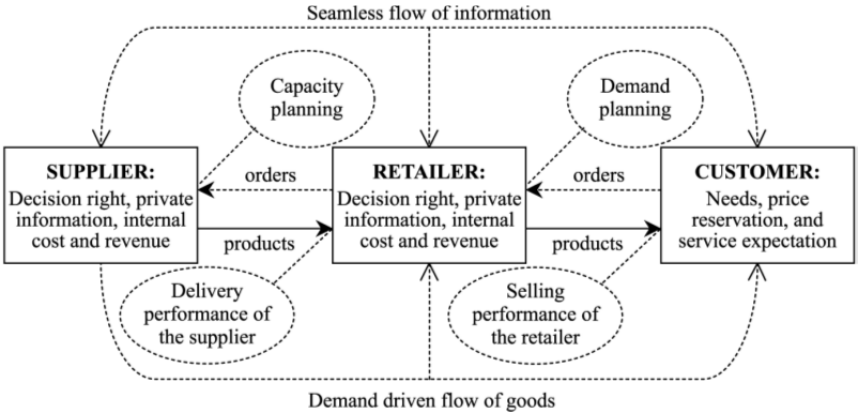

Figure. 1. A simple structure of a collaborative supply chain (Simatupang, and Sridharan, 2004)

Figure 1 shows a simple structure of the collaborative SC with two players who are on the same consumer. Consumers may be included in the collective, if it takes a major role participating in the development and delivery of the product. The following properties are inherent to SC: the retailer has the right to make decisions to make (for example, placing orders and targeted sales), personal information, (e.g. consumer demand) and internal costs and revenues. The supplier also has the right

to their own solutions (e.g. supply and installation of the production), personal information (e.g., product specifications) and the internal costs and revenues (Simatupang, and Sridharan, 2004).

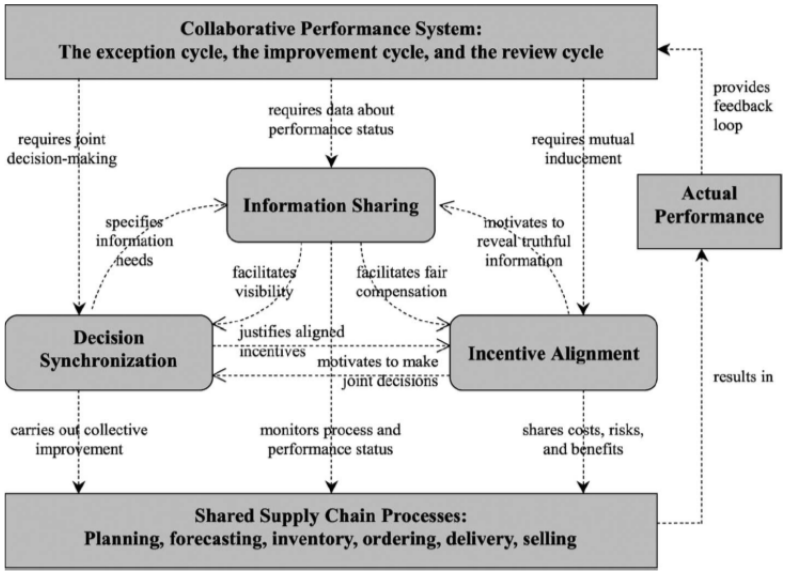

Figure. 2. the collaborative supply chain framework (Simatupang and Sridharan, 2005).

Simatupang and Sridharan (2005) presents a framework for understanding the phenomenon of interaction among the different characteristics of cooperation in the supply chain of the Inter-Organization perspective. It consists of five cooperation elements, that constitute the core of the collaborative supply chain framework (CSCF): (1) a collaborative performance system (CPS), (2) information sharing; (3) decision synchronization, (4) incentive alignment; and (5) integrated supply chain processes, as show in figure 2. By theoretical, in addition with empirical background evidence is produced to justify and support the proposed framework (Simatupang and Sridharan, 2005). Each function can be considered as the favourable factor that facilitates collaboration acts. The arrows in Figure 2 represent an attempt to capture the dynamic nature of the reciprocal relationship between multiple frame of connection characteristics.

Methodology

Data collections and sample

In this paper, we construct the questionnaire survey, based on collaborative supply chain framework (CSCF) which proposed by Simatupang and Sridharan (2005). A regional self-reported manufacturer questionnaire survey was carried out in food processing industry sector in Thailand. A sampling based on the Chaopraya watershed area (according to Department of Water Resource (DWR), comprises, geographically, of 19 provinces, this thesis will scope the area in 9 provinces: Nakhon Sawan, Chainat, Singburi, Ang Thong, Ayutthaya, Pathum Thani, Nonthaburi, Bangkok and Samut Prakan, following the Chaopraya water board, as stated by DWR.) was conducted to ensure the representativeness of the regional-wide surveyed sample. Data were collected from the enterprises of food processing supply chain in the area.

Factor	Catigories	Amount	Percentage
Number of employees	Up to 10	18	11.92%
	11-50	72	47.68%
	51-250	42	27.81%
	over 250	18	11.92%
Registed Capital (THB Million)	Up to 2	11	7.28%
	3-10	40	26.49%
	11-55	24	15.89%
	56-100	12	7.95%
	Over 100	13	8.61%
Annual income (THB Million)	Up to 10	10	6.62%
	11-50	39	25.83%
	51-100	25	16.56%
	101-500	12	7.95%
	over 500	14	9.27%
Ownership structure	Domestic private	72	47.68%
	Domestic public	13	8.61%
	Foreign	0	0.00%
	Combined domestic/foreign	15	9.93%
Indusrty	Prcessed Fruit	58	38.41%
	Packed Rice	61	40.40%
	sugar	32	21.19%
		151	

Table 2 Summarizes the company characteristics of the respondents to this survey

Source: Authors' own research

The questionnaire was distributed to organizations in the four food industry supply network i.e. sugar, packed rice, and processed fruit. The sampling unit is the business firms and the questionnaire was rated by respondents with the main responsibilities for supply chain risk management. General company-profiles (e.g. number of employee, registered capital, annual income level, entrepreneurship status, and industry type) were also collected. Of a total of 300 questionnaires sent out, 151 were returned, with a successful response rate of 40.33 per cent, as shown in Table 2.

Data analysis and results

The results from one-way ANOVA tests shown in Table 3 indicate that food processing manufacturers' practices toward awareness of collaboration strategy, namely well development of front end agreement, create joint business plan, and create sales forecast, indeed differ among these three clusters, respectively ($F\text{–value}_{sugar}$=565.32, p<0:0001; $F\text{–value}_{packed\ rice}$=35:98, p< 0:0001; $F\text{-value}_{processed\ Fruit}$= 1313:05, p< 0:0001). The mean scores of the respondents' well development of front end agreement for sugar, packed rice, and processed meat are 2.44, 3.90, and 5.5.57, respectively; and the mean scores of the respondents' create joint business plan for sugar, packed rice, and processed fruit are 5.00, 4.87, and 5.64, respectively. The mean scores of the respondents' create sales forecast: sales forecast exception criteria for sugar, packed rice, and processed fruit are 2.61, 4.07, and 5.60, respectively.

The results from repeated measures ANOVA tests for each segment are also reported in table 3. The respondents of each segment indeed have different levels of collaboration strategy practicing in the nine criterion of CSCF, based-on to the food supply chain network (FSCN) investigated in this study ($F\text{-value}_{sugar}$ = 3:86; p < 0:0001; $F\text{–value}_{packed\ rice}$= 27:33; p < 0:0027; $F\text{–value}_{processed\ fruit}$= 8:76; p < 0:0001).

Charaterization by Collaboration Strategy	Sugar		Packed Rice		Processed Fruit			
	n_1=25		n_2=35		n_3=51			
	Mean	SD	Mean	SD	Mean	SD	F-Value	Pr>F
1. Well development of front end agreement	2.44	0.87	3.90	0.77	5.57	0.85	565.32	<0.0001
2. Create joint business plan	5.00	1.30	4.87	0.85	5.64	0.83	35.98	<0.0001
3. Create sales forecast: sales forecast exception criteria	2.61	0.66	4.07	0.41	5.60	0.53	1313.05	<0.0001
4. Identify exceptions for order forecast: order forecast exception criteria	2.43	1.00	3.71	0.92	5.18	1.11	295.18	<0.0001
5. Resolve on exception items	2.62	0.91	4.19	0.74	5.69	0.75	583.92	<0.0001
6. Resolve on Delivery condition	2.51	0.88	3.93	0.74	5.54	0.84	550.31	<0.0001
7. Order forecast	3.45	1.19	4.64.	0.95	5.61	0.82	185.81	<0.0001
8. Order generation	2.76	1.03	4.11	0.83	5.73	0.69	485.23	<0.0001
9. Delivery process	2.87	1.32	4.59	1.08	5.85	0.82	290.9	<0.0001
	3.86		23.71		8.76			
	<0.0027		<0.0001		<0.0001			

Table 3 Mean scores characterization of food processing manufacturers by Collaboration Strategy
Source: Authors' own research

Conclusion

In conclusion, FSCN with the Chaopraya Watershed no matter whether industrial types are lack of strategically supply chain risk management, they do significantly not exploit collaborative strategy practices. However, the respondents among the three food processing networks all utilize joint business plan. Furthermore, the respondents loosely possess cooperation in delivery and order fulfil processes.

Indeed, the manufacturing process may be designed in different ways. For example, changes in manufacturing activity may be indicated by a comparison output during certain subsequent periods. This method of analysis generally provides acceptable measurement variable success of the manufacturing process, but says little about the production process itself. Nothing indicated the relative importance of different types of productive activity or the respective amounts of productive resources are used in the production of different types of property. The study helps manufacturers in the development and implementation of effective FSCN. The next step is developing a damage recovery from flood disasters numerical model, based on the complexity beyond the capability of existing supply risk management approaches.

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COMPARING DIFFERENT PERCEPTIONS TOWARD LOGISTICS MEGA PROJECT: A CASE OF PAKBARA DEEP SEA PORT IN THAILAND

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Introduction

Nowadays, the logistics infrastructure was play important role in developing area. Especially, the mega logistics project can ease daily live and can also bear the social attitude, which is the dominant factor to the project. There are many people who had affect with the project; government sector, private sector, especially local residents. This paper aims to demonstrate the conflict of perception on logistics mega project by using the case of Pakbara deep-sea port in Satun province, which is the project that had been planning for long time but there is no permission to construct until now. People who live in project area disagree with the government and push their campaign to against this project consistently.

The goal of this study is to better understand the difference perception between local residents on the logistics mega project in the case of Pakbara project in Thailand, including their concern about the project.

Literature Review

Social support

Social support is the support from individuals or groups. The social support may be in terms of information, money, workforce, or emotional support. This support can push the people who get supported o reach the goals (Caplan, 1976). In Addition, Gottlieb (1985), Duangkhamsawad, (1996), Cassel (1997) mentioned in the same that social support is giving the helps in terms of information data and psychological support for those who were supported.

In another way, there is the difference definition of social support. Albrech et al. (1987) mentioned that social support is the reaction between the donor and recipient to help, including the developing the awareness of the issues. In this paper, the study of perceptions of the people to mega project in Thailand: Pakbara deep-sea port, was develop the support model under the concept of social support from Caplan (1976), Gottlieb (1985), Duangkhamsawad, (1996), and Cassel (1997). The social support in mega project divided into 4 aspects: emotional, appraisal, information, and instrument support.

Literature in port development project

There are many papers that studied about the development in port. Anastasopoulos, Kolios,, & Stylios (2011) Wang (2011), Jiun-Bing Sheu et. Al (2013), Burskyte, Belous, and Stasiskiene (2011), and Shan, Yu, and Lee (2014) mentioned about port development that the key factor of successful port development is the readiness of basic facility. The seaports in the many countries have successful in port operation because they had good infrastructure. For example, Rotterdam port in Netherland has the warehouse for special containers; there are a lot of technology to transfers the containers, etc.

From the literature review found that the most of researches were about port operation, including the impact arising from port operation. There is less studied about the perception of the port project. In

addition, there is less research about the conflict on the logistics project from stakeholders, especially institutional trust. Therefore, this study aims to demonstrate the perception of people on port project by comparing the difference perception between stakeholders in that area.

Methodology

For comparing the perception of locals, the respondents were separated in 2 groups. The multiple group analysis will be in term of the difference in gender (male and female) and the difference in address (La-ngu district and other district) (Figure 1).

The perceptions of supporting Pakbara deep-sea port was used under the sustainable development model which consists of 3 aspects: economic, environment, and social and culture (WCED, 1987). Moreover, this study aims to examine the perceptions on logistics mega project, the logistics and technology aspect was added to the model. In addition, this project has a lot of conflict between stakeholders. Therefore, the trust aspect was added to the model as well.

In endogenous latent variable, the supporting theory was used to explain the supporting of the project. The social support is consists of 4 aspects; emotional, appraisal, information, and instrument support (Gottlieb, 1985).

Construct		Items	Item description
Supporting the project	SUP	SUP_1	emotional support
		SUP_2	appraisal support
		SUP_3	information support
		SUP_4	instrument support

Table 1: The observed variables for endogenous latent variable

Construct		Items	Item description
Economic	ECN	ECN_1	better income distribution
		ECN_2	higher employment
		ECN_3	higher land value
		ECN_4	higher foreign investment
		ECN_5	better economic in overview
Environment	ENV	ENV_1	air pollution
		ENV_2	noise pollution
		ENV_3	waste pollution
		ENV_4	marine resource
		ENV_5	worse environment in overview
Social & culture	SOC	SOC_1	more safety
		SOC_2	better life style
		SOC_3	more turbulence
		SOC_4	worse in health
		SOC_5	better social and culture in overview
Logistics & Technology	LOG	LOG_1	variety of transportation mode
		LOG_2	variety of route
		LOG_3	easier to connect by electronics
		LOG_4	better technology in port
		LOG_5	better logistics in overview
Institutional Trust	TRS	TRS_1	more trust in main government
		TRS_2	more trust in local government
		TRS_3	more trust in project owner
		TRS_4	more trust in institution overview

Table 2: The observed variables for exogenous latent variables

The data of this study were collected through a self-administrative questionnaire. The questionnaire was distributed to 310 people who live in Satun province. The number of samples was calculated by the Rule of Thumb in the ratio of 1 parameter to 5 samples (Diana, 2006). The questionnaire consisted of 4 parts: social-economic demography, the perception of impact from this project, the perceived support in this project and the suggestion for this project. The questions of this study were used in Likert scale questions from 1 (strongly disagree) to 5 (strongly agree). The multiple groups – structural equation model (MG-SEM) was conducted for measuring the difference local perceptions.

This paper use Structural Equation Model (SEM) using "Lavaan" package in R software to access the relationship between the impact and support for the project. SEM estimation consists of Confirmatory Factors Analysis (CFA) that was run to test the measurement model and Path analysis which is used to test the relationship between exogenous latent variable (impact) and endogenous latent variable (support). in this study, the multiple group structural equation model was used to demonstrate the SEM in terms of difference characteristics of respondents.

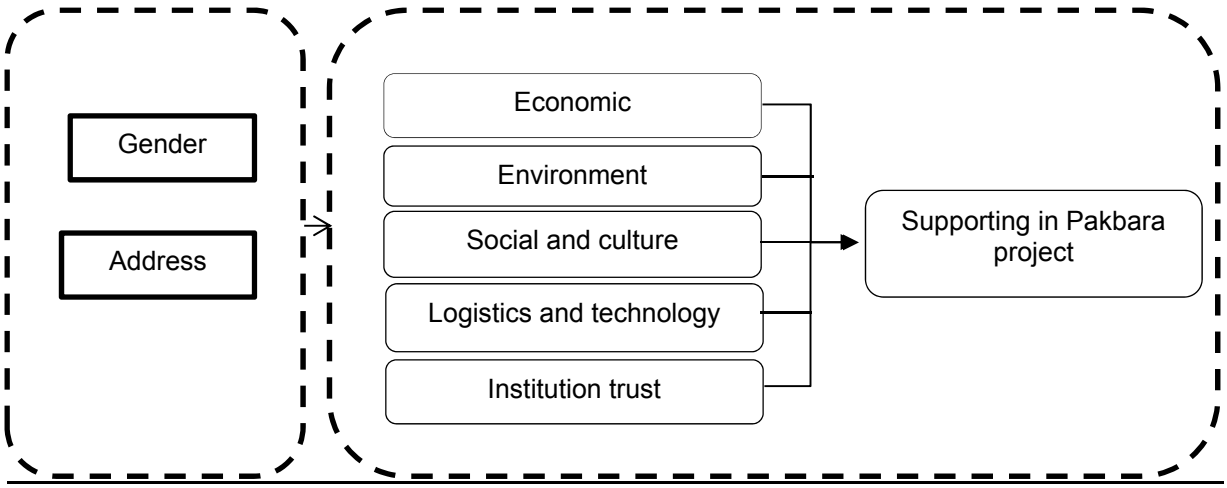

Figure 1: Conceptual Framework of this study/ Research model

Result

The characteristics of respondents

Genders	**Frequency**	**per cent**
Male	119	38.39
Female	191	61.61
Address		
La-ngu district	196	65.33
Other district	114	34.67
Total	**310**	**100.00**

Table 3: The characteristics of respondents

Respondents were questioned about demographic characters as shown in Table 1. There were 61.61% female respondents and 38.39% were male. The majority respondents were lived in La-ngu

district which is the project area, with 65.33%, and 34.67% were live in the other district in Satun province as well.

The multiple groups – structural equation model (MG-SEM) (in Gender)

In term of gender, the multiple groups – structural equation model is statistically fitted to the data at the goodness of fit index more than 95% (CFI = 0.960, TLI = 0.952).

In measurement model of female, all items in economic aspect have statistically significant at at $p<0.05$. Higher land value (ECN_3) has highest factor loading (0.913). Better economic in overview (ECN5) has 0.904, higher foreign investment (ECN4) has 0.857 of factor loading, more job creation (ECN2) has 0.772, better income distribution (ECN1) has 0.733, respectively. In environment aspect, all items have significant. More waste pollution (ENV3) has highest factor loading, with 0.928, worse environment (ENV5) has 0.921, worse in marine resource (ENV4) has 0.918, more noise pollution (ENV2) has 0.854, more air pollution (ENV1) has 0.787, respectively. In social and culture aspect, there are only 3 items that have statistically significant; worse in health (SOC4) with 0.934 of factor loading, 0.892 in better social in overview (SOC5), and 0.663 in more turbulence (SOC3). In logistics aspect, 4 items have significant at $p<0.05$. Trust in project owner (TRS3) has highest factor loading, with 0.882, 0.787 in overview trust (TRS4), 0.836 in local government, and 0.673 in main government.

In measurement model of male, there is the same structure significant but there is a little bit different on factor loading. All items in economic aspect have statistically significant at at $p<0.05$. Higher land value (ECN_3) has highest factor loading (0.938). Better economic in overview (ECN5) has 0.888, higher foreign investment (ECN4) has 0.843, more job creation (ECN2) has 0.777, and better income distribution (ECN1) has 0.771, respectively. In environment aspect, all items have significant. More waste pollution (ENV3) has highest factor loading, with 0.906, worse environment (ENV5) has 0.872, worse in marine resource (ENV4) has 0.836, more noise pollution (ENV2) has 0.853, more air pollution (ENV1) has 0.788, respectively. In social and culture aspect, there are only 3 items that have statistically significant; worse in health (SOC4) with 0.922 of factor loading, 0.852 in better social in overview (SOC5), and 0.698 in more turbulence (SOC3). In logistics aspect, 4 items have significant at $p<0.05$, with 0.798 in variety of route (LOG2), 0.774 in better in logistics overview (LOG5), 0.767 in easier connect the information (LOG3), and 0.567 in variety of mode transportation (LOG1). In institutional trust, trust in project owner (TRS3) has highest factor loading, with 0.882, 0.787 in overview trust (TRS4), 0.836 in local government, and 0.673 in main government.

From figure 2, the MG – SEM in female was shown that the factors that have effect to female support are environmental impact (ENV) and institutional trust (TRS) with factor loading of -0.181 and 0.442. This means that the environmental impact had effect to female's support in negative way but it was quite small impact. The institutional trust had effect to female's support in positive way. On the other hand, the factor that has effect to male's support just only logistics and technology impact (LOG), with the factor loading 0.373. This means that logistics and technology impact has positive impact to male's support.

Construct	Estimate	Std. err	Z-value	P(>|z|)	Std. lv	Std. all
ECN	0.101	0.106	0.949	0.343	0.075	0.075
ENV	-0.227	0.100	-2.269	0.023	-0.181	-0.181
SOC	-0.195	0.123	-1.585	0.113	-0.125	-0.125
LOG	0.261	0.147	1.778	0.075	0.184	0.184
TRS	0.704	0.156	4.519	0.000	0.442	0.442

Table 4: The path analysis in MG-SEM (Female)

Construct	Estimate	Std. err	Z-value	P(>|z|)	Std. lv	Std. all
ECN	-0.015	0.154	-0.100	0.921	-0.012	0.012
ENV	-0.323	0.179	-1.800	0.072	-0.234	-0.234
SOC	-0.206	0.216	-0.957	0.339	-0.130	-0.130
LOG	0.728	0.345	2.112	0.035	0.373	0.373
TRS	0.143	0.207	0.693	0.448	0.082	0.082

Table 5: The path analysis in MG-SEM (Male)

The multiple groups – structural equation model (MG-SEM) (in Address)
In analysis of MG – SEM with the difference in address, we separate the respondents in 2 groups, the people who have lived in La-ngu district and other district in Satun province. The model was fitted more than 90% level of goodness of fit (CFI = 0.949, TLI = 0.939).

In measurement model of La-ngu people, all items in economic aspect have statistically significant at at $p<0.05$. Better economic in overview (ECN_5) has highest factor loading with 0.914, higher land value (ECN_3) has 0.895, higher foreign investment (ECN4) has 0.889, better income distribution (ECN1) and job creation (ECN2) has 0.808, respectively. In environment aspect, all items have significant too. More waste pollution (ENV3) has highest factor loading, with 0.889, worse in marine resource (ENV4) has 0.884, worse environment overview (ENV5) has 0.867, more noise pollution (ENV2) has 0.814, more air pollution (ENV1) has 0.691, respectively. In social and culture aspect found that there are only 3 items that have statistically significant; worse in health (SOC4) with 0.936 of factor loading, 0.879 in worse social and culture in overview (SOC5), and 0.679 in more turbulence (SOC3). In logistics aspect, 4 items have significant at $p<0.05$, with 0.845 in better in logistics overview (LOG5), 0.815 in easier connect the information (LOG3), 0.755 in variety of route (LOG2), and 0.716 in variety of mode transportation (LOG1). In trust aspect, trust in overview has highest factor loading with 0.882, 0.880 in trust in project owner (TRS3), 0.806 in local government trust, and 0.719 in main government, respectively.

In measurement model of other district people, there is the same structure significant but there is a little bit different on factor loading like the estimation in gender. All items in economic aspect have statistically significant at at $p<0.05$. Higher land value (ECN_3) has highest factor loading (0.949). Better economic in overview (ECN5) has 0.877, higher foreign investment (ECN4) has 0.805, more job creation (ECN2) has 0.718, and better income distribution (ECN1) has 0.661, respectively. In environment aspect, all items have significant. More waste pollution (ENV3) has highest factor loading, with 0.912, worse environment overview (ENV5) has 0.909, worse in marine resource (ENV4) has 0.871, more noise pollution (ENV2) has 0.858, more air pollution (ENV1) has 0.828, respectively. In social and culture aspect seen that there are only 3 items that have statistically significant; worse in health (SOC4) with 0.935 of factor loading, 0.846 in better social in overview (SOC5), and 0.653 in more turbulence (SOC3). In logistics aspect, 4 items have significant at $p<0.05$, with 0.890 in variety of route (LOG2), 0.786 in easier connect the information (LOG3), 0.667 in variety of mode transportation (LOG1) and 0.627 in better in logistics overview (LOG5). In institutional trust, trust in project owner (TRS3) has highest factor loading, with 0.899, 0.795 in local government (TRS2), 0.777 in overview trust (TRS4), and 0.544 in main government (TRS1).

From figure 3, the MG – SEM in address model is interesting that the people who live in project's area and others have completely difference perception in supporting this mega project. The impact aspect

that has effect to people who live in La-ngu district are logistics and technology impact (LOG), institutional trust impact (TRS) and social impact (SOC) with the factor loading 0.388, 0.293 and -0.268, respectively. This means that social and cultural that may change from this project has negative effect to La-ngu people's support.

Construct	Estimate	Std. err	Z-value	P(>|z|)	Std. lv	Std. all
ECN	-0.122	0.096	-1.264	0.206	-0.121	-0.121
ENV	0.233	0.125	1.861	0.063	0.154	0.154
SOC	-0.369	0.120	-3.080	0.002	-0.268	-0.268
LOG	0.495	0.186	2.660	0.008	0.388	0.388
TRS	0.404	0.188	2.153	0.031	0.293	0.293

Table 6: The path analysis in MG-SEM (La-ngu people)

Construct	Estimate	Std. err	Z-value	P(>|z|)	Std. lv	Std. all
ECN	0.488	0.184	2.658	0.008	0.313	0.313
ENV	-0.487	0.139	-3.505	0.000	-0.433	-0.433
SOC	0.067	0.193	0.348	0.728	0.042	0.042
LOG	0.216	0.191	1.128	0.259	0.132	0.132
TRS	0.308	0.176	1.749	0.080	0.158	0.158

Table 7: The path analysis in MG-SEM (Other district people)

Female Model **Male Model**

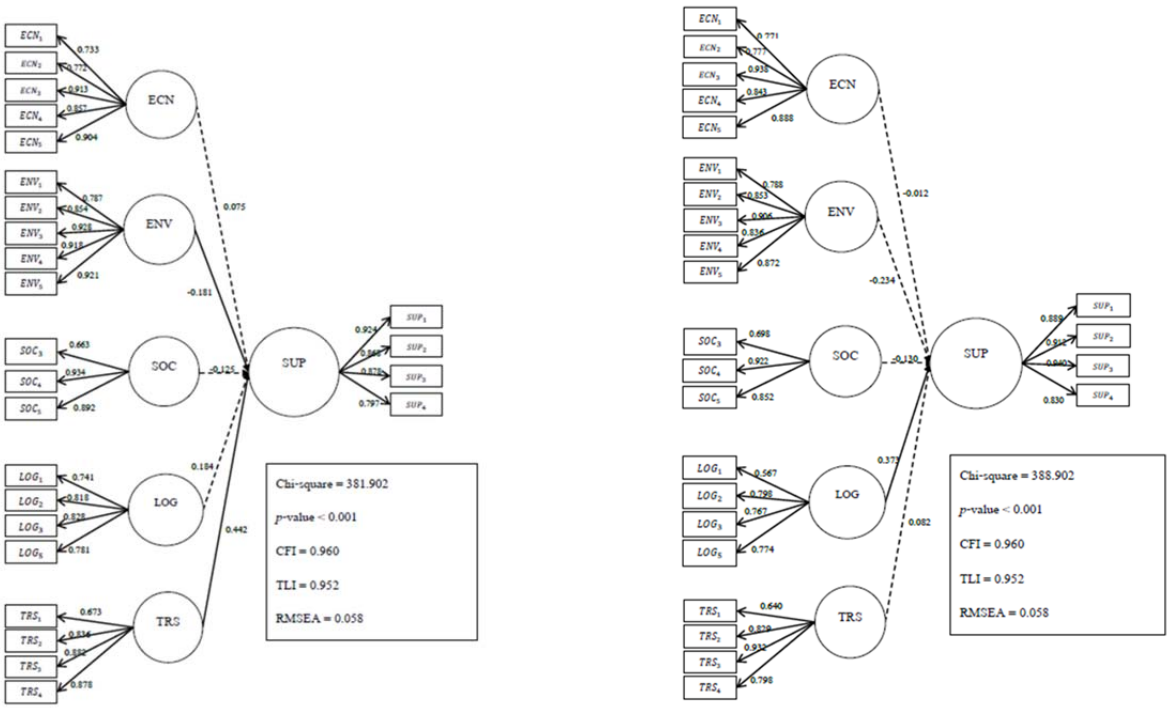

Figure 2: The MG – SEM analysis in term of gender

La-ngu district Model **other district Model**

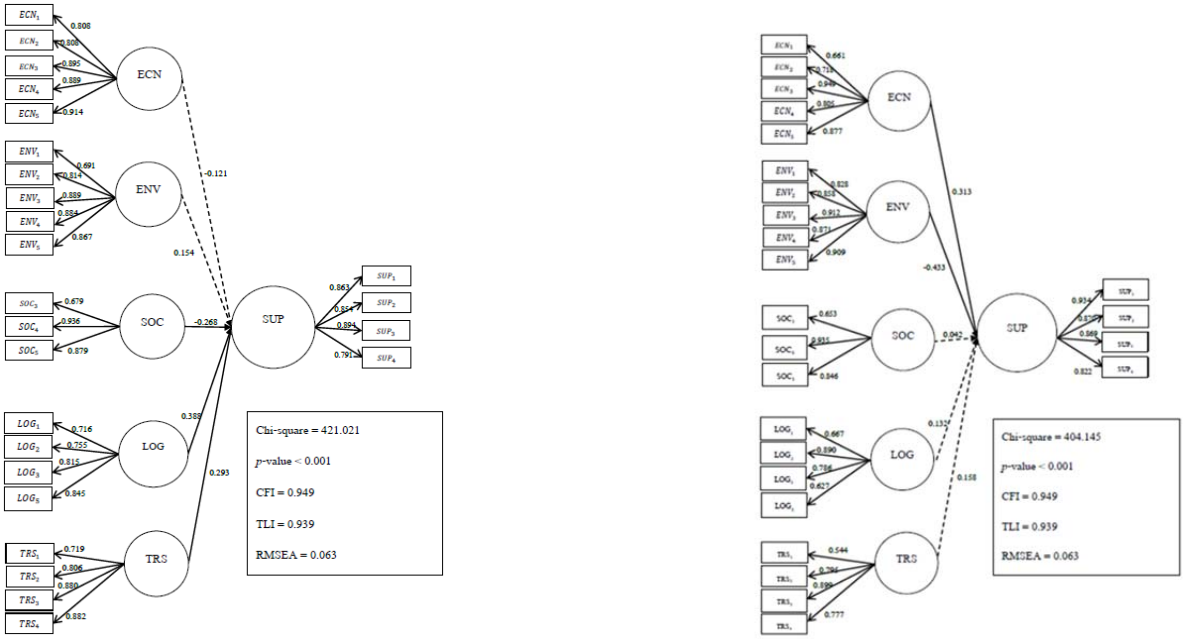

Figure 3: The MG – SEM analysis in tern of address

Conclusion

The mega logistics project has affected many stakeholders. There are evidences that the people with different characteristics have the difference perception. In this case, the result shows that the difference in gender and address has significant in their perception on logistics mega project. Female are more concerned about environmental and institutional aspect, but only logistics aspect that has affected to male. Moreover, it is interesting that people who live in difference area has completely difference perception in the mega logistics project. People who live near the project's area concerned about social and culture changing, logistics development, and institution trust, while the others more concerned about economics and environmental aspect. Therefore, the institution who conducted the project should consider in the different perception of stakeholders in order for project to proceed smoothly.

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DEMAND FORECASTING FOR SPARE PARTS – A PERSPECTIVE FROM THE MARINE PORT INDUSTRY

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Introduction

Spare parts (also known as service parts) are those parts that are used in the course of production of goods or services, such as during maintenance of equipment, but they are not constituents of the intermediate or final product. Service parts can be divided into two categories: Repairables (which in case of failure, are swapped with new parts and sent to a repair centre) and consumables (which are not technically or economically repairable) (Botter and Fortuin, 2000). Furthermore, there are two fundamental types of maintenance – scheduled (preventive) maintenance, and unplanned (corrective) repair (Kennedy et al., 2002). For preventive or scheduled maintenance, the demand for spare parts is predictable and it may be possible to order parts to arrive just in time for use, but for unplanned repair, the consequences of stock-outs often include production loss.

Compared to other types of inventories, spare parts inventories are unique in several aspects (Kennedy et al., 2002). Maintenance policies, rather than customer usage, dictate the need for spare parts inventories. Reliability information is generally not available to the degree needed for the prediction of failure times. Demands for parts are sometimes met through cannibalism of other parts or units. The costs of stock-outs generally include quality deficiency as well as lost production, and these costs are difficult to quantify. Obsolescence may be a problem as the machines for which the spare parts were designed become obsolete and are replaced by newer models. Consequently, spare part inventories cannot be managed by standard inventory control methods, since the conditions for applying the underlying models are not satisfied (Botter and Fortuin, 2000).

This research seeks to investigate via a case study the forecasting practices for spare parts from an industry perspective of a marine port operator. The secondary objective is in describing the challenges in achieving good forecast accuracy across commodity groups at the subject company.

Literature Review

The field of research in management of spare parts (or service parts) is not new. The reader is referred to the papers by Kennedy et al. (2002) and Rego and Mesquita (2011) for in-depth literature reviews on the subject. This review presents only a selection of relevant papers and is divided into three main parts. An overview of selected research on spare parts inventory control is first introduced. A review of the developments in the field of analytical forecasting of intermittent demand is then conducted, followed by a brief discussion on judgmental forecasting methods.

Botter and Fortuin (2000) presented a framework for service parts inventory control for a two-echelon network of warehouses, to answer the questions of which, where and how many parts should be stocked. Strijbosch et al. (2000) developed a compound Bernoulli model (CBM) for spare parts inventory control, which incorporates undershoots, differentiates between zero and nonzero demand during lead-time, and utilizes the gamma distribution as the demand distribution. They found that the model yields a close-to-desirable service level in a case study on a production plant of a confectionery producer. Louit et al. (2011) presented risk and cost models for the optimization of inventories of both non-repairable and repairable spares. Most of these models are based on a Poisson process approximation for spares demand.

Bacchetti and Saccani (2012) investigated the gap between research and practice in spare parts management. They found that very few empirical studies compare spare parts management practices

of companies, but those that did point out that substantial benefits can be achieved through the adoption of simple but formalized methods or of an organizational perspective towards spare parts inventory management. They proposed several directions for research in order to bridge the gap, among them to define contingency-based managerial guidelines and to supplement theoretical models with practical relevance.

In general, forecasting techniques may be classified into time-series statistical methods and judgement/environment based approaches. Webby and O'Connor (1996) used a contingency framework and identified the characteristics of the time series (which include the periodicity of the data, trend, seasonality, noise, instability, number of historical data points and number of forecasts required) and those of the judgment/environment (experience, context, motivation).

Several time-series based methods have been developed for demand forecasting, yet only a few with the special focus on spare parts demand forecasting (Hellingrath and Cordes, 2014). Intermittent demands are particularly difficult to predict (Hua et al., 2007). Two methods are commonly used in practice: Croston's method and the Syntetos-Boylan Approximation (SBA) method. Croston (1972)'s method separates the estimation of intervals between demands of the amounts demanded in each occurrence, while the SBA method (Syntetos and Boylan, 2001) corrects the bias in the original Croston's method.

Among recent advances in the forecasting of intermittent demand in the past 15 years, Willemain et al. (2004) used the bootstrapping technique to assess demand distribution during lead-time, considering autocorrelation and introducing small demand variations to the original series (jittering). Comparing the new model to Croston's method and exponential smoothing, Willemain et al. (2004) concluded that the first provides better results, especially for small historical series. Hua et al. (2007) further proposed an Integrated Forecasting Method (IFM) that combines bootstrapping and regression analysis in demand forecasting of parts in the petrochemical industry, with promising results compared to exponential smoothing, Croston's method, and the Markov bootstrapping method. More recently, Gu et al. (2015) developed models that consider parts aging and focus on impending demands.

Despite the availability of statistical methods in forecasting, forecasts in most organisations are either entirely based on judgment or judgmental adjustments are applied to the forecasts of a statistical method (Goodwin, 2002). There is relatively little recent research on the use and performance of judgmental forecasting (or judgmental adjustments) for demand of spare parts, even though Lawrence et al. (2006) note that there is an "explosion of research interest" in the area of judgmental forecasting. They reviewed the literature on the importance of human-interaction factors in forecasting and conclude that the accuracy of judgmental eyeballing may be roughly equivalent to the statistical methods, but the major contribution of judgmental approaches lies in the ability to integrate this non-time series information into the forecasts. On the contrary, Goodwin (2002) suggests that the choice of forecasting method may even have little to do with the accuracy associated with the method, but the voluntary integration (of judgmental inputs to statistical methods) is more likely to lead to forecasts that are more likely to be acceptable to the forecaster and decision makers.

To round up, the review of literature has revealed that many researchers have focused extensively on technical approaches towards forecasting intermittent demand for spare parts. Others suggest that judgement-based forecasting methods have a role to play, such as in cases when spares parts usage are not truly random (due to planned maintenance programs, inter-dependent part failures or aging of equipment). However, there has been almost a surprising lack of insights derived from the industry's perspective and current practices on spare parts management, which is a gap that this paper aims to address.

Background & Methodology

This research is centred on Company A, which has been selected as the subject of the case study, not least because internal historical data is reliable and well-archived within an Enterprise Resource Planning (ERP) system. Company A is one of the world's largest marine port operators and operates numerous berths at its container terminals. Equipment used in running the port business include quay and yard cranes, empty stackers and prime movers. It is important to ensure that such equipment are in good working condition in order to avoid down-time during operations. As such, adequate spare parts and consumables are necessary to be available for any repair or maintenance works.

To establish the background to the case, interviews were conducted with store personnel, technicians and engineers at Company A, on the procedure on how spare parts are procured, how they are requested from inventory and how work orders are approved.

Company A makes use of term contracts to work with suppliers to ensure that the spare parts are available just in time or on a consignment basis. The company outsources the management of spare parts to vendors and the term contracts are signed based on demand forecasts provided by Company A. Suppliers are responsible for stocking the spare parts (or procuring them at short notice) if they are awarded the contract. Company A will issue a purchase order as and when the items are required. A contract would lapse at the end of the agreed term or when the value of consumed parts reaches the agreed contract sum, whichever comes first. Thus, it is important to ensure forecasts of demand are close to the actual demand.

In Company A, the procurement department works with the engineering department directly on the term contract in terms on pricing, technical requirements and delivery details. On the other hand, the inventory management department is in charge of extracting past parts usage data, working with the inventory stores and technicians if a work order (WO) is required. Once a WO has been approved, it is sent the procurement department as a purchase request (PR). If there is a valid term contract available, the PR is used to issue a purchase order to the assigned supplier.

Despite the use of term contracts, certain spare parts may at times be required in quantities that are much higher than the average forecasted quantity. This may catch suppliers by surprise, as they may not be prepared to meet the sudden surge in demand, leading to stock-out issues in Company A and therefore maintenance delays and down times. Suppliers may also be obligated to pay liquidated damages if deliveries are not fulfilled on time. Occasionally, urgent ad-hoc purchase orders have to be made to minimise machine down times. Inaccurate forecasts would therefore not only affect the operational running of the business, but would also result in extra costs from urgent purchases and expedites. On the other hand, if Company A does not fully consume the quantity of items as forecasted in the term contract, it may (depending on the terms of the specific contracts) be required to purchase the unconsumed parts. Alternatively, the supplier would have to bear the cost of the unused spare parts. Both scenarios put strains on the working relationship between Company A and the supplier.

The challenges that Company A has in meeting demand for planned and unplanned maintenance is best epitomized by Figure 1, which shows the example of monthly time-series usage data for an MRO part (a sensor that is used in an empty stacker) over 10 years. It can be observed that the monthly usage pattern is highly intermittent, with some months seeing very high demand, followed by almost zero demand in the following periods. Overall, there is a trend of higher and more frequent usage of parts as time passes (i.e. the time-series is non-stationary and exhibits a trend), which is partly attributed to the ageing of equipment whose parts need to be replaced. Furthermore, scheduled replacements and preventive maintenance are sometimes conducted (e.g. in December 2014) whereby the sensors in the entire fleet of empty stackers were replaced.

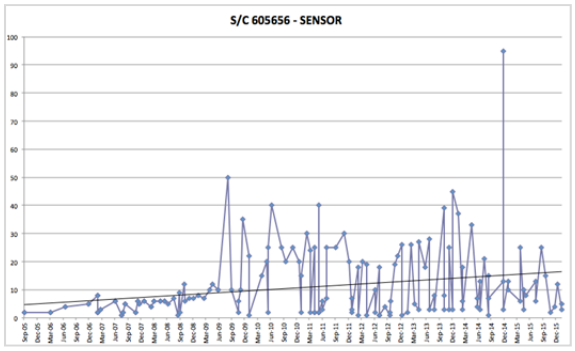

Figure 1: Monthly usage for sensor (year 2005 To 2015)

Company A makes use of both Enterprise Resource Planning (ERP) and Enterprise Asset Management (EAM) systems to manage their finances, inventories and assets. Frequently purchased items are assigned with individual stock codes and are called “stock items”. There are more than ten thousand stock items listed in the ERP system. Primary data from up to 5 years ago is generally available to be extracted, e.g. item description, last purchase price, purchase frequency information and duration of term contract.

Company A groups its spare parts in terms of commodity types (such as vehicle spares and empty stackers spares) or in term of brands. Thus, there are numerous items listed in the same term contract in different categories. For example, some are for daily usage whereas some are for replacements during repair.

Interviews with store personnel, technicians and engineers also yielded some further insights on how requests for spare parts are processed. When a particular spare part is required, the technician will refer to the physical part manual and enter the required stock code into the EAM system to request for a work order (WO). Approval of the WO is not required if that spare part is stocked in inventory and listed in the term contract. Once the WO has been created, the technician can collect the spare part directly from stock. If the spare part subsequently is found to be defective, the technician will have to follow-up with the procurement and inventory department to resolve the problem (e.g. one-to-one exchange with the supplier). On the other hand, if the technician has withdrawn the wrong spare part, he/she could amend the WO and do a reverse of inventory. A new WO for the correct spare parts can also be requested but they are not necessarily required to return the item that was wrongly issued.

To ensure that the procurement department has sufficient time to prepare for a new contract, an alert will be triggered as soon as more than 70% of parts procured under a term contract has been utilized or 3 months before the contract is due to expire, whichever comes first. If the purchase request for individual stock item is higher than the estimated quantity remaining in the term contract, this is usually resolved by calling an interim term contract or renewing the term contract before its expiry date.

Apart from qualitative insights obtained from interviews and quantitative data obtained from the ERP system, a survey of participants in the demand forecasting process was conducted. A questionnaire was sent to the spare part coordinators via email, with questions mainly related to the type of spares handled, the forecasting methods used and factors in the making of these forecasts.

Results & Discussions

To limit the scope of parts to be analysed in the study, the term contract for spare parts of empty stackers was selected for analysis. An empty stacker is a vehicle used in Company A to transport empty containers across the entire terminal. The term contract for empty stacker spare parts is

suitable because it contains all major groups of parts, such MRO parts, consumables and repairable parts. The contract also includes parts that can be grouped by whether they are usually replaced under preventive or corrective maintenance.

The analysis on forecast accuracy involves the calculation of forecasting error, which is the deviation of the actual usage from the forecasted quantity, such that:

Forecast Error = (Actual Demand – Forecast Demand)/(Actual Demand)

Table 1 shows a sample of the spare parts and their associated forecast errors. Within the list, it could be observed that most of the items with poor forecast accuracies are consumables (e.g. springs, nuts, seal rings and wheel bolts) and MRO parts (e.g. wiper arms and magnetic valves). On the other hand, parts that are used as part of planned or scheduled maintenance schemes tend to have good forecast accuracies.

Part Description	Category	Planned?	Forecast	Actual	Error	Error (%)
Over-forecasts						
Seal Ring, Grease Seal Spindle	Consumable	No	37	4	-33	-825%
Thermostat	Repairable	No	15	2	-13	-650%
Shim, Lock Plate Single	Consumable	No	20	3	-17	-567%
Retaining Ring, Spindle Bottom	Consumable	No	32	5	-27	-540%
Spring, Accelerator Padel Return	Consumable	No	20	4	-16	-400%
Screw, Spindle Bottom	Consumable	No	192	40	-152	-380%
Brake Shoe Lining, Parking	MRO	Yes	46	10	-36	-360%
Sensor, Tm Oil Pressure	MRO	Yes	12	3	-9	-300%
Gasket, Exh Manifold	MRO	Yes	8	2	-6	-300%
Shim, Spindle	Consumable	No	22	6	-16	-267%
Magnetic Valve Parking	MRO	No	22	7	-15	-214%
Light, Side Tail Lamp Assy	MRO	No	14	5	-9	-180%
Hose Lower Radiator	MRO	No	19	7	-12	-171%
Retaining Ring, Tilt Minder Shaft	Consumable	No	32	12	-20	-167%
Plug, Engine Oil Sump-Kalmar	Consumable	No	10	4	-6	-150%
Lifting Cylinder Rubber Guide	MRO	Yes	30	14	-16	-114%
Wiper Arm,Front	MRO	No	17	8	-9	-113%
Bolt, Spindle	Consumable	No	2	1	-1	-100%
Shaft, Tilt Cylinder Pin	MRO	No	14	7	-7	-100%
Seal Ring, Drain Plug	Consumable	No	10	5	-5	-100%
Potentiometer, Accelerator	MRO	No	4	2	-2	-100%
Screw, Air-Con Belt Tensioner	Consumable	No	27	14	-13	-93%
Slide Plate, Spreader Side	MRO	No	380	200	-180	-90%
Washer, Sealing	Consumable	No	38	21	-17	-81%
O-Ring, Drive Axle	Consumable	No	10	6	-4	-67%
Nut, Wheel Bolt Front Axle	Consumable	No	36	22	-14	-64%

Part Description	Category	Planned?	Forecast	Actual	Error	Error (%)
Under-forecasts						
Spring, Toc Pin	Consumable	No	8	56	48	86%
Shim, Lock Plate Double-Kalmar	Consumable	No	42	185	143	77%
Hose, Air Intake	MRO	No	4	17	13	76%
Magnetic Valve,Spreader	MRO	No	2	6	4	67%
O-Ring, Service Hrake Hub Outer	Consumable	No	28	83	55	66%
Screw, Half Shaft	Consumable	No	16	44	28	64%
Ring, Stop, Twist Lock	Consumable	No	4	11	7	64%
Wheel Bolt, Front Axle	Consumable	No	52	142	90	63%
Bushing, Top, Twistlock	Consumable	No	6	16	10	63%
Relay, Signal Light Flasher Unit	MRO	No	4	10	6	60%
Good forecasts						
Over Centre Valve	MRO	No	3	3	0	0%
Hydraulic Pump	Repairable	Yes	4	4	0	0%
Piston Rod End, Telescopic	MRO	No	2	2	0	0%
Seal Kit, Lifting Cylinder	MRO	Yes	18	18	0	0%
Control Valve, Hydraulic Main	MRO	Yes	9	9	0	0%
Steering Wheel Panel	MRO	No	2	2	0	0%
Control Unit, ECU4	Repairable	Yes	2	2	0	0%
Control Unit, ECU1	Repairable	Yes	2	2	0	0%
Fuel Gauge	Repairable	Yes	3	3	0	0%
Unlock Light, Assembly, Red	MRO	No	12	12	0	0%

Table 1: Forecast accuracy for selected parts

The online questionnaire was sent out to 30 engineers and coordinators from the procurement department within Company A. They are all involved in providing estimates and also the formation of term contract. The questionnaire received a total of 24 responses, with 75% of responses from the engineering department and 25% from the procurement department.

Survey results show that within the organization, the majority of respondents deal with spare parts that are repairable (Figure 2a) and that preventive replacement methods are used more often used than corrective methods (Figure 2b).

Figure 2: (a) Type of spare parts handled (b) Replacement method adopted by survey respondents

Figure 3 shows the most important factors that respondents think would affect the usage of spare parts. A majority of respondents think that the amount of equipment down-time is an important factor. This can be explained by the incidence of inter-dependent part failures and/or low quality components that leads to repeated equipment malfunctions. Moreover, a significantly minority of respondents think the availability of stock is important, which is somewhat surprising, as this suggests that spare parts coordinators may be inclined to inflate their forecasts if they perceive that the on-hand inventory of a spare part is going to be low.

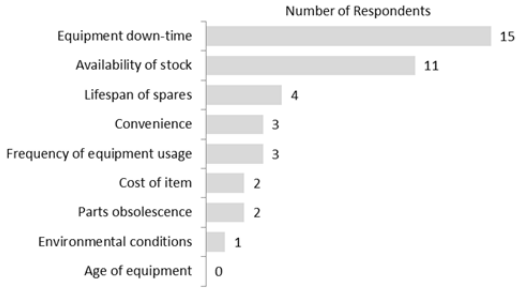

Figure 3: Respondent's views on important factors in forecast quantities and accuracies

Furthermore, it can also be observed that contrary to what might be expected from the review of literature (e.g. Gu et al., 2015; Botter and Fortuin, 2000), the age profile of equipment is not seen as a factor when forecasting demand for spare parts. One plausible reason for this is that while respondents may agree that the usage of spare parts would increase with age of equipment, such information may not be readily available to technicians and spare parts coordinators.

On an aggregated basis (regardless of spare parts type), the most often used forecasting method is past usage pattern (30% of respondents) followed by planned and schedule replacement (27%), statistical forecasting methods (17%), casual forecasting methods (9%), judgmental forecasting methods (8%) and consensus-based forecasting methods (6%).

The results are further broken down to analyse each part type against the forecasting methods used (see Figure 4). Planned replacement, past usage pattern and judgement-based methods are commonly used regardless of the type of parts. Both statistical and causal-based methods are less preferred for consumables and MRO parts, while consensus-based forecasting is used only for MRO parts.

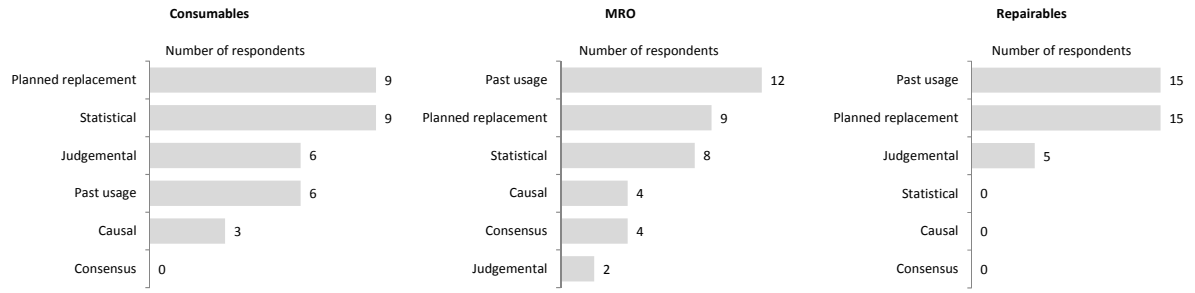

Figure 4: Survey results on forecasting methods used for consumable, MRO and repairable spares

The results also show that the forecasting methods for MRO parts are highly diverse, with all 6 methods employed within the organization. On the other hand, the demand for repairable parts are most often forecasted using information related to past usage and future planned replacement, which is consistent with the findings from Kennedy et al. (2002).

Conclusion

This research has contributed to the literature on spares management in three ways. First, it has provided a valuable perspective from the industry. As Rego and Mesquita (2011) note, case studies are needed to reduce gaps between theory and practice on the applications of models and techniques for inventory control of spare parts in real companies. Our study has reaffirmed the observation from literature that judgmental forecasting methods tend to be more widely practiced for spare parts that have planned or scheduled maintenance schemes. Similarly, results suggest that judgmental forecasts are more accurate for repair and refurbished parts, but less so for consumables and MRO spares. Overall, there is no one single method that practitioners in the case company use in forecasting the demand for spare parts.

Secondly, this paper has also shed some light on reasons for the prevalence of judgmental-based forecasting by practitioners, as well as some pitfalls of relying in human judgment in forecasts. Results of the interviews suggest that there are some challenges faced by the case company, which favour judgmental forecasting methods. For instance, usage may be occasionally distorted by the withdrawal and subsequent non-return of wrongly issued parts. Quality issues with batches of spare parts may also lead to one-time jumps in usage. Both of these issues would not be easily accounted for in time-series based forecasting. This is in line with the prevailing view in the literature that the major contribution of judgmental approaches lies in the ability to integrate non-time series information into the forecasts (Webby and O'Connor, 1996). However, results of the survey also indicate some evidence (albeit inconclusive) that judgmental forecasting may be susceptible to behavioural bias, such as technicians' tendencies to inflate forecasts when shortage is expected (Lee et al., 1997) or to make trivial forecasts based on past usage.

Thirdly, while the literature has no lack of academic studies on ways to improve forecasts for the intermittent demand of spare parts, few seem to make reference to how spare parts are actually managed in the industry. As this research illustrates, the use of term contracts to manage spare parts is a way that some companies have approached the problem. While at first glance the term contract management of spare parts appears to simply transfer responsibility (and the associated challenges) of inventory control to the supplier, it does confer significant advantages in that it enables risk pooling to be carried out. Backed by the port operator's committed usage forecasts over the contract term, suppliers can aggregate the demand for spare parts for (say) quay cranes with other ports in the region, thereby greatly diminishing the importance of making accurate time-series forecasts for intermittent demand. Nonetheless, the trade-off is that the port operator gives up significant control

over inventory levels to the vendor and is obligated to make forecasts of demand at the onset of the term contract. Another practical implication of findings from the study is that while demand may be intermittent, they are often not truly random. Instead, there is scope for managing intermittent demand for spare parts based on a set of contingent managerial guidelines (Bacchetti, and Saccani, 2012), for example by classifying parts as MROs, consumables and repairables, and whether they are used as part of a planned maintenance or corrective repair regime.

This research is however not without its limitations. As is the case with case studies, results are based on the data and experience from just one company in the port industry. The case study method is inherently unable to generalise from a single case study beyond theoretical propositions (Yin, 2013). Secondly, this study is focused on the accuracy of forecasts over the period of a term contract (typically two years), rather than from a time-series perspective. This has to do with the nature of spare parts procurement and the use of term contracts at Company A, but nonetheless the accuracy of forecast of demand over a contract period is appropriate for the purpose of this study.

The purpose of this paper is certainly not to advocate one forecasting method over another, nor is it to assert that the company in this case study has adopted good practices (or otherwise) in spare parts management. Rather, it is to better understand the gaps that exist between academia and industry (Bacchetti and Saccani, 2012) on forecasting demand for spare parts. While there appears to be a strong focus in the academia on statistical forecasting methods, evidence from the literature suggests that the industry remains heavily reliant on judgmental forecasting methods (Goodwin, 2002).

In conclusion, this study has illustrated the typical challenges faced by large corporations in forecasting demand for spare parts, due to the sporadic nature of the demand. The company in this study has not adopted a standard forecasting method for its spares, but has instead used a myriad of methods, depending on type of spares and even the individuals who are responsible for providing the forecasts. Most respondents in the survey also professed a large degree of reliance on their own judgment in the projections of spare parts usage. As Goodwin (2002) puts it very well, human behaviour is perhaps the most important factor in the choice of forecasting methods and decision makers are more likely to accept forecasts if they have a sense of ownership of the forecasts, because they have contributed to the process that derived them. As such while sophisticated forecasting techniques exist, judgment-based approaches are likely to remain important among practitioners in the industry.

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DESIGN OF BIODEGRADABLE PACKAGING SYSTEM FOR ELECTROLYZERS APPLYING A METHODOLOGY IMDNP

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Introduction

General Context

Now a days the production of fossil fuel energy, in hand with its excessive consumption, is part of a serious and unjustified pollution environment; all together adding health problems to the population. Reducing the consumption of fossil fuel energy has become an urgent necessity to reduce the emission of carbon dioxide in the atmosphere. The harmful effects on the environment are not linked only by the combustion products, but also to its means of transportation and the sub products that they generate (solid and toxic waste). This situation aggravates, when it includes the reduction of active deposits, the over growing demand of energy, the increase of global population and its industrial development (González, 2013). The big scale production of alternative fuels, offers an opportunity, for developing countries, to reduce their dependence to petroleum imports. Although, in developed countries exist an ever growing trend for technologically based jobs that use different renewable energy sources, as well as the use of alternative fuels.In the 1970's Veziroglu and Basar developed a computational model to characterize the technical, social, economic and environmental impacts of the substitution of fossil fuels for electrolytic hydrogen, obtained by the use of solar energy, this model has been used in different studies around the world such as the case in the coast of Ceará, Brasil. For the period between 2015 and 2110, it was developed a study in Brasil, which includes three aspects: total energy demand, hydrogen production and fossil fuel demand. According to this study in a slow introduction panorama of hydrogen, the fossil fuel demand grows until the year 2040, after that, the consumption of fuels decreases until it is zero in the year 2065. Until then, it is projected that hydrogen will have already replaced it. In a fast introduction scenario, the dependence from fossil fuels would be achieved in ten years less, it means, by the year 2055. It is estimated that, by the year 2035 that replacement will generate US 3.4 million (Sacramento, 2013). Hydrogen energy has been exploited as a renewable energy storage system, to produce electric power and inject it to and internal combustion engine, which has been harnessed by vehicles that use it in its liquid form, hydrides or methanol for small automobiles and compression for big vehicles (Gutiérrez, 2005). As electricity, hydrogen can be produced from different resources including fossil fuels, renewable energy and nuclear energy. Hydrogen can develop from electric power using electrolysers and hydrogen electricity using fuel cells. Electrolysers are hydrogen and oxygen generating devices, using a sodium or potassium hydroxide electrolytic substance, through the electrolysis process. This process consists of separating the elements within a compound by means of electrical flow. The electrolyser generates a decomposition of water, this decomposition results in two partial reactions in the electrodes, hydrogen is produced in the cathode and oxygen is released in the anode. The

capture of electrons by the cations in the cathode (a reduction) and the liberation of electrons by the anions in the anode (an oxidation) takes place. Important economic sectors, such as, transportation, maritime, mining, agriculture, are interested in the use of hydrogen by electrolysers, this is the reason why developing a sustainable packaging system is extremely necessary for its transportation and distribution due to the fragility of these devices. The next section of this paper, presents the design concept development of the packaging system, using integral model for designing new products (Rico, 2016). Subsequently, the concept development and prototype development are exposed. Finally, the conclusions and the future works are shown.

Packaging System

Background

Packaging is a core element for the logistics of any product, its quality depends on the function to protect the product until its final destination. Companies see packaging as an investment and it is as important as the product itself (Nilsson, 2015). Packaging is affected by the requirements in every step of the supply chain, from its production, to its final user. In logistics, the requirements involve transportation, handling and storage. Within these requirements are, information about the product, volume, weight, product quantity, dimensions and the easy of handling, the last one involves package ergonomics. According to (Nilsson, 2015) packaging is a silent seller and he describes it as a powerful selling instrument that highlights the qualities and advantages of the product. The added value of a package system is to reunite all the requirements mentioned before, since, for example a package does not contain the complete information (specifications, weight, dimensions, stowage capacity, etc.), and it would affect the next steps of the logistics chain, such small details, and result in major problems in the delivery.

Integral Model for Designing New Products

Integral Model for Designing New Products IMDNP, (Rico, 2016) is based on the numerical succession found by the Italian mathematician Fibonacci during the Middle Age. (Koshy, 2001) (Benjamin, 2003.) (Miller, 2012). His studies have contributed in different areas, such as, Architecture, Statistics, Applied Mathematics, Cybernetics (Assimakis, 2013) (Saari, 2014), among others, and now it has become an inspirational source for analyzing processes involve in the development of this project, including functional methodologies such the case of the Quality Function Deployment (QFD).
The information obtained to accomplish the research in this project is derived from different bibliographical sources, referring to packaging concepts, however, there were not found publications that contribute to the packaging analysis for such specialized product as the electrolysers, for that reason, the IMDNP is used. Figure 1. Illustrates its first phase, which has 6 steps:

Origin – Client – Maritime transportation
Market Analysis – Requirements – Specifications – QFD results
Design Tools. – Brain storming,
Design Concept – Fibonacci succession, Alternative Development
Experimental and Numerical Analysis –Mechanical Properties Analysis FEM
Final Prototype - Manufacturing

The first step originates with the customer needs. The second step consists of analyzing the market, obtaining a list of requirements and specifications (Table 1), this is done, through the QFD quality matrix, which is classified in categories according to the necessities to accomplish. (Table 2.) Once these requirements are classified, they are used to perform a brainstorming exercises (Third step). In the fourth step, the design alternatives are elaborated. In the fifth step, it is developed the experimental and numerical analysis from the selected design concept, with the chosen material and specifications established through the Finite Element Method FEM solve by ANSYS®. For effects on this paper, this step is only mentioned because it requires a specific analysis, which will be published in future works. At last, in the sixth step, the final prototype model is manufactured, scale 1:1.

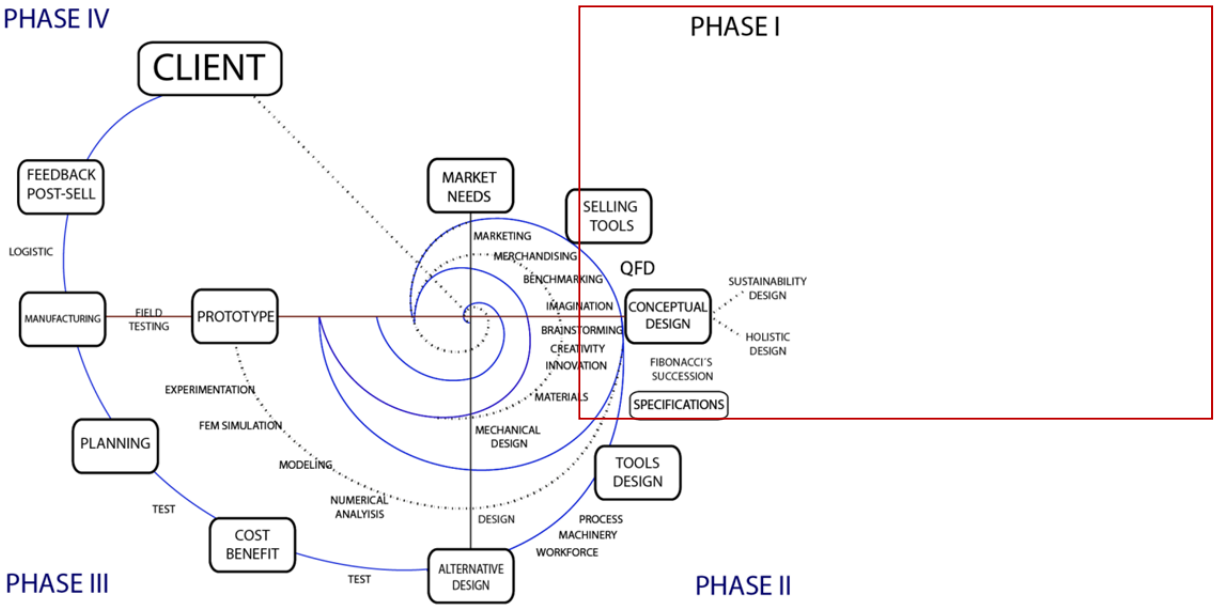

Figure 1. Integral Model for Designing New products (IMDNP)

Market

Maritime transportation contributes in a very important way to the international economic growth considered the spine of global commerce, 70% of its value is move by boat through parts from around the world. Worldwide, global commerce has growth 3.7% while maritime commerce 3.5% annual average. Likewise in Mexico it is seen an 11.3% continuously growth and linked to maritime with 131 countries and more than 490 destinations around the 5 continents. Representing the major energy consumption (44.8%). Indeed the necessity of the goal market comes up by starting the distribution of electrolysers in the Mexican maritime ports.

Market Requirements

In Table 1. It is shown the market requirements, which have been classified in four criteria: use, function, design and identification. In use requirements it is taken into consideration the direct interaction, packaging – user; In function requirements, physical and mechanical packaging with specific properties are classified; In design requirements appropriate aesthetic characteristics for the product and finally the identification requirements have to do with brand image and product specifications for its marketability. For effects on this step of the research, they are only mentioned as they will used in future works. Once the requirements are classified, the QFD matrix is developed. Table 2 shows the obtained results of the analysis, applied to market necessities, from which, resistance, easy handling, attractiveness, ergonomics and easy merchandise where the major percentage characteristics, 17%, 11%, 9%, 9%, 9% y 6%, respectively.

No	USE	FUNCTION	DESIGN	ID
1	Dimension	Resistant to	Attractive	Print
2	Practicality	stowage	Innovative	Ink tones
3	Secure	Resistant to Impact	Ergonomic	Finish
4	Easy to handle	Stable	Anatomic	Color
5	Easy to transport	Light	Easy to	
6	Anthropometric	Biodegradable	Manufacturing	

Table 1. Classification of the requirements of the market.

Product Description (electrolyzer)

Alkaline electrolysers are extremely delicate devices; the reason is that they contain a Potassium or Sodium hydroxide watery alkaline solutions a highly corrosive electrolyte. The alkaline electrolyser is manufactured with two external aluminum caps of ¼" thickness, the electrodes are made of stainless steel sheet 10 cal., separated in between by a 2mm thickness Teflon plate, joint together with six fine string screws ¼" diameter. The general dimensions of the product are 150mm diameter by 35mm thickness.

Evaluation Criteria 0 It has no relation 5 High level of relation	Requirements of the Client	Client priority	Material Specifications	Material Requirements	Customer satisfaction	Quality indicators	Machinery and Tools	Product design	Structural design	Process	Manufacturing operations	Packaging	Percentage
1	Dimensions	5	5	5	5	1	5	5	5	5	4	5	3%
2	Practicality	3	5	5	5	5	5	3	3	5	5	0	2%
3	Sure	4	5	5	5	5	3	4	4	4	4	0	**11%**
4	Easy to handle	5	4	4	3	3	0	1	5	0	5	5	4%
5	Transportation	3	3	0	3	4	1	0	0	4	1	5	**6%**
6	Anthropometric	4	4	4	5	4	4	4	5	1	3	0	3%
7	Resistant to stowage	5	5	5	5	5	4	3	5	5	5	0	**17%**
8	Resistant to impact	5	5	5	4	5	0	0	5	0	0	5	**9%**
9	Stable	5	5	5	4	5	0	5	5	0	0	0	3%
10	Light	3	5	3	1	3	0	0	5	0	5	5	1%
11	Biodegradable	4	5	4	2	1	0	0	0	0	0	5	2%
12	Attractive	5	2	1	5	5	0	5	0	0	0	0	**9%**
13	Innovative	5	4	4	5	4	3	5	5	4	4	0	4%
14	Ergonomic	5	1	1	5	4	3	5	5	4	4	0	**9%**
15	Anatomic	5	3	3	4	5	0	5	5	0	0	0	3%
16	Easy to manufacturing	5	5	5	4	5	4	3	3	5	5	0	**6%**
17	Print	3	4	4	3	5	5	1	0	5	5	0	1%
18	Ink tones	3	1	1	3	4	5	0	0	5	5	0	1%
19	Finish	5	1	5	3	5	0	0	5	5	0	0	3%
20	Colour	3	1	1	3	3	5	5	0	0	0	0	1%
													100%

Table 2. Weighting matrix of the requirements resulting from the application of QFD

Design Concept

The design concept is oriented on creating perfect mathematic designs leading to its maximum level of proportion, which makes a nice and functional object, is in this stage where imagination and creativity combine. Also, a system was designed under an eco-design packaging concept, which consists of analyzing the packaging life cycle, considering every step of the process, from development, production, distribution, and use, to its disposal in such way that the packaging system can renew, reuse or discard in biodegradable recycling deposits.

Figure 2- Product – alkaline electrolyzer in performance analysis. Fuente: (Fuentes, 2016)

Alternatives selection

According to Table 2. The most important requirements are: Resistance, easy handling, attractiveness, ergonomic and ease of production. There were three design alternatives created for this project with different approaches, then, the design concept is selected through an evaluation matrix using two criteria, (Table 3.) The next phase is material selection and specifications establishment, like dimensions, stowage, and capacity, among others. In this selection a compatible material research is made, in this case, for electrolysers, it must have the same sustainable and ecological characteristics that are required. Three alternatives were developed, with A1, A2, and A3 nomenclature, respectively, which were analyzed under the characteristics of each alternative within the requirements mentioned before. The results of the analysis are shown in Table 3. Two evaluation criteria's were established:

(0) does not satisfy the requirement and (5) that meets satisfactorily the requirement. The highest score alternative corresponds to A3 with 92 points (Table 3).

ID	Requirements	A1	A2	A3
1	Dimensions	5	5	5
2	Practicality	1	4	4
3	Secure	3	4	5
4	Easy to handle	3	3	5
5	Transportation	3	3	5
6	Anthropometric	2	3	5
7	Resistant to stowage	4	3	5
8	Resistant to impact	2	3	5
9	Stable	3	4	5
10	Light	3	4	4
11	Biodegradable	5	5	5
12	Attractive	3	5	4
13	Innovative	3	5	4
14	Ergonomic	3	4	5
15	Anatomic	2	4	5
16	Easy to manufacturing	4	4	5
17	Print	4	1	4
18	Ink tones	3	1	4
19	Finish	3	2	4
20	Colour	3	1	4
		62	68	**92**

Table 3. Matrix selection of alternatives

Development of selected alternative

Figure 3 shows the result of the ergonomic development of the design concept, whose proportion corresponds to the represented relation of the golden rectangle. The Ec. (1) shows the start of proportion, in which a = 1

$$a + \varphi = b \quad \text{.....Ec (1)}$$

$$\varphi = \frac{1+\sqrt{5}}{2} \quad \text{Ec (2)}$$

Proportion is a highly important characteristic due to the fragility of the product. An ergonomic appropriate design allows a proper handling of the packaging and stowage arrangement, since its proportion adapts to the stacking of products inside the transportation unit.

Materials

For companies, environmental impact is an extremely important factor in packaging designs, since it has to include the packaging life cycle with its feasibility to degrade without causing environmental problems or even better, its feasibility to recycle, this is why, and it is manufactured with cellulose fibre materials, made up from water base polymers.

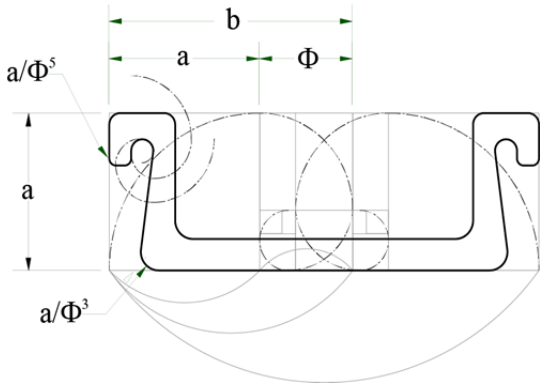

Figure 3. Conceptual Design

Prototype Elaboration

For the prototype elaboration two types of structure were manufactured, the first one corresponds to the lateral caps and the second one forms the central structure that, when joint together, they form the packaging. These pieces were manufactured with 4mm corrugated cardboard made of cellulose fibres material in flute shape B. Figure 4 shows the structures manufactured with laser cut model CO2 high precision laser cutting. Subsequently Figure 5 Shows the structure assembly, whose components were joint with a water base polymer. Figure 6, present the assembly packaging with 14 electrolyzers.

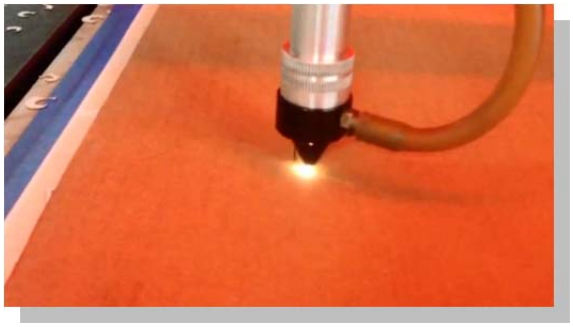

Figure 4. Laser cutting process

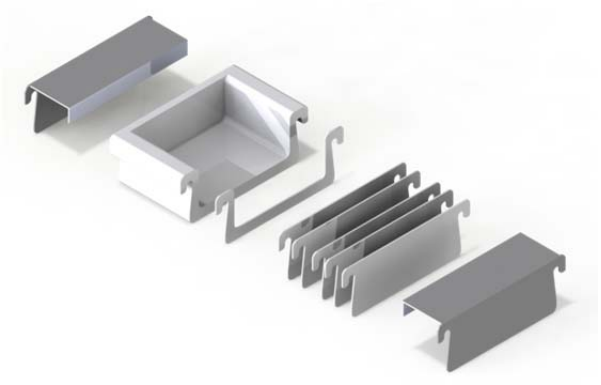

Figure 5.Assembly of packaging

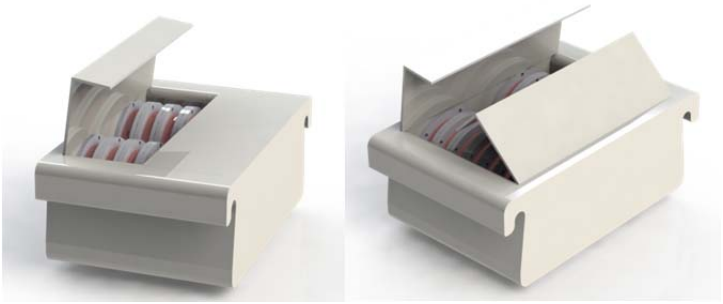

Figure 6.-Sustainable packaging with product

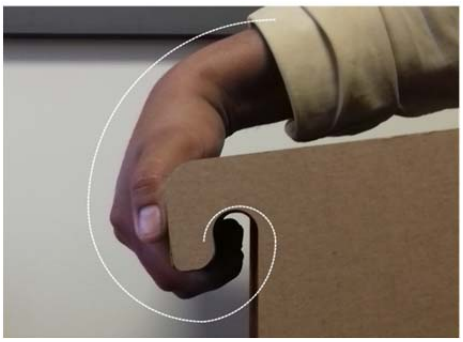

Figure 8. Result Analysis Ergonomic Sustainable Packaging for electrolyzers

Results

The packaging structure is designed from three different pieces only. Optimizing in an enormous way the assembly and production process. Figure 8 depicts the final prototype of the packaging system, which shows an aesthetic appearance and resistance. The purpose of this study is to consider the proportional aspects of the product, the synergy within the harmony and, at the same time, the functionality and use of the product. Figure 9 illustrates the result of the ergonomic study. On the other hand, the contribution of this packaging system ensures the security of the product in its logistics process and delivery to final users, meeting the entire list of requirements.

Conclusion

A prototype of a sustainable packaging system was obtained, with a perfect mathematic proportion, ergonomics, highly resistance to stowage, with an auto-ventilated system, anatomical to the product, anthropometric for the user and completely recyclable, which function is to protect electrolysers through logistics, from the production departure, storage, transportation, distribution, up to the

costumer delivery applying the Integral Model for Designing New products, since it is an excellent tool for creating designing alternatives by object proportions, for this reason the results are optimum and reliable for the for the management of this system. The packaging structure is designed from three different pieces only. Optimizing in an enormous way the assembly and production process. However, this work only covered the first stage of the IMDNP, meaning this it is in the future to analyze and evaluate in works to come the following stages: Numerical analysis and experimental system by FEM, test analysis and risks, costs analysis, planning and manufacturing feasibility.

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DEVELOPING A HUMANITARIAN SUPPLY CHAIN DIAGNOSTIC TOOL

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Introduction

The humanitarian organization are faced with logistics complexity, destabilized infrastructure and environment and their staff works in an extremely chaotic environment. For an effective humanitarian supply chain management, the diagnostic tools are crucial. The aim of this paper is to apply Quick Scan Audit Methodology (QSAM) as an effective humanitarian supply chain health-check tool for the humanitarian organization. The research question is "Can the QSAM be adapted for the humanitarian organization?"

The layout of this research was demonstrated by the foundation of the original QSAM as developed by the Logistics System Dynamic Group (LSDG) at Cardiff University and was designed to refine the existing QSAM to be consistent with the characteristics of the humanitarian context and the use of the humanitarian organization as a case study. The adjusted QSAM will be under the consultancy of QSAM experts as well as staffs of humanitarian organization before its implementation in the case study. Since QSAM had been established as a health-check methodology for use as an automotive manufacturing supply chain diagnostic tool, the implementation of QSAM has been increasingly expanded to a number of various types of industry. There still has been no achievement of implementing QSAM within humanitarian context.

Quick Scan Audit Methodology (QSAM)

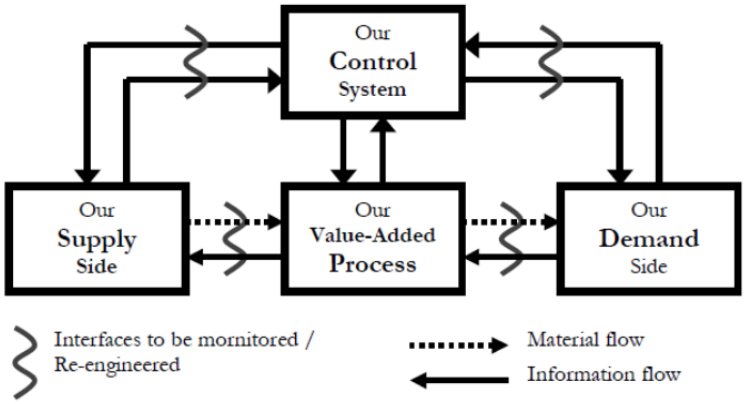
Quick Scan Audit Methodology (QSAM) is a systematic supply chain diagnostic approach to the collection and synthesis of qualitative and quantitative data from a supply chain (IMRC, 2008; Childerhouse et al., 2007). QSAM has been developed by the Logistics System Dynamic Group (LSDG) at Cardiff University in collaboration with their industrial partners (Lewis et al., 1998) to be a robust diagnostic tool (Potter, 2005). QSAM could be also called by its original name of Quick Scan (Childerhouse et al.,1999).

The aim of the development of QSAM is to have a practical and effective diagnostic tool for understanding and documenting a supply chain before re-engineering or fixing it (Childerhouse et al., 1999). However, the ultimate aims of QSAM also have two contradictory conditions which are: maximising the knowledge of the supply chains or value stream under QSAM, but minimising their impact on the everyday processes of the firms (Berry et al., 1999). Since the QSAM was first presented (Childerhouse et al., 1999), it has been both directly implemented within real cases using the original pattern (Childerhouse, 2002; Childerhouse, Disney et al., 2004; Potter, 2005; Hosoda, Naim et al., 2007) and it has also been developed for specific cases.

The QSAM methodology could be separated seven main stages (Childerhouse et al.,1999) as follows.

(1) **Identify a suitable supply chain business process.** First of all, a suitable supply chain process of the business under QSAM has to be identified in order to be the best practice or benchmark model.

(2) **Get buy-in from the business champion.** After the suitable supply chain business process is identified, buy-in from the business champion is also needed to be obtained to enable a better understanding of the value stream under the QSAM.
(3) **Preliminary presentation.** In this study, the methodology of QSAM will be explained as well as the objectives of the firm. The interview will be scheduled and the questionnaire will be issued.
(4) **Conduct a quick scan via four data collection techniques.** The data and information used to analyse in QSAM were obtained from qualitative and quantitative questionnaires, process mapping, structured interviews, and archival information in order to have a comprehensive picture of the current state of the value stream. In this stage a simple generic model of the causes of uncertainty in the product delivery process (see Figure 1) is utilised.

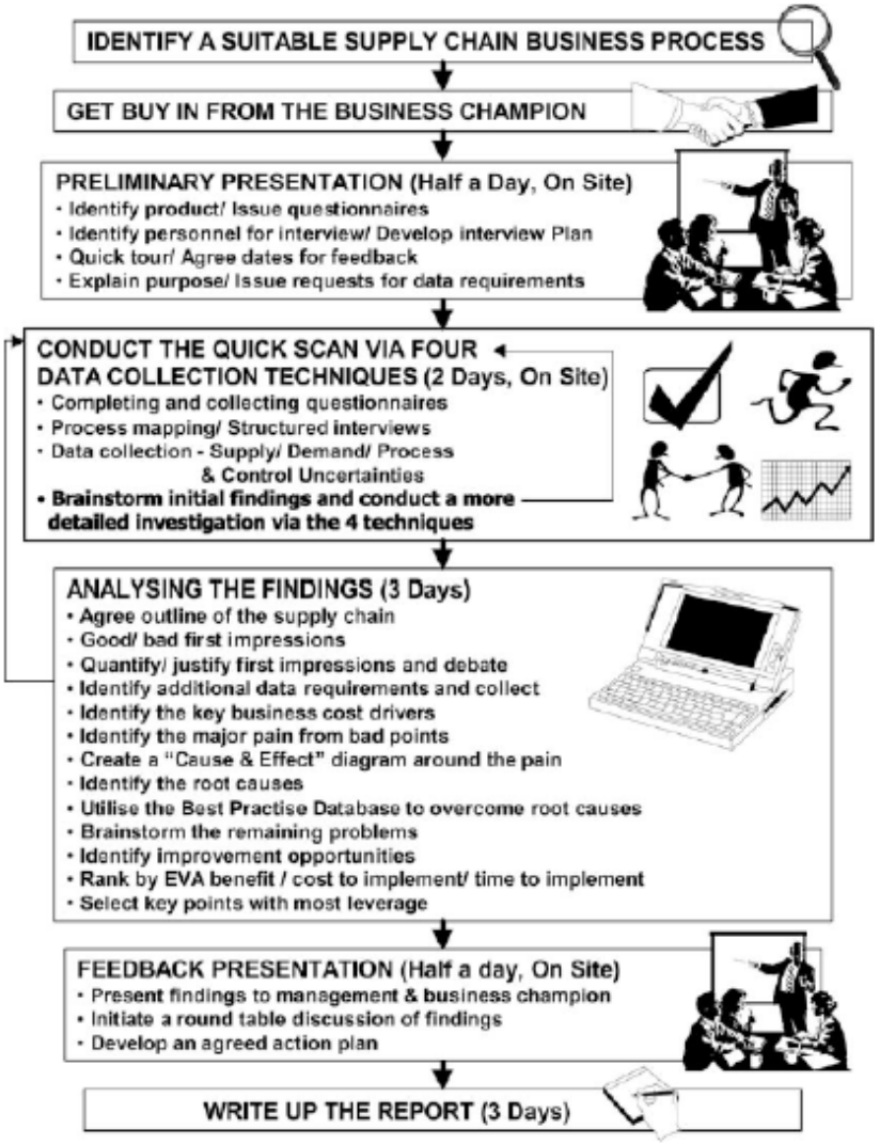


Source: Mason-Jones and Towill, 1998.

Figure 1: Uncertainty cycle used for data collection

Based. on the model of the causes of uncertainty mentioned previously, the primary data is collected into four main sources of uncertainty which consist of: (i) Supply side; (ii) Demand side; (iii) Process side; and, (iv) Control side. Details of these major causes of uncertainty could be presented as in Figure 2.

(5) **Analysing the findings.** Triangulation plays a significant role in this stage in order to avoid an individual bias. Not only triangulations of data but analysis methods are also triangulated to ensure the variety dimensions of the results. The methods in use include Cause and Effect Analysis, Pareto Analysis etc.
(6) **Feedback presentation**. This stage is very important for the firm under QSAM. QSAM teams will present the results of an analysis and staff or workers of the firm will provide their comments or opinions on the results which are then followed by mutual discussion.
(7) **Write up the report.** The results of the analysis and the feedback obtained from the feedback presentation will be presented in this report.



Source: Chiderhouse et al., 1999.

Figure 2: Major stages in Quick Scan

Characteristics of Humanitarian Supply Chain

Humanitarian supply chain management and humanitarian logistics are used interchangeably in this study as well as in the literature (Ertem et al., 2010). In general businesses, supply chain links the sources of supply (suppliers) to the owners of demand (end customers). The ultimate goal of any supply chain is to deliver the right supplies in the right quantities to the right locations at the right time. Supply chains comprise all activities and processes associated with the flow and transformation of goods from the raw material stage through the end user (Beamon and Balcik, 2008). Similar to commercial supply chain, supplies flow through the relief chain from the donation to the consumers. There is no single form of humanitarian supply chain, although a typical supply chain could follow the sequence. Government and NGOs are the primary parties involved. Governments hold the main power with the control they have over political and economic conditions and directly affect to supply chain processes with their decisions. Donors, public and private organisations are the other significant players in the humanitarian supply chains. Donors have become particularly influential in prompting

humanitarian organisation to think in terms of greater donor accountability and transparency of the whole supply chain (Wassenhove, 2006). Two-way arrow in the figure represents two-way communications in information, product and fund flows among the parties in the humanitarian chain.

According to McLachlin et al. (2009), humanitarian supply chains tend to be unstable, prone to political and military influence, and inefficient due to lack of joint planning and inter-organisational collaboration. They deal with inadequate logistics infrastructure, along with shifting origins of and/or destinations for relief supplies without warning. Further, donors often request their funds be spent on direct materials and food, and even at a particular disaster location, rather than on crucial but indirect services such as information systems, staff training, and/or disaster preparedness (Oloruntoba and Gray, 2006; Wassenhove, 2006; Kovacs and Spen, 2007). Therefore, humanitarian supply chain management does not only deal with delivering goods, materials or information to the point of consumption for the purpose of alleviating the suffering of vulnerable people, but also need to manage value to donors and other stakeholders.

The Fritz Institute defines humanitarian logistics 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 the point of consumption for the purpose of alleviating the suffering of vulnerable people (http://www.fritzinstitute.org). The function encompasses a range of activities, including preparedness, planning, procurement, transport, warehousing, tracking and tracing, and custom clearance (Thomas and Kopczak, 2005). Considering at the meaning of humanitarian logistics, it focusses mainly on alleviating the affected people while the definition of humanitarian supply chain is broader and cope with more activities to response to the stakeholders in the supply chain.

Even though the structure of humanitarian chains is similar to most business supply chains, the humanitarian supply chain is often unstable (Oloruntoba and Gray, 2006). As a result, coordination and management of disaster supply chains are increasingly needed and must be put in place in the humanitarian supply chains. Goals, revenue sources, and performance metrics of humanitarian and regular supply chains differ notably. Unlike the humanitarian supply chains, which do not have any profit targets and rely heavily on volunteers and donors, in regular supply chains, stakeholders are the “owners” of the chain. The source of revenue for humanitarian supply chain is government funding, charitable donations from individuals and corporation, and in-kind donations. The goal of humanitarian supply chain is to be able to respond to multiple interventions, as quickly as possible and within a short time frame (Wassenhove, 2006). In addition, performance measurement in the nonprofit sector include the intangibility of the services offered, immeasurability of the missions, unknowable outcomes, and the variety, interests and standards of stakeholders (Beamon and Balcik, 2008). More comparison is given in Table 1.

Topic	**Business SCM**	**Humanitarian SCM**
Main objective	Maximise profit	Save lives and help beneficiaries
Demand pattern	Fairly stable	Irregular
Supply pattern	Mostly predictable	Unsolicited donations and in-kind donation
Flow type	Commercial products	Resources like vehicles, shelters, food, drugs
Lead time	Mostly predetermined	Approximately zero lead time
Inventory control	Safety stocks	Challenging inventory control
Delivery network structure	Location of warehouses, DCs	As hoc distribution facilities
Technology	Highly developed technology	Less technology is used.

Performance measurement methods	Based on standard supply chain metric	Time to respond the disaster, meeting donor expectation, percentage of demand supplied

Table 1: Comparison of Business and Humanitarian SCM

A Humanitarian Organization Case

The primary version of QSAM for humanitarian organization was developed based on the original QSAM which was used in the automotive and retail industry. The changes made were primarily in the use of language in the humanitarian context.

An original questionnaire was used as the default pattern and tested on site. The result found that the current version of the QSAM questionnaire does not work in this context. An adjustment of the questionnaire was needed in order to get information from the value stream or company under the study. The questionnaire was developed to be more understandable for people in the humanitarian organization by cooperating between researcher and the staff of humanitarian organization.

A QSAM was conducted at the Khon Kaen Municipality, a local administrative organization under the Department of Local Administration at the Ministry of the Interior. In accordance with, the Disaster Prevention and Mitigation Act 2007 or DPM Act 2007, the local administrator is designated as director of local for disaster management in local area. The local organization is the first public sector which faced with disaster in local level. The director of local must operate prevention and mitigation disaster suddenly. Khon Kaen Municipality is responsible for an area of 46 square kilometres. Khon Kaen currently face with the flood and thunderstorms. One of the major mission of the Khon Kaen Municipality during the disasters is to provide the relief kits to the victims. The scope of the supply chain reflects a basic or direct supply chain with three levels: the disaster victims, the Khon Kaen Municipality and the suppliers. Figure 3 describes the scope of the supply chain under study.

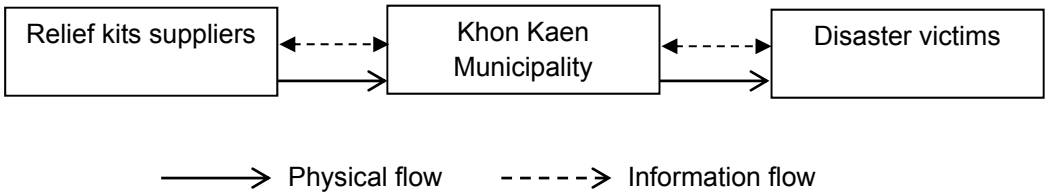


Figure 3: The supply chain scope

In order to refine the unit of analysis, the case study was developed to reflect the information and physical flow that occurs within the Khon Kaen Municipality supply chain. Figure 4 describes the flows moving within the supply chain. The information flow starts from the request for aid by the victims, while the physical flow in the supply chain under study starts from the suppliers. The humanitarian information flow has to inform the Mayor for the aid approval. The Mayor appoint investigation committee to survey and investigate the victims' demand. After the investigation, the committee report to the Mayor for the aid approval. Then, the Division of Finance proceed the procurement process. After procurement process, the supplier delivers the relief kits to the Khon Kaen Municipality. The Bureau of Social Welfare transport the kits to the victims.

An input/output diagram can be helpful to view how information and physical flow within the organization flows from function to function. It was found that there are seven related functions within this humanitarian supply chain: disaster victims, Village Headman or Member of the Municipal Council, Bureau of Social Welfare, Mayor, investigation Committee, Division of Finance and supplier –

as shown in Figure 5. This shows that the Bureau of Social Welfare is the focal point for either information or physical flow.

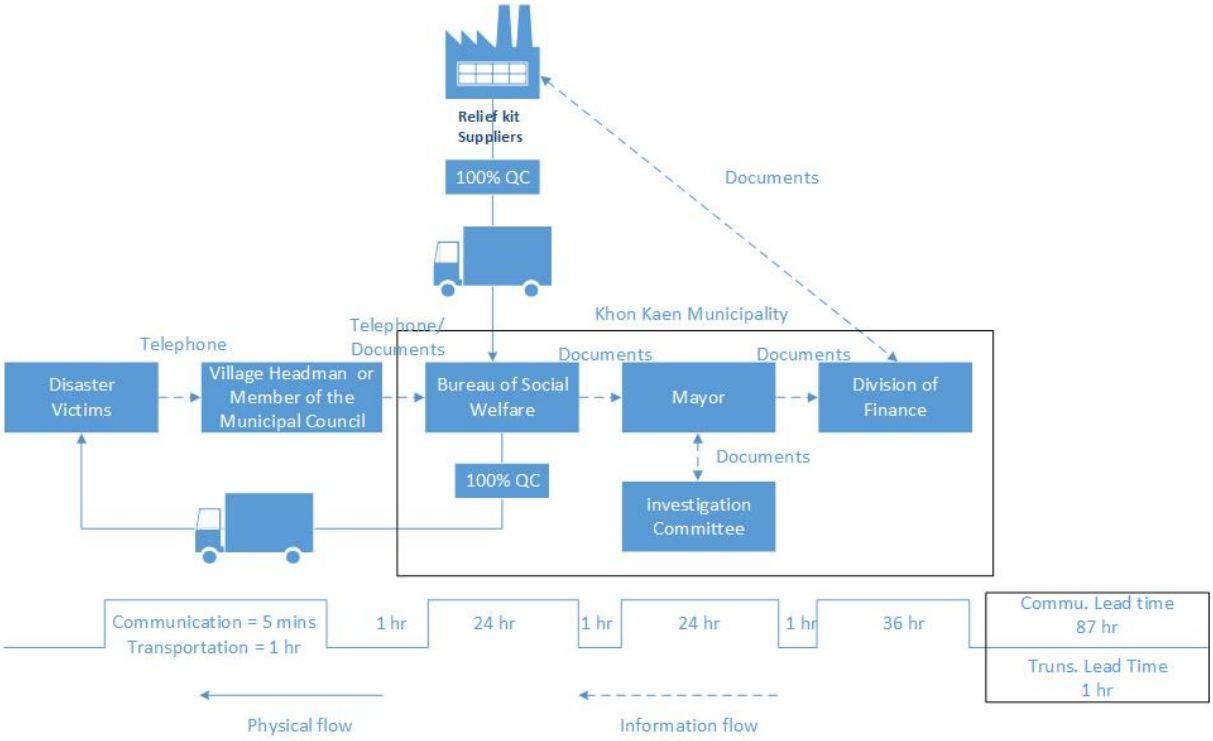


Figure 4: Information and Physical Flow in Khon Kaen Municipality Supply Chain

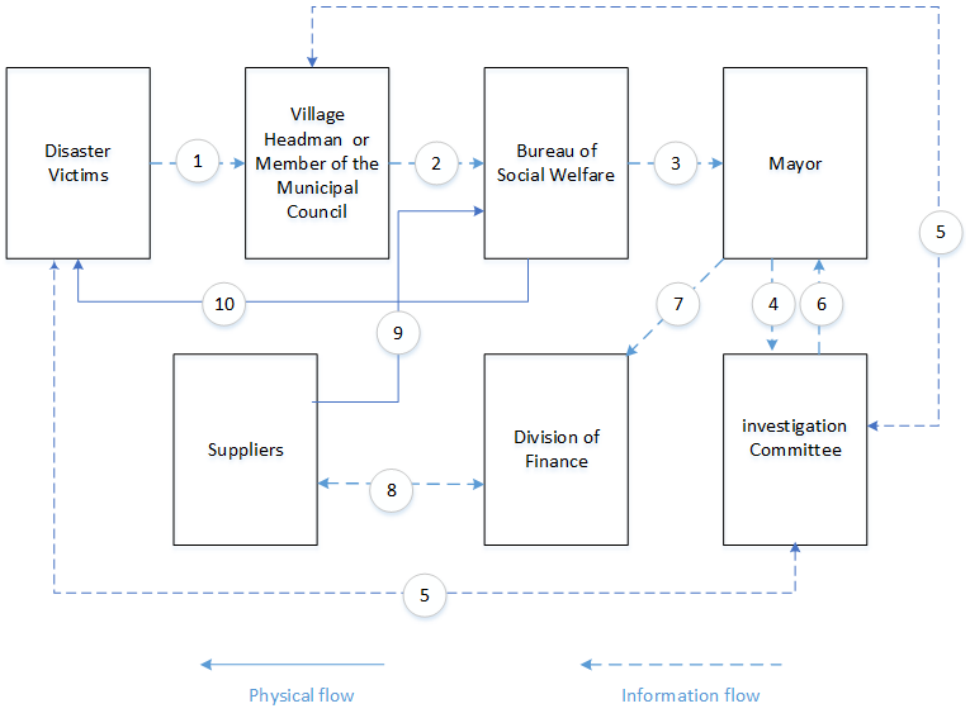


Figure 5: Input and output analysis

Khon Kaen Municipality supply chain 'uncertainty' cycle highlighted that its process uncertainty impacted the supply chain under study. In many instances, there was a long process of aid approval. Figure 6 summarizes the supply chain uncertainty circle in the Khon Kaen Municipality supply chain under study.

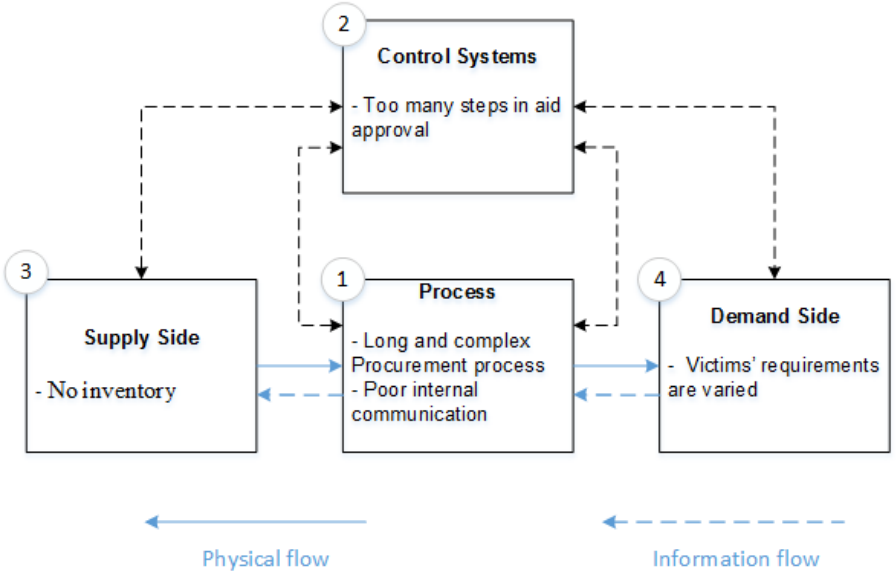


Figure 6: The uncertainty circle

The last analytical technique used is the causal loop diagram described in Figure 7. The main problem is the long response lead time caused by both internal and external uncertainty, as discussed above. This problem has five main root causes as follows:

No inventory keeps at Khon Kaen Municipality
Complex Procurement process
Poor internal communication
Too many steps in aid approval
Victims' requirements are varied

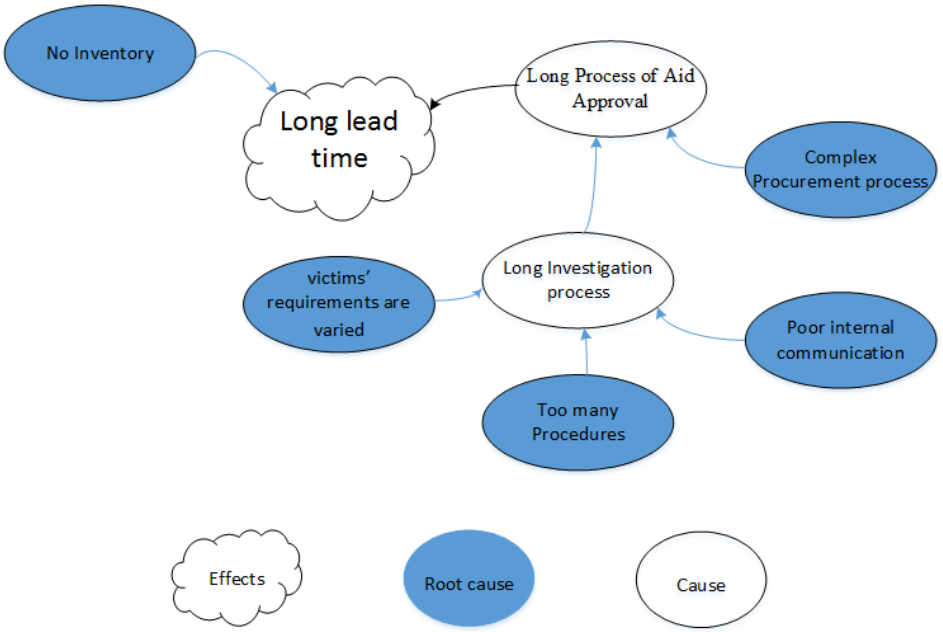


Figure 7: Cause and Effect Diagram for the Root Cause

The main symptom of this humanitarian supply chain is the long lead time to respond to a humanitarian situation. It is important to segregate the symptoms from the root causes. In order to find the root causes it is often useful to ask 'why' at least five times. This is a commonly used heuristic to help uncover the real problems. The advantage of using the causal loop diagram technique is that it also enables the identification of close loops within the humanitarian system under study. The identification of these close loops is critical and needs to be dealt with as a priority, as their impact is to self-reinforce the observed symptoms. In this particular case long process of aid approval is a key root cause.

Conclusions

The case study found that the original QSAM could not be properly used within the humanitarian context. The industrial and retail questionnaires of the QSAM did not work adequately in the humanitarian organization. The reasons for this discrepancy should be documented.

The result was found that the existing QSAM as it stands is not fully fit to be implemented in the humanitarian context. The original structure of QSAM may still be brought in to humanitarian organization, but an adjustment of timing on data collection should provide some room for analysis of the demand side rather than the supply side as was the case in the original version.

Based on the obtained results, as presented here, the team that audited the humanitarian supply chain was able to provide a number of short-term and medium to long-term suggested improvements for the Khon Kaen Municipality to implement.

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DIGITALIZATION OF LEARNING RESOURCES IN A HEI: ANALYSIS OF THE CRITICAL FACTORS FOR TRANSFORMATION

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SIM University, Singapore

Introduction

Continuous Improvements in Education Service Delivery

The last two decades have witnessed an increased pressure from customers and competitors for greater value from their purchases whether based on superior quality, faster delivery or lower cost (or combination of both) in both the manufacturing and service sectors (George, 2002). A number of organisations, including learning organizations such as Higher Education Institutions (HEIs) have adopted continuous improvement strategies for finding the balance amongst quality, cost and delivery.

In striving for continuous improvement, the use of technology for learning has grown tremendously in the last decade. The need for continuous just-in-time training has made learning technology an indispensible part of life. Nowadays, we are living in a world of increased mobility where the proliferation of mobile technologies is creating a host of new "anytime" and "anywhere" learning contexts. We live and learn in a connected world. Schools, colleges, and universities must adapt to these new sets of needs and expectations. To meet such diverse needs of learners, education service providers such as the HEIs have to constantly improve through the provisions of innovative pedagogical solutions in the form of novel and highly interactive self-learning digital materials.

This paper examines a case in a HEI that has ventured into the space of digital self-learning resources to provide students quick and easy access to their learning resources that leapfrog temporal and spatial constraints. Through this study, the authors provide a platform for informed debate across all sectors of education and learning and identify the critical factors that enable the major milestones in the tranformation journey.

The objective of this paper is twofold. Firstly, the authors aim to identify and analyse the difficulties encountered in the implementation of self-learning digital resources (henceforth called, "e-learning resources") in the form of interactive study guides (iStudyguide) and e-textbooks at a higher education institution, outlining the main critical factors concerning the major milestones on the journey of conversion. Secondly, we hope to highlight issues surrounding the use of technologies in learning so that other educational managers who are considering to pursue the deployment of similar e-learning resources can draw insights from the experience of this case study. To achieve the two-fold objective, the authors raise the following research question (RQ) to guide their study:

RQ1: Which are the key factors that facilitate the conversion of printed learning resources to e-learning resources in a higher education institution?

The various sections of the paper attempt to discuss the following: The first part reviews the relevant literature and summarizes general ideas about the use of digital technology for enhancing teaching and learning in a HEI and the concept of continuous improvement. The second part describes the major developmental milestones and characteristics of the digitalization initiatives including several critical decisions that are instrumental in shaping the transformation to the usage of digital e-learning resources in the HEI. We conclude by summarising the key lessons learned from this case study and propose our recommendations for continual improvement and future research work.

Literature Review

In an age of knowledge economy influenced by continually changing information technology (IT), network technologies have increased the pace of learning. Organizations encounter effects caused by drastic changes in this environment and individual learning and living are also connected to trends in the digitized world. It is important to include modern IT applications in education. Because of continuous technological progress in computer software development and application technologies as well as breakthroughs in digital data network bandwidth bottlenecks, e-learning technologies have changed the educational ecosphere of schools and corporate training systems. This phenomenon is extremely influential in managing the processes of teaching and learning (Govindasamy, 2001). HEIs have to harness the benefits of modern information technology and encourage students to learn through the use of digital media. Additionally, HEIs must endow students with sufficient information and response abilities, and allow them to become core points of strength that develop with the times.

The lean principle prescribes an operational system that places more emphasis on results and effectiveness rather than process and not a system that proposes standardized management logic (Fullerton and McWatters, 2001). The central idea in the “lean principle” is the removal of unnecessary waste during the production process. If resources are consumed without creating value, they become waste. Ohno (1988) defined seven types of waste that create no value: Over-production, defects, inventory, transportation, waiting, motion and over-processing. Liker (2004) proposed an eighth type of waste: inappropriate design. If these categories of wastes can be removed and the manufacturing process continually improved, a perfect lean production enterprise should be an achievable goal. Womack and Jones (2005) were the first scholars to apply the principles of "zero waste, zero defects and precise value" to the consumption end of the equation; they emphasized that lean consumption should consider production, service and consumption as three areas in which to eliminate waste. The priority of this approach is satisfying customer demand which further reduces company costs and the creation of "win-win" situations for both customers and companies.

Current understanding of pedagogical processes indicate that a major factor that drives the learning experience of students generally centers on the bundle of self-learning resources that include not only the course materials but also the supplementary resources accompanying the subject to be mastered. Thus, the methods employed to deliver the supporting self-learning resources in HEIs is a point of concern for institutions today. This concern leads to the hope of developing and establishing an educational and experience system that will engage and facilitate learning without barriers arising from constraints of time, space and location. In this study, the limiting conditions affecting students’ learning imply the concept of lean management. Lean management is derived from the manufacturing industry; it is a unique operational model taken from Toyota Production System (Ohno, 1988).

Using the concept of lean service, we examine a higher education learning environment that harnessed the use of technology to convert printed resources; including textbooks and study guides to interactive e-learning formats that are easily accessible to all learners. We aim to unveil how the use of technology can help the HEI lower its costs of operations, enhance self-learning efficiency and quality and improve its market competitiveness through the provision of superior e-learning pedagogy. The concept of lean service is applied to a unique case – a higher education institution (HEIs) context. By examining how learning resources in this HEI is digitalized and converted to online resources, this study identifies key factors that faciliate the transformation journey of the educational environment in the conversion process from the development of printed learning resources to interactive online digital self-learning resources that not only overcome issues relating to temporal and spatial barriers to learning but also provide learners “value-added” dimensions that are interactive and engaging.

Research Method—Case Study

As the digitalization of learning resource is a complex process and it involves multiple functional groups and departments, we chose a single case study approach (Yin, 2003). We conducted an in-depth case study (Eisenhardt & Graebner, 2007; Sigglekow, 2007). Our data sources include three methods: interviews, direct observation of the studied process, and analysis of e-learning resource database related to the studied process. Using an interpretative analysis approach, the data collection, analysis, and theory matching occurred iteratively over the course of our research.

Case Context - Digitalization of Learning Resources at an HEI

When evaluating the pedagogical methods adopted in HEIs, this study considered a number of criteria: - the ease of access to self-learning resources, temporal and spatial flexibility and cost, and resources logistics. These evaluation criteria that we have considered include the achievements of learning at any time, learning at any location, interactive learning and accessibility to diverse knowledge respectively.

A Process View of the Digitalization Journey

The HEI's decision to convert printed learning resources to the digital format is aligned with its mission to provide ease of access of self-learning materials to the student with minimum limitations of space and time. With effect from May 2015, the management committee of the studied HEI announce the decision to cease provision of printed study guides in a phased manner: level 1 courses in July 2014 (already completed), level 2 courses in July 2015, level 3 courses in July 2016 and level 4 courses in July 2017.

The process of developing learning resources in the HEI involves planning and coordination across multiple functional groups (academic and admininstrative) including internal departments as well as external stakeholders such as the publishers and external vendors that are engaged for the packaging and delivery services that prepare and deliver the course materials to the HEI. We present the roles and key responsibilities of the personel in these departments which are actively involved in the preparation, distribution and storage of course materials in Table 1.

Departments	Operational roles and key responsibilies
Educational Technology and Production Department (ETP)	The ETP provides course development support to enable the establihment of an engaging and interactive learning environment for the student of the HEI that includes: • The provision of pedagogical and instructional design advice for the creation of online courses • Creation of multimedia for e-learning developments • Copy-editing and formatting of course materials • Ensuring content copyright clearance • Tracking development processes to ensure timely completion of course materials for presentation and timely payments to course developers, and, • the Provision of Audio/Video (AV) Production and Training Upon receipt of the course development support/approval from the particular school of study at the HEI, the Learning Development Support will set up the project kick-off meeting with Head of Program (HoP), Course Developer (CD) and relevant External

Departments	Operational roles and key responsibilies
	Organisation participating in the course development process (if applicable). At this meeting, a detailed schedule of the deliverables will be confirmed, and agreed by all parties. The Learning Development Support will also provide the required development templates, forms and show the Course Developer personnel a sample Interactive Study Guide (iStudyguide).
Schools (Head of Programs, Instructors, Course Developer)	The Head of Programme will appoint a Course Developer and request course development support from the ETP.
Curriculum Administration (CA)	The Curriculum Administration (CA) department procures and produces the University's course materials for all students, associates and external examiners. CA department also takes charge of the distribution of the course materials to students and associates during and outside the Semestral Distribution period. A distribution process necessitates the smooth workflow in ensuring the materials are disbursed punctually and orderly.

Table 1: A summary of the generic Course (or Module) Development Process at the HEI

Overview of the Current and Modified Process Flows

Figures 1 and 2 together depicts the overall work flow for the course development, storage and distribution of print study materials at the HEI of interest. It can be observed that course development must be started first, generally about two semesters (or about a calendar year) ahead of work commencement by CA to place orders on textbooks and make arrangements to process print study materials developed by the course developers. CA will generally take about two to three calendar months to complete its materials ordering and delivery tasks ahead of distribution which normally takes place a week or two ahead of the commencement of study in a particular semester. Observations of the descriptions shown in Figures 1 and 2 reveal that the main drawbacks of providing print materials in the form of printed textbooks and study materials for every student on the course, would incur not only a laborious process of course development, but at the same time higher operating costs due to the need to maintain a huge materials store and logistics distribution network. Currently approximately half the total number of courses at the HEI still utilize this mode of course development that requires storage and distribution of printed study materials.

Figure 2 depicts the modified work flow required to accommodate the transition from the course development, production and storage of print study materials to that of the course development, e-production and cloud storage of e-study materials and assessments. A comparison of the print versus "e" course development/storage strategy would reveal that from the standpoint of physical storage and distribution, the logistical requirements of using print study materials entail time, manpower and maintenance costs to store and distribute print materials. By contrast, a leaner logistical structure can be maintained if the HEI adopts only the usage of e-materials for teaching and assessments. Although the initial financial overheads in terms of payments for intellectual and creative development/testing of e-contents, the pay-off for the high initial financial investments work favourably for the HEI in the long run.

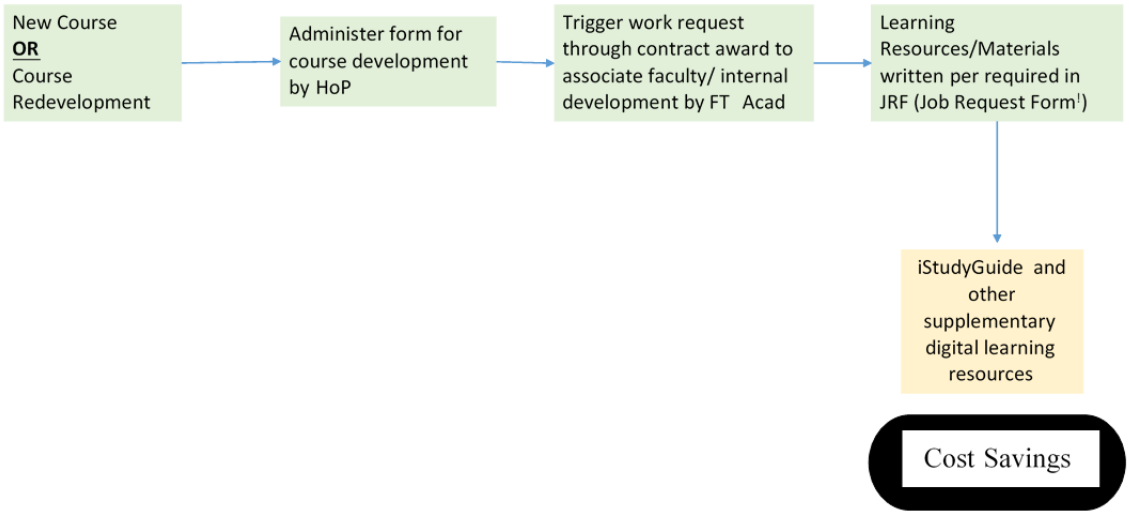

Figure 1: The key steps involved in the preparation, distribution and storage of e-course materials
[1]Learning resources/materials are modified in the digitalization journey to imply conversion from print to e-format with high interactivity.

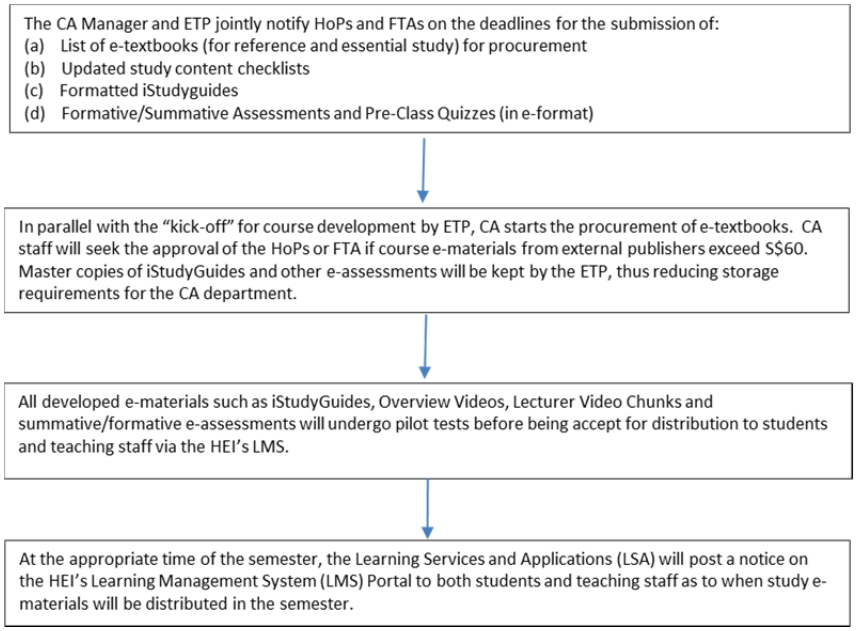

Figure 2: Workflow for CA, ETP and LSA Departments for the production and distribution of e-course materials

Figure 2 shows the modified work flow required to accommodate the transition from the course development, production and storage of print study materials to that of the course development, e-production and cloud storage of e-study materials and assessments. A comparison of the print versus "e" course development strategy mainly differs in physical storage and distribution as the logistical requirements of using print study materials entail greater handling time, manpower and maintenance costs in the storage and distribution of the print materials. In contrast, a simplified logistical structure can be maintained if the HEI adopts only the usage of e-materials for teaching and assessments. Although the initial financial overheads in terms of payments for intellectual and

creative development/testing of e-contents is higher, the pay-off for the high initial financial investments work favourably for the HEI in the long run.

Findings and Discussions

With the cessation of print learning materials requirements for level 1 and 2 courses, the HEI has been able to achieve not only monetary savings but also reap environmental benefits due to reduced paper usage. The bulk of the cost savings are mostly derived from the reduction in book printing, binding and shrink-wrapping of the printed learning materials that were required for the print resources. Other areas of improvements are observed in the new work process flow that is incorporated with advanced planning for e-Course development. A longer development time frame is implemented as the process for e-Course development entails greater support and interaction from multiple functional departments. Although there is little change in the space requirements, the amount of manual handling required in the logistical and material distributions for printed course resources by the operations staff at the CA Department are also reduced. Through an internal repository, the e-learning resources can be downloaded from an online platform that is secured by the student and instructor with password protection.

Scenario Analysis

To provide deeper insights from the case, the authors attempted a cost comparison based on a scenario that take into consideration the one-off costs to develop e-courses against future savings the the following scenarios. The purpose for the scenario is to provide a deeper understanding of the case through a quantitative measure. This is possible as one of the authors is an experienced course developer in the HEI. Based on his experience and data gathered from the context, the following scenario was analysed.

Currently, the HEI runs about 400 courses. We assume a scenario when it is possible to convert 100% of its existing courses to e-Courses at the HEI so that it may be possible to totally eliminate materials storage and handling cost. This will result in an approximate saving of 35% in operating cost. Other advantages that were recognised by the informants include the provision of greater access to digital materials which could faciliate an expansion of the HEI educational market reach to both the South-East Asian region and beyond through the medium of the world-wide web.

Reflecting on the Journey of Transformation

If we reflect on the transformation journey of the HEI, our case analyses elucidates evidence of lean management philosophy as illustrated in Table 2 .

Theoretical framework of Lean	Literature	Evidence of Lean from case findings
(1) “Lean” is essentially a strategy to reach both flow efficiency and resource efficiency	(Modig and Åhlström, 2012)	Savings on space, laborious manual handling of physical stock of learning materials at CA. Cost savings from elimination of book printing, binding and shrink wrapping. At the strategic level, there is an internal e-learning committee within the HEI that provides advisory guidance on strategic improvement initiatives and planning issues to ensure structured e-Course development and delivery.

Theoretical framework of Lean	Literature	Evidence of Lean from case findings
		The deployment of an appropriate e-Course pedagogy also supports the HEI's enterprise risk management strategy in ensuring Academic Continuity in the event of disasters.
(2) "Lean" as a methodology/ using a mix of technical and managerial aspects, such as low inventories and operator-driven improvement work	(Krafcik, 1988; Liker, 2004; Womack *et al.*, 1990).	Physical inventories that includes all forms of distributed print materials, inclusive of printed study guides and textbooks are reduced. Internal employees across multiple departments and the part-time associate teaching faculty and students from the HEI are heavily involved in skills upgrading, training and process streamlining to support the development of e- learning resources.
(3) "Lean" characteristics are often associated with continuous improvement, employee involvement and the aim is to remove waste	(Assarlind *et al.,* 2013) (Ricondo and Viles, 2005) (Holbeche, 1998) (Näslund, 2008).	The quality of course materials is monitored through internal audit and via current student and instructor feedback. The Quality Assurance office follows a strict auditing procedure where random samples of the learning materials are audited. In addition, feedback from instructors are gathered in the process of course delivery and during course development to the Learning Services and Applications Department (LSA) and Educational Technology and Production Department (ETP). Other supporting functions such as the hosting maintenance quality is also overseen by LSA. Within the respective academic schools, the Dean and Head of Programs are consciously aware of the need to ensure that the development of courses should be ideally done in a single pass in order to reduce rework and waste. As such, feedback is constantly sought from course developer, external academic content assessor and supporting publishers so that the e-Course materials can be refined to facilitate effective teaching and learning. The Academic External Assessors'

Theoretical framework of Lean	Literature	Evidence of Lean from case findings
		reports on the courses that have been developed form a major part of the continual improvement process. They are instrumental in facilitating the focal areas for course content improvements and their feedback and comments are highly regarded in the decisions taken for further enhancements and revisions to the developed courses when necessary.

Table 2: Theoretical Framework of lean and case evidence of lean management

Characterisation of the critical factors

To characterise the key factors that facilitate the conversion of printed learning resources to e-learning resources in this HEI case, we focused on understanding the coordination as a mechanism to explain our observations and address this gap in the literature.

Based on our in-depth analysis of the case study data, what come across from the interviews are

1) Clear vision and purpose articulated by the higher management
A broader understanding of the entire process, guided by shared goals and knowledge helps to create an environment in which employees feel psychologically safe and empowered to suggest possible process improvements, while reducing waste associated with a culture of finger pointing (Edmondson et al, 2003).

2) Staff openness to facilitate the change and willingness to engage in job redesign
The management decision to cease the provision of printed resources and converting all students and instructors to a learning environment that employ mainly digital learning resources has triggered numerous work redesign and process refinements that are closely aligned with the development of e-learning resources. Such a prerogative to re-design existing work, reconfigure layout and upgrading of technical skills to support the development of the digital learning materials have been enhanced by the staff openness to change and upgrade their knowledge through training to meet the technical requirements needed to facilitate the conversion to digital resources across functional groups in the HEI.

3) Relationship management with key stakeholders suppliers – publishers supportive of the HEI's learning resource digitalization by providing assistances in the form of training support to familiarize with the use of the e learning resources for their textbooks as well as the entire learning resources bundle that include both the e-textbooks as well as the Interactive Study Guide (iStudyguide).

In summary, a process improvement initiative can be coordinated by fostering close relationships among key stakeholders within the course material development process. Successful process transformations that crosses both internal and external boundaries hinges on the extent of timely and clear communication, shared goals and knowledge and dedicating conscious efforts in relationships management of multiple stakeholders. Finally, the continued participation of all stakeholders in the transformation efforts may be contingent to achieving the shared goal of the desired.

Conclusions and Recommendations

The study critically appraises the conversion process of the print to e-learning resources in an HEI with an aim to identify the key enabling factors that have facilitated a HEI to successfully implement

the digitalization of learning resources. Through a unique case study at a HEI in Singapore, we examined how the HEI increases customer value, expand its reach to regional market, while at the same time contribute to environmental sustainability by spearheading the digitalization of learning resources through a three-year implementation work plan that spans from 2013 to 2015. We make use of well-established lean principles to conceive the case and focuses on how the diverse functional department achieve superior performance despite encountering a highly uncertain and variable customer demand – a context considerably different from that of the typical lean manufacturing environment.

Finally, it must be emphasized that since this research is an exploratory case study, the results obtained cannot be generalized. Additionally, the enhanced connectivity enabled by online access to download digital learning resources requires internet connectivity to be readily available. Therefore, a comprehensive understanding of specific infrastructural capabilities and constraints that may varies across different context is necessary to enable an accurate assessment of similar digitalization initiatives. Future research can be conducted to provide an impact analysis of the potential risk factors if the use of printed study materials is completely eliminated, in favour of e-study materials. A potential study would be the risk impact to the HEI when there is a data network failure

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EXPLORATORY FACTOR ANALYSIS OF SERVICE QUALITY FACTORS FOR THAI LOW-COST AIRLINE INDUSTRY

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Introduction

Low-cost airline refers to an airline that generally has lower fares and operation under the policy to reduce unnecessary costs (Pels, 2008). After open sky policy, low cost airlines have become consistently more competitive in order to gain market share in the domestic airline industry, especially in Singapore Malaysia Indonesia and Thailand (Connell and Williams, 2005; Sengpoh, 2015).

Under this circumstance, Airlines are not only attempt to establish more convenient routes, but also introduce more promotional incentive. Nevertheless, the marginal benefits of marketing strategies gradually reduce because most of the airlines act similarly (Chang and Yeh, 2002). Price is also initially used as the primary competitive weapon. However, airlines soon realize that competition on price alone represents a no-win situation in the long term (Tsaur et.al., 2002). To deliver superior service quality from customer expectation understanding is a key of success and survival in the very hectic and competitive environment of airline industry (Gilbert and Wong, 2003). Furthermore, It is commonly believed that the higher service quality can lead to a customer's higher overall satisfaction and a long-term competitive advantage (Chen, 2008).

Therefore, this study acknowledges the importance of high quality service that has powerful effect on airline performance by analyzing those factors to measure the service quality towards focused three low-cost airlines; Nok Air, Air Asia and Thai lion air. The purpose of this study aims to categorize service quality factors for performance measurements of Thai low-cost airlines industry. Besides, to perform an effective quality assessment, Jomnonkwao and Ratanavaraha (2016) stated that evaluators must discern factors which have the greatest influence towards quality perception. Also Exploratory Factor Analysis (EFA) is the statistical methods widely used for group categorization that can be applied in this case. Despite, the Analytic Hierarchy Process (AHP) is used to evaluate the weighted factors by pairwise comparison.

Service quality in the airline industry

In general, service quality is defined as the overall satisfaction of the customer whom associated with the service organization performance (Prak et al., 2004; Liou et al., 2011). To deliver a better service for the airline, the organization should understand the passenger expectations and perceptions (Chen, 2008). The extensively used measure of service quality is SERVQUAL and divided them into five dimensions such as tangibles, responsiveness, reliability, assurance and empathy (Parasuraman et al., 1988).

Among the relevant studies found in the literature, this SERVQUAL model is mostly used statistical techniques to test the hypotheses or monitor the service levels of the airlines (Liou et al., 2010). According to Chang and Yeh (2002), the airline service quality can be measured by distinguishing between the service expectations and perceptions. Likewise, many researchers tried to compare the differences between passenger expectations and perceptions about the service quality from the airline (Prak et al., 2004; Gilbert and Wong, 2003; Chu and Kou 2009). In research of Leong et al., (2015), SEM was taken to determine the impact of SERVPERF dimension in customer satisfaction in order to build up a loyalty in the airline industry. In addition, Milioti et al. (2015) conducted a survey of traveler's perception about factors that are important to the choice of airline services by applying Multivariate Probit Model.

Moreover, Multiple-criteria decision-making (MCDM) monitors the airline service levels and point out the necessary of service improvement (Liou et al., 2010). This MCDM has been applied with

Fuzzy Set Theory to get the weight factors and/or the alternative ranking (Chou et al., 2011; Chang and Yeh, 2002; Tsaur et al., 2002; Nejati et al., 2009). As Liou et al. (2011), both modification method of Grey relation and the modified VIKOR were applied to evaluate the airline services. Originally, these two methods were adapted from the MCDM traditional airlines in order to prioritize strategy services. In addition, the services quality was ranked and improved by the concept of a novel interval-valued fuzzy MCDM (Kuo, 2011). Also Wang et al. (2011), DEMATEL and Fuzzy set were combined to define the service quality features of the airline properly.

Factor analysis

Factor analysis is a statistic technique that reduces a set of variables to lessen a number of the new variables. It provides the tools for analyzing the structure of the interrelationships (correlations) among a large number of variables (e.g., test score, test items, questionnaire responses) by defining sets of variables that are highly interrelated, known as factors (Joseph et al., 2010).

Two types of factor analysis

- Exploratory Factor Analysis (EFA) is used to determine the appropriate number of common factors that are needed to explain the correlations among a set of observed variables.
- Confirmatory Factor Analysis (CFA) is used to confirm the relationship between a set of observed variables and a set of common factors or latent variables

Regarding Liou et al. (2010), the research was applied factor analysis to extract factor and Dominance-based Rough Set Approach (DRSA) to determine the airline strategy. Similarly, many researchers used the factor analysis to categorize the inputs of the service quality survey from airline passengers (Pakdila and Aydın, 2007; Erdila et al., 2011; Jager et al., 2012). Besides, Basfrinci and Mitra, (2015) studied the impact of customer satisfaction in the context of social culture by Factor Analysis and Kano model.

The Analytic Hierarchy Process (AHP)

The AHP is a Multiple-Criteria Decision-Making (MCDM) approach developed by Thomas L. Saaty in 1970s. AHP is the theory of measurement through pair-wise comparisons and relies on the expert judgments to derive priority scales. The pair-wise comparisons technique uses a scale from 1-9 (1=equally important…9= extremely important) (Saaty, T.L. 2008; Singh and Nachtnebel, 2016). The AHP weighting factor was calculated as Esq. (1), (2) (3) and (4) respectively.

The research of the AHP involves the estimation of priority weights of a set of criteria or alternatives from a square matrix of pair-wise comparison $A = [a_{ij}]$, which is positive. If the paired comparison judgment is perfectly consistent, it is reciprocal, i.e., $a_{ij} = 1/aji$ for all $a_{ij}=1,2,3,..,$ n.

The final normalized weight, w_i, is given by

$$w_i = \left(a_{ij} / \sum_{k=1}^{n} akj \right) \quad \forall = 1,2,\ldots . n \tag{1}$$

The error on the judgment is unavoidable. The suggestion of Eigen value method computes *w* as the principal right Eigen value of the matrix *A* or *w* satisfies the following system of n linear equations: A*w*= λmax*w*, where max is the maximum Eigen value of A. This is to say that

$$w_i = \frac{\sum_{j=1}^{n} a_{ij} w_j}{\lambda max} \quad \forall = 1,2,\ldots . n \tag{2}$$

The natural measurement of inconsistency or deviation from consistency, called consistency index (CI) is defined as

$$CI = \frac{\lambda max - n}{n - 1} \tag{3}$$

The consistency index of a randomly generated reciprocal matrix from scale 1 to 9, with reciprocals forced, for each size of matrix called random index (RI).

Consistency ratio $CR = CI/RI$ (4)

RI is function of matrix size and $CR < 0.1$ is as an acceptable limit, otherwise it need to be revised and adjusted accordingly.

Another task in the hierarchy is the synthesis of the judgments throughout the hierarchy in order to compute the overall priorities of the alternatives with respect to the goal. The weights are created by summing the priority of each element according to a given criterion by the weights of that criterion.

Methodology

The study included both exploratory and conclusive phases; exploratory phase was primarily used as background study and questionnaire development, whereas conclusive study was dealt with data collection from actual respondents through a structured questionnaire.

Designing of research instrument

The airline service quality attributes were collected and defined by a cumulative frequency from the research during the year 2000 to 2015. As a result, over 33 interesting attributes were found. By Pareto diagram, these attributes were screened and remained only 18 important attributes. Then they were consulted by experts who had experienced in airline industry. Those experts recommended to detect or add the attributes into the initial list. For instance, flight safety was disregarded because it was basic requirement that all airlines must have. On the other hand, the comfort and cleanness of seat was expanded to two parts which are the comfort of seat and the cleanness of seat. The experts refined the list to 18 airline service quality attributes for performance measurements of Thai low-cost airlines industry. Then the initial draft of questionnaire was test-checked by a sample of 35 respondents about appropriateness in terms of wording and sentence structure. The final outcome of this phase showed that the research instrument contained 18 vital attributes (variables) to check Thai low-cost airline passenger′s responses on airline service quality. All attributes were scored by a 5-point Likert′s scale (a score of 1 indicated least important, whereas the score of 5 indicated most important).

Sampling and data collection

Population for this research was defined as a domestic passengers who had travelled at least two airlines or only one airline (In this case, the respondents should have the travel experience on that airline at least 3 times.) from three low-cost airlines in Thailand. Primary data was gathered directly from these passengers. The survey was conducted in the middle of May 2016 and over 308 sets of questionnaires were distributed to the passengers as well.

Data Analysis and extraction of factors

Data collected from 308 respondents were subjected to data reduction by using Exploratory Factor Analysis (EFA). The analysis was involved with the use of scores which attained from 18 airline service quality attributes to conduct group classification. This study used principal component analysis for factor extraction and varimax rotation with Kaiser Normalization through SPSS ver. 22.0.

Factor weighting by AHP method

The factors were derived from Exploratory Factor Analysis (EFA) and then calculated weight factors by primary experts who involved with airline industry through pair-wise comparisons. Then the result will be used in further study.

Results and Discussion

Checking suitability of data for factor analysis

1. Sample size

As the general rule, the minimum sample should consists of the observations at least five times over the number of variables to be analyzed, however, the more acceptable sample size should have a 10:1 ratio (Joseph et al., 2010). In this study, the sample were appropriated by samples and variables ratio (Sample= 308 and variables= 18).

2. Kaiser-Meyer-Olkin (KMO) and Bartlett's test of Sphericity (Wadkar et al., 2016).

- The Kaiser-Meyer-Olkin is the measure of sampling adequacy which varies between 0 and 1. The values that are closer to 1 regarded as better value and the value of 0.6 is the suggested minimum.
- The Bartlett's Test of Sphericity is the test for null hypothesis that the correlation matrix has an identity matrix.

H_o: There is no statistically significant interrelationship between variables.

H_1: There is statistically significant interrelationship between variable

As demonstrated in table 1, KMO value found that the sample was adequate for the analysis (KMO = 0.891). Bartlett's test of sphericity (Chi-Square= 2480.454, df= 153 and p= 0.000), we therefore reject the null hypothesis (H_o) and accept the alternate hypothesis (H_1). There is a statistically significant interrelationship between variables. It also implies that the correlation coefficients among all the variables are suitable to do EFA.

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.891
Bartlett's Test of Sphericity	Chi-Square	2480.454
	df	153
	Sig.	0.000

Table 1. Result of KMO and Bartlett's Test

Demographic Information

Regarding to Questionnaire survey, the percentage of those respondents were 34.70% Male and 65.30% female passengers. Almost 59.10% of the respondents aged between 21-30 years old. The occupation of passengers were mainly students, 37.40%. Furthermore, the salary of passengers were almost 52.60% less than 577 USD (20,000 Thai Baht). In term of annual travel frequency, the percentage was mostly 61.80% less than or equal to 5 times. By the way, the Demographic Information was shown in table 3.

Results of Exploratory Factor Analysis

Exploratory Factor Analysis condensed 18 variables into four factors. Besides, all factor loadings were greater than 0.50 and they were considered as practically significant. In addition, these four factors had eigenvalues higher than 1, explaining 62.196% of the variance together. The eigenvalue and the percentage of explained common variance were represented in Table 2, whereas the results of EFA were exposed in table 5.

Factor 1- Cabin crew service. This factor was comprised of seven variables (attributes) and explained as 24.668% of total variance. These variables were consisted of individual attention to passenger, crew's willingness to help, solve unexpected situation, crew's response, courteous of crew, professional skill of crew and crew's personality. Since all these variables pointed to airline passenger's service expectation from Cabin crew, therefore, it was labelled as "cabin crew service".

Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.879	38.216	38.216	6.879	38.216	38.216	4.440	24.668	24.668
2	1.902	10.568	48.784	1.902	10.568	48.784	2.962	16.457	41.126
3	1.394	7.746	56.529	1.394	7.746	56.529	2.085	11.586	52.711
4	1.020	5.666	62.196	1.020	5.666	62.196	1.707	9.484	62.196

Table 2 Eigenvalues and Percentage of explained common variance

		Frequency	Percentage
Gender	Male	107	34.74%
	Female	201	65.26%
Age (year)	< 20	25	8.12%
	21-30	182	59.09%
	31-40	51	16.56%
	41-50	23	7.47%
	51-60	20	6.49%
	>61	7	2.27%
Occupation	Student	110	35.71%
	Business owner	36	11.70%
	Employee/Office worker	97	31.49%
	Government officer	43	13.96%
	State Enterprises	18	5.85%
	Other	4	1.30%
Salary (Baht)	< 20,000	162	52.60%
	20,001-30,000	77	25.00%
	30,001-40,000	36	11.69%
	40,001-50,000	17	5.52%
	50,001-60,000	9	2.92%
	> 60,000	7	2.27%
Annual travel frequency	≤ 5	190	61.69%
	6-10	73	23.70%
	11-15	29	9.42%
	>15	16	5.19%

Table 3. Demographic Information of Thai low-cost airline passengers.

Factor 2- Convenience to airline passengers. Factor number two composed of six variables and regarded as 16.547% of total variance. This factor included the cleanliness of seats, the comfort of seats, payment channel, Check-in channel, waiting time at check in service and baggage delivery. Each of these variables was a convenience or ease for the airline passengers. Therefore, it was labelled as “Airline convenience”.

Factor 3- Inflight Entertainment. This factor in this analysis regarded as 11.586% of the total variance and contained with two variables or airline service quality attributes. Variables in this factor were consists of Food & Drink and Magazine, labelled as “Inflight Entertainment’’.

Factor 4- Flight Scheduling. This factor comprised of three variables and explained 9.458% of total variance. The variables included with frequent flights, Direct flight and the punctuality of flights. This factor was labelled as flight scheduling because all variables were engrossed.

Reliability of factor out put

Reliability was established by estimating Cronbach's alpha for each factor, with values of 0.6 to 0.7 deemed the lower limit of acceptability (Joseph et al., 2010). According to Table 4, the results were shown that the alpha value for all the factors were above 0.65 indicating the reliable output.

Factor no.	Factor title	Cronbach's alpha
Factor 1	Cabin crew service	0.880
Factor 2	Airline convenience	0.813
Factor 3	In-flight Entertainment	0.778
Factor 4	Flight Scheduling	0.651

Table 4. Reliability and validity of EFA results

Factor no.	Factor title	Variables included	Factor loading
Factor 1	Cabin crew service	Individual attention to passenger	0.819
		Crew's willingness to help	0.769
		Solve unexpected situation	0.782
		Crew's response	0.765
		Courteous of crew	0.692
		Professional skill of crew	0.673
		Crew's personality	0.541
Factor 2	Airline convenience	The cleanliness of seat	0.711
		Payment channel	0.645
		Check in channel	0.642
		The comfort of seat	0.582
		Waiting time at check in service	0.552
		Baggage delivery	0.523
Factor 3	In-flight Entertainment (IFE)	Magazine	0.826
		Food and Drink	0.793
Factor 4	Flight Scheduling	Frequent flights	0.796
		Direct flight	0.684
		The punctuality of flights	0.530

Table 5. Results of Exploratory Factor Analysis (N=308)

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax rotation with Kaiser Normalization

Factor weighting

According to Figure 1, it was represented the relative weight of all service quality factors which were obtained by applying AHP. The weight for each of factor was flight scheduling (0.578), cabin crew service (0.201), convenience to airline passengers (0.155) and in-flight entertainment (0.078) respectively. Flight scheduling was found as the highest relative weight and the most important factor when airline service quality's performance measurement was conducted. Especially, the weight factors also described that flight scheduling is the most important concern towards experts. It expressed the reliance towards airlines which they can provide the service based on airline agreements, including the punctuality of flights, flights frequency and direct flight.

Ranked by the weight, the top five sub-factors or attributes were the punctuality of flights (0.420), direct flight (0.091), flights frequency (0.067), professional skill of crew (0.044) and to solve unexpected situation (0.043). These results were as the preliminary stage and required more interviews with airline industry experts. Then all collected data will be analyzed in order to increase validity and reliability for a further study.

Conclusion

This study aims to categorize service quality factors for performance measurements of Thai low-cost airlines industry, focused three low-cost airlines. EFA was used in order to categorize the attributes into four groups with 18 attributes or variables, Cabin crew service (Factor 1), Convenience to airline passengers (Factor 2), Inflight Entertainment (Factor 3) and Flight Scheduling (Factor 4). All factor loadings scores were relatively high (>0.5), indicating that the variables had strong potential for service quality performance measurements of Thai low-cost airlines.

In addition, the weight factors from AHP through pair-wise comparisons represented that the primary experts were aware of airline flight scheduling as the most important factor and the least one as in-flight entertainment. Among the eighteen sub-factors or variables, the top five sub-factors were the punctuality of flights, direct flight, frequent flights, and professional skill of crew and solve unexpected situation.

In future study, the factor outputs from EFA will be examined the validity value. Likewise, the researcher will do interview with more experts who involved with airline industry in order to increase additional data validity and reliability of factor weighting in AHP.

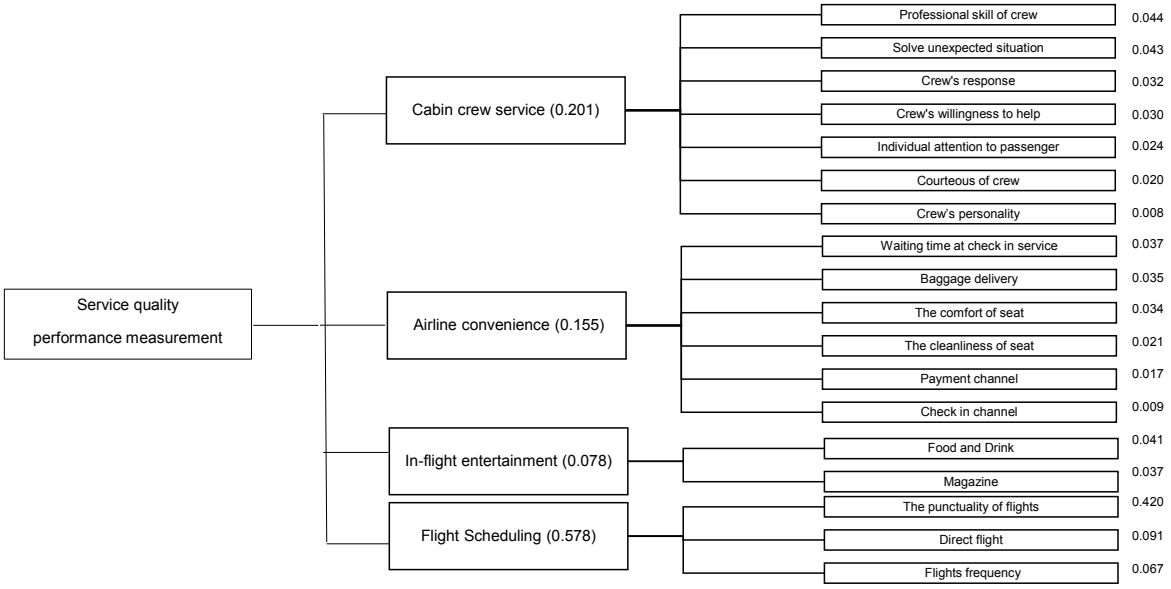

Fig. 1 Weighs of the factors

Research limitations/implications

In this study, flight safety was disregarded because it was basic requirement that all airlines followed by ICAO safety standard. Besides, the weighted factors were initially calculated by experts but required further data in order to increase additional data validity and reliability.

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IMPROVING AND OPTIMISING SPARE PARTS INVENTORY MANAGEMENT

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Introduction

With increasing market globalisation, the spare parts logistics in Asia-Pacific region has prosper to achieve high business margin for corporate profits. Managing spare parts inventory is challenging. Organisations are realising the higher customers' expectations on quality and prompt after-sales support to ensure spare parts availability. This is mainly because end customers hope to extract the maximum value from products by extending products' lifecycle.

In order to satisfy customers, organisations need to deliver the right products, in right quantities and the right conditions, to the right place at the right time for the right customer at the right price. However, there will be tremendous cost implications when organisations try to improve the current supply chain to transport and stock spare parts in a more efficient, reliable and timely manner. Figure 1 shows a detailed flow of the continuous sequence of stock replenishment and reduction to meet demand.

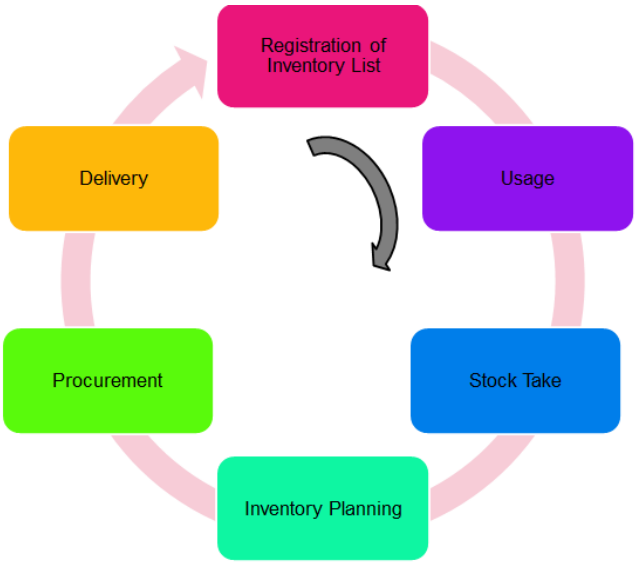

Figure 1: Basic Spare Parts Management Flow

Global Part Centre Singapore (GPCS) is an after-sales division of Company A, a printer manufacturing company. This company aims to progressively emerge to gain and retain end-customers through competitive advantage.

Current Spare Parts Management

GPCS spare parts are delivered in two modes. The first mode is to deliver spare parts under warranty service for repair. Whenever end customers (consumers) purchased printer from Company A, there will be a warranty contract binding Company A to provide free replacement of spare parts for a limited period. Once the printer becomes faulty, end customers will send it for repair at respective service centres. Some repair will require replacement of spare parts so service centres will purchase them from GPCS.

The second mode of delivering spare parts is for after warranty purposes. When end customers send their out-of-warranty printer for, they are required to make payment for the replacement of spare parts and services. It is important to ensure space parts availability for both under warranty and after warranty repair because it can boost the confidence of end-customers to retain and attract new customers.

Using demand forecasting system and liaising closely with the world-wide service centres; GPCS calculates the quantities to procure spare parts from both in-house and original equipment manufacturer (OEM) suppliers. At any time, there will only be one supplier for each SKU.

When the stocks arrive at the warehouses, GPCS will allocate the necessary quantities to customers by issuing 3rd Party PO in SAP to instruct the warehouses to pick and pack stocks for delivery.

In GPCS, there are both make-to-service and make-to-stock replenishment methods. The critical orders need to be satisfied immediately will be fulfilled with spare parts make-to stock. Replenishment quantities for make-to-stock can be derived by adding safety stock quantities to the multiplication of GPCS forecasted future demand quantities and lead time. The less critical maintenance orders can be satisfied with make-to-service spare parts where customers provide a fixed lead time and GPCS will not plan safety stocks. Some examples of make-to-service spare parts are user manuals and software CD-ROMs. The reason for not stocking safety stock for user manuals is because paper can obsolete fast by turning yellowish and delivery key performance index (KPI) will improve given that customers provide a fixed demand lead time. Inventory management in GPCS is much more complex as it involves conflicting objectives across various organisation segments and tentative nature of supply and demand.

In Figure 2, the production lead time refers to the time required by supplier(s) to source raw materials and produce according to Purchase Order (PO) requirements. The production lead time for each spare part varies. This is due to the necessity to ensure clean room (a controlled environment with lowest level of pollutants) availability for clean parts production, acquiring of new moulds or kitting of child parts (Dekker, 2013). Transportation lead time is the duration needed to bring spare parts from a stock location (e.g. suppliers' premises) to service network (e.g. warehouses) and service centres (e.g. GPCS' customers). Depending on the mode of transport and geographical distances, ocean transportation lead time can take up to a month to reach end customers. One of the important deciding factors to determine which warehouse to stock the spare parts is dependent on the total lead time required from the point where GPCS issues SPR to fulfilling the customers' orders.

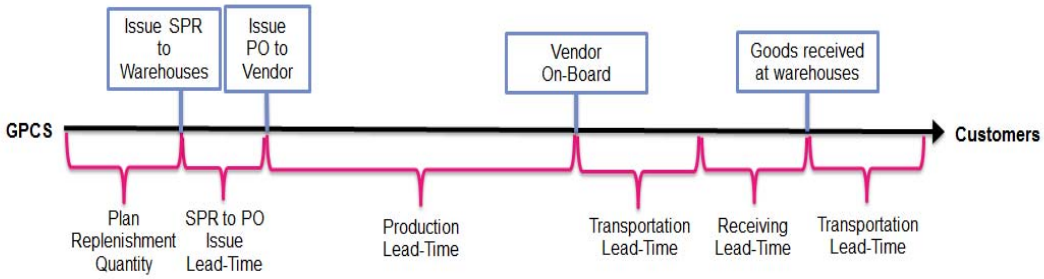

Figure 2: GPCS Spare Parts Process Flow Map

More than 50% of GPCS' sales orders cannot be fulfilled in a month. GPCS like other organisations across the industries is looking for ways to fulfil their commitments to customers by improving response time.

To achieve perfect order fulfilment, GPCS must deliver spare parts with complete and accurate documentation without delivery damage. This is often very difficult to achieve in practice as demand is uncertain. For instance, spare part failures are dependent on the cannibalism of other spare parts and how users use and maintain the printers. Especially when the dependence relation is unknown and there is no accurate information, these uncertainties will cause erratic demand and have an immediate impact on spare parts inventories. The tentative nature of unpredictable supply and demand is shown in Figure 3.

Figure 3: Tentative nature of unpredictable supply and demand

Therefore, it is necessary for service centres to provide quick repair of a product or system that is faulty. To guarantee a high service level, spare parts need to be stocked appropriately at some points in the supply chain

Scope of this Study

As shown in Figure 4, the main scope of this project will focus on the replenishment planning for spare parts within GPCS to ensure stocks availability to Company A's (multi-national company, MNC) service centres world-wide. The replenishment planning is on the upstream of the supply chain.

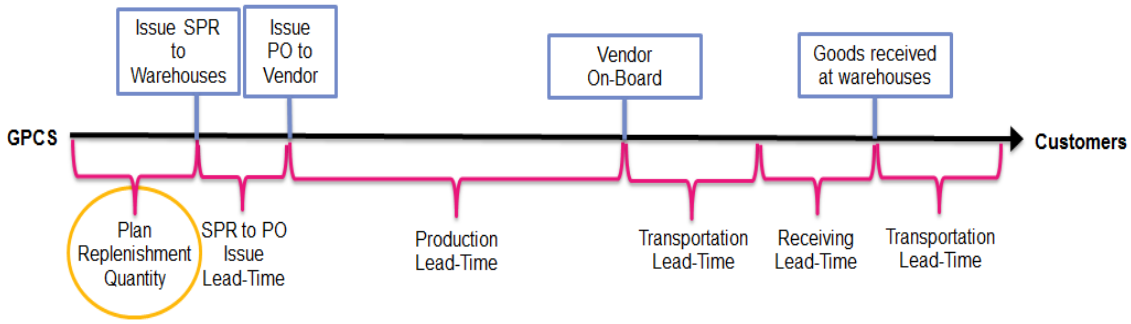

Figure 4: Scope of study in GPCS' Spare Parts Process Flow Map

Challenges

Often an unexpected event like customers being awarded a contract with government agency or some big companies can completely turn GPCS planning upside down because of the higher service standard required. This is because both parties would usually enter a contractual agreement with GPCS promising to deliver spare parts within a certain timeframe known as time-based service level. The first reaction is for GPCS to increase safety stock. However, this project aims not only to increase the safety stocks but propose solutions during replenishment planning to improve spare parts availability and customers' satisfaction.

Figure 5 shows the different departments of GPCS seeking to increase or decrease inventories. Though each has differing viewpoints, they share the same goal of achieving better profitability.

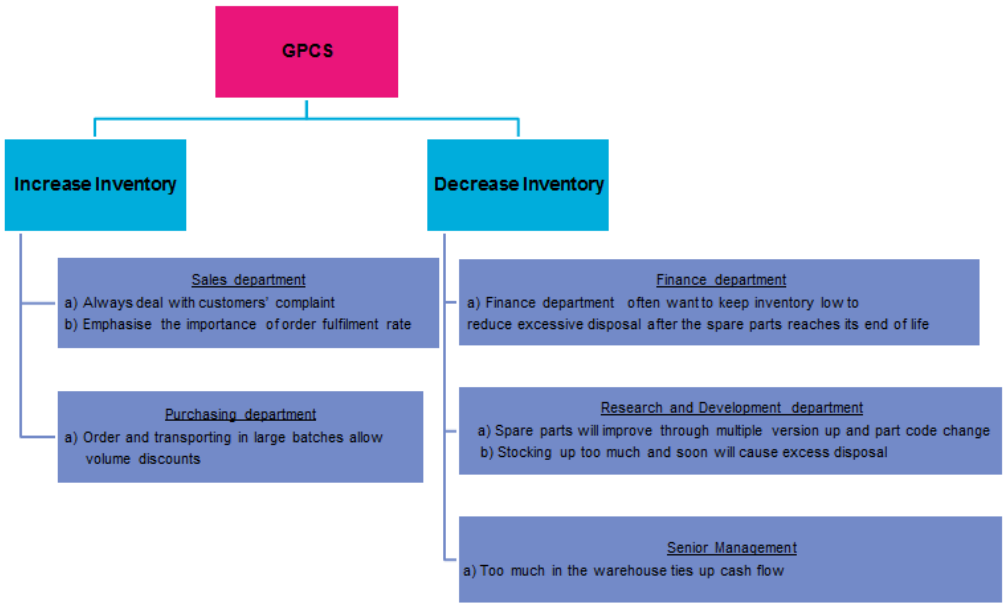

Figure 5: Conflicting Objectives in GPCS

Hit Rate

Hit rate is a form of performance measure indicator for order fulfilment. It is defined as the percentage of meeting customer orders within the time window (Wheatley, 2014). Figure 6 shows the increasing GPCS hit rate and decreasing outstanding sales orders. Figure 7 shows the decreasing stock amount at GPCS warehouses. Comparing Figure 6 to Figure 7, an increasing "hit" ratio is achieved at a lower stock amount. This implies GPCS is keeping the right spare parts for higher stock turnover.

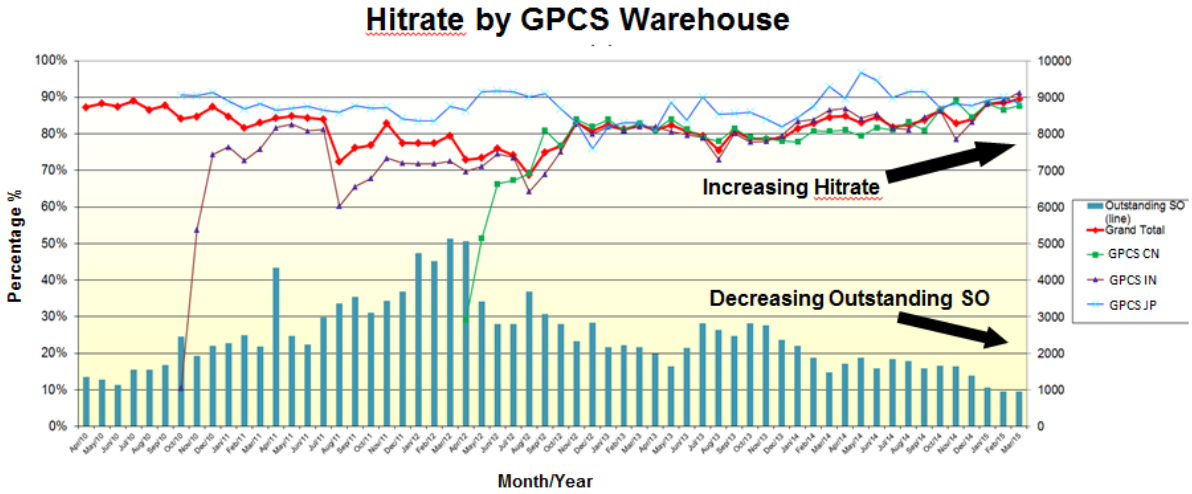

Figure 6: Hit rate by GPCS Warehouse

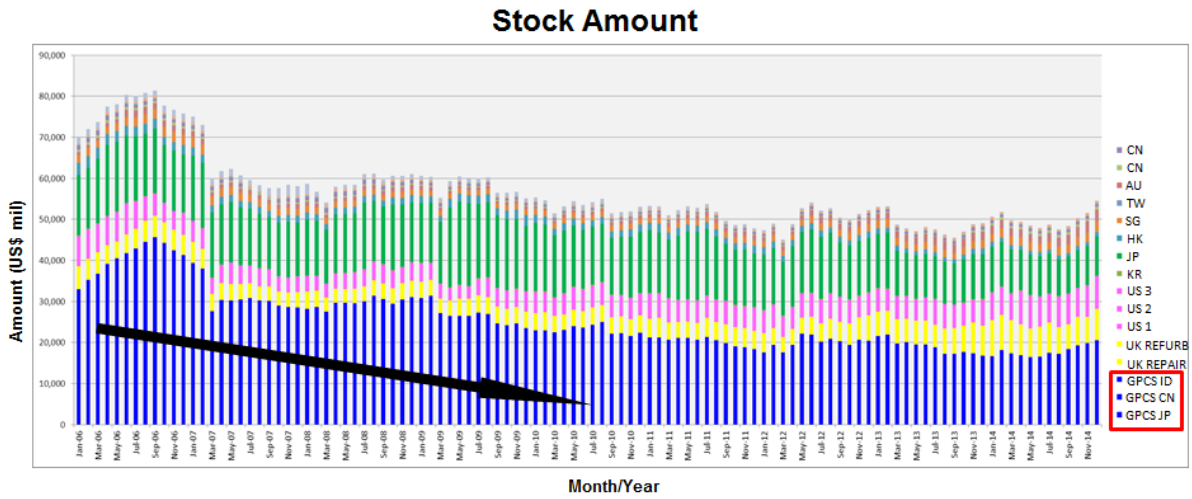

Figure 7: Stock Amount by GPCS Warehouse

Improved Inventory Policy

In order to efficiently compete in the market, GPCS is reviewing its inventory management to concentrate on areas to produce significant and short-term results (Wintle & Patch, 2003).

Safety Stocks

The current stocking policy in GPCS is based on product categories. Among the different product categories, GPCS can focus on part classification with high volume and low hit rate (Figure 8).

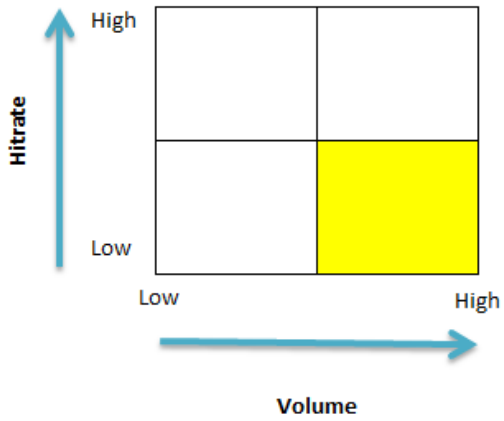

Figure 8: Matrix of Hit rate and Volume

As shown in Figure 9, the Pareto Analysis identified 20% of the part classifications to represent 80% of the sales. Having GPCS to spend time to focus on these 20% can produce 80% of the results. The top 20% of the part classificaions are namely mainboard, I/S supply assy/ unit, panel and printer mechanism.

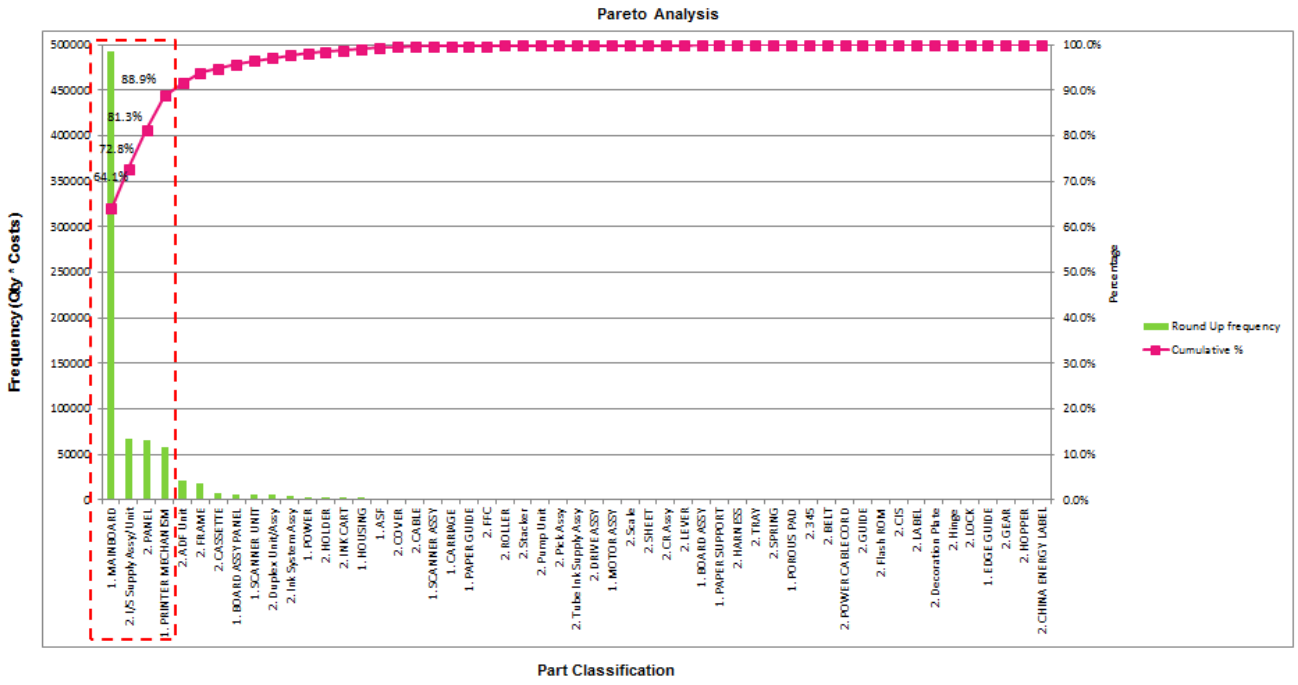

Figure 9: Pareto Analysis

Minimum stock quantities

Slow and recently introduced parts tend to have intermittent demand character and lead time is uncertain. Unlike moving parts, the re-order point for slow and recently introduced parts cannot be determined easily. This is mainly due to the insufficient sales history to generate forecast quantities. It is important to select the best inventory policy to improve customer service and reduce inventory holding costs.

Business Printers

Compared to other product categories, unit costs for Business Printers' spare parts are relative expensive and they will experience more frequent part change due to quality issues. The management of GPCS needs to consider the impact judiciously.

To avoid excess disposal due to minimum stock policy, the scope of targeted parts should shrink. For instance, spare parts which are created more than three years ago with no sales should be removed from the target part list. The reason for setting three years is because the printer should have already entered its mature stage in product lifecycle. If there is no sale within the three years, it simply reduces the probability of them having any demand in future.

Table 1 shows the average customers ordered quantities in the past one year. It shows the percentage of sales order (SO) lines that can be covered by the minimum stock quantities. For instance, if GPCS were to ensure that all Business Printer spare parts in the target list to have at least 10 pieces on-hand stock at all times, GPCS is expected to be able to cover 29.7% of total Business Printer sales order lines.

Summary (Business Printer)

Monthly SO Qty	Average Number of Part Codes (Monthly)	Average Number of SO Lines (Monthly)	Cumulative Number of SO Lines	Cumulative % of SO Lines
1-5pcs	118	150	150	17.2%
6-10pcs	66	109	259	29.7%
11-20pcs	69	124	383	43.9%
21-30pcs	25	72	455	52.2%
31-40pcs	14	57	512	58.7%
41-50pcs	7	20	532	61.0%
> 51pcs	67	340	872	100.0%
Total	366	872		

Table 1: Monthly Order Pattern (Business Printer)

The simulation results are shown in Table 2 to Table 4. According to the simulation results, the option of keeping minimum stock quantities at 20 pieces will allow GPCS to achieve the highest Delivery On Time (DOT) improvement of 5.9% at a moderate inventory amount increase of $ 86908.82 and Days of Supply (DOS) improvement of 10 days. Moreover, it can cover approximately 43.9% of Business Printer SO lines per month. In option 1 and 2, the different minimum stock quantities are applied to parts based on its importance. For example, the most important spare parts will be assigned to minimum stock quantities of 20 pieces and the least important spare parts will be assigned to 5 pieces in Option 1.

DOT				
	Jan'15	Feb'15	Mar'15	Average DOT %
Business Printer DOT (Actual)	82%	75%	76%	77.7%

Minimum Stock Policy	Jan'15	Feb'15	Mar'15	Average %	Improvement
Business Printer DOT Option 1 (min stock = 5pcs, 10pcs, 20pcs)	85%	77%	81%	81.1%	3.4%
Business Printer DOT Option 2 (min stock = 10pcs, 20pcs, 30pcs)	87%	79%	83%	83.0%	5.3%
Business Printer DOT Option 3 (min stock = 10pcs)	85%	78%	82%	81.8%	4.1%
Business Printer DOT Option 4 (min stock = 20pcs)	87%	79%	85%	83.6%	5.9%

Table 2: DOT Improvement for Introducing Minimum Stock Policy

(Business Printer)

Inventory Amount			
Minimum Stock Policy	Actual	Increase by	Improved Final Inventory Amt
Business Printer Option 1 (min stock = 5pcs, 10pcs, 20pcs)	$ 775,789.88	$ 50,869.01	$ 826,658.89
Business Printer Option 2 (min stock = 10pcs, 20pcs, 30pcs)	$ 775,789.88	$ 147,640.29	$ 923,430.17
Business Printer Option 3 (min stock = 10pcs)	$ 775,789.88	$ 37,790.70	$ 813,580.58
Business Printer Option 4 (min stock = 20pcs)	$ 775,789.88	$ 86,908.82	$ 862,698.70

Table 3: Inventory Amount Increase for Introducing Minimum Stock Policy

(Business Printer)

DOS			
Minimum Stock Policy	Actual (days)	Increase by	Improved Final DOS (days)
Business Printer Option 1 (min stock = 5pcs, 10pcs, 20pcs)	90	6	96
Business Printer Option 2 (min stock = 10pcs, 20pcs, 30pcs)	90	17	107
Business Printer Option 3 (min stock = 10pcs)	90	5	95
Business Printer Option 4 (min stock = 20pcs)	90	10	100

Table 4: DOS Improvement for Introducing Minimum Stock Policy

(Business Printer)

Conclusion

Due to the costs involved in holding inventory, it will aim to hold the minimum amount possible while still being able to satisfy orders from its customers. In this study, several stock increase simulation have been conducted for slow moving and recently introduced critical product categories like Business Printer to improve order fulfilment rate. Taking into consideration the DOT improvement and inventory amount increase, GPCS management is recommended to implement minimum stock policy of 20pcs for Business Printer. In order to achieve effective inventory management in the competitive changing demand market, it is important that GPCS conduct quarterly reviews on the minimum stock policy. Besides procuring parts from suppliers, GPCS can consider to buy back excess quantities from customers to reduce the overall inventory in Company A.

Strategic stock increase for minimum stock quantities have to be implemented in different phases so that it will not affect Company A's financial performance. Introducing the minimum stock quantities is not a one-time application. It needs to be reviewed regularly on a monthly basis. Minimum stock quantities may be adjusted according to market demand. Due to the time constraint of this project, GPCS should also consider to optimise the inventory level of the moving parts by studying the inventory situation further. Solution Effect Analysis can be used to check on the effects that the proposed solutions will cause. This ensures that having agreed on a solution will not cause another problem to occur.

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IMPROVING CARBON EFFICIENCY THROUGH CONTAINER SIZE OPTIMIZATION AND SHIPMENT CONSOLIDATION

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Introduction

Most of the goods in the world today are manufactured in Asia due to affordable labor cost and finished goods are transported to the other parts of the world via containerized sea shipments. Many manufacturing companies choose to ship their products by purchasing full containers and take the responsibilities for packing the goods themselves. This is known as the Full Container Load (FCL). Another shipping option is known as less-than-container load (LCL). In LCL, a third party logistics service provider (LSP) is responsible for packing the goods into container. The choice of FCL or LCL often depends on a variety of factors, such as cost, timeliness of delivery and risk of damage. It is common for companies to use a combination of FCL and LCL to meet their shipping needs.

Unfortunately, often, companies using FCL may not be able to maximize the utilization of the container's capacity. This could be due to varying transportation volume or lack of consolidation capabilities. Companies may order fixed sets of containers for each manufacturing site in shipment period (e.g., weekly, monthly) based on contract terms. Containers are filled up with whatever demands, resulting in low container capacity fill during low demand periods. Inefficient use of containers, thus results in a total carbon footprint being higher than necessary.

Carbon footprint in this paper refers to the total amount of carbon emissions for all shipments via sea and land transportations. Typically, actual carbon footprint of particular shipment takes into account of various factors such as carbon efficiencies of the ship, type of fuel used and routes taken. For the purpose of this study, we are interested in comparing carbon emission contributed by the number and sizes of container used. As such, detailed calculation of carbon footprint is not necessary. Instead, carbon consumption ratio is used, e.g., the carbon consumption ratio of container per KM for 20-foot standard container, 40-foot standard container, and 40-foot high-cube container is 1:2:2.2. This ratio is realistic based on our domain knowledge carbon accounting of sea freight.

The objective of this paper is to support decisions on selection of appropriate combination of container sizes and shipment consolidation for a manufacturing company. The two-steps model which first takes the volumes to be shipped as an input and provide the combination of container sizes required; then evaluate possibility of shipment consolidation from multiple ports (of loading) within the same country to the same destination (port of discharge). In both steps, the objective function is to minimize carbon footprint by applying linear/integer programming. Only consolidation within the same country is considered due to practical considerations to avoid the need for cross border clearances.

We verify our model with a real-world business case (and data) in the consumer product manufacturing industry. By applying the proposed approach and models, the company can reduce the carbon footprint by 13.4% by using the optimal container size and further reduce the carbon footprint by 12.1% from consolidation of shipments as compared to the current practice without optimization.

Our model had been implemented by using AIMMS (Advanced Interactive Multidimensional Modeling System) which supports linear/integer programming. We believe that our approach and implementation technology can be easily adopted by various transportation companies in the industry.

Literature Review

(Dekker et al., 2012) covered an overview on operations research for green logistics that contributes in terms of the background of containerization, containers and the container related activities. It covered a number of variables that affect carbon footprint of the shipment without consideration for optimization of carbon footprint. (Lim et al., 2014) focused on green shipping management capability and (Wuisan & Wageningen, 2012) paper was on green shipping through private governance. Private governance is not adopted easily. (Leonardi and Browne, 2009) developed a method for assessing the carbon footprint of ocean freight. Optimization was not considered.

Other container selection and consolidation works have little relevance to sustainability. In the domain of procurement, (Mark et al., 2009) presented a concept called lean procurement through the application of procurement consolidation techniques. This is to reduce transportation cost and to improve production efficiency in the supply chain for small-to medium-sized enterprises (SMEs). In the area of freight consolidation and containerization, (Qin et al., 2014) constructed a model to solve issues with shipping from a port to multiple destinations after arriving at the port of discharge. This work did not consider environmental sustainability.

In the area of container selection, (Lin et al., 2014) developed a decomposition based solution methodology for the selection of standardized modular containers to reduce the number of containers used for shipping products and maximize the space utilization rate of the containers. The authors showed that using fewer container sizes can also reduce the waste associated with the water, energy and carbon dioxide emissions associated with manufacturing.

Another related area of research related to efficient use of container is a container-packing problem. (Thapatsuwan et al., 2012) developed algorithms to solve packing rectangular boxes into a set of containers. In their scenario, the size of the containers was fixed. (Jin et al., 2004) also looked into solving the container-packing problem with additional practical constraints such as loading stability, the rotation of items around the height axis, and the fixed loading (unloading) orders.

To our best knowledge, none of the work in the literature considered consolidation and selection of appropriate sizes of containers with the objective of reducing carbon footprint.

Purpose

We are motivated by a real-world business case that manufactures a consumer product with major production plants in China. The goods are shipped to the US for sales. Goods are shipped by ocean freight and the containers selected for this study are the most common ones, namely, 20-foot standard container, 40-foot standard container, and 40-foot high-cube container. In reality, 100% usage of the container is rare due to packing issues and size of goods. We investigated using our data set it is possible to fill up to ~95% of a container. Hence, we will use 95% fill rate as the highest possible fill rate in our analysis. Table 1 shows the available container volumes at the two different capacity fill rates.

	20 foot standard container	40 foot standard container	40 foot high cube container
Maximum container volume (cubic meters)	33.2	66.7	76.2
~95% container volume (cubic meters)	31.5	63.4	72.4

Table 1: Container Volumes at Different Fill Rates

The company's current practice is to ship the containers as and when there is demand (orders from US) and it is usually shipped from a port of origin (port near manufacturing plant in China) to a destination port (in US) directly. We found in the data that there is a potential to better fill the containers with better selection of combination of containers of different sizes.

We propose an integer programming model for Container Size Optimization (CSO) problem that optimizes the carbon footprint by considering both the selection of ideal sizes of containers for the shipment volume. The model also determines the optimal number of containers that satisfies the shipment volume. In CSO, we assume that the shipments can only be shipped directly from ports of loading (i.e., a port in China) to ports of discharge (i.e., in U.S) via sea. The idea is that it is more carbon efficient to use a set of containers which is just enough for the shipment volume as different container sizes has different carbon emission factors.

To further improve carbon emission factors, we also propose consolidation of shipments within a country (CSC). CSC combines shipments from different ports of origin within a country to a single consolidation port. A scenario is considered for CSC only when there is more than one shipment (from different manufacturing plants) on a single day. For each shipment, we provide an option to transport the goods from the manufacturing plant by road (truck) to a port of consolidation or be shipped directly from the port of origin. The options are mutually exclusive.

Our consolidation model takes the total volume to be shipped of all shipments (from various ports of loading), origin and destination as inputs. The output of the model minimizes the overall carbon footprint and provides 3 possibilities (Figure 1): (1) direct shipment from original port of loading; (2) use road freight to consolidate all shipments at a single port of loading in the same country; (3) combination of direct and consolidated shipment. In the case of consolidation (options 2 and 3), the model will also provide the most suited port of loading.

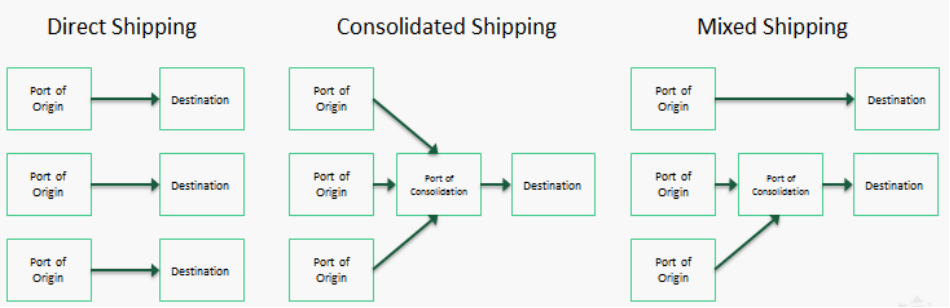

Figure 1: Three possibilities of shipping

Methodology: Mathematical models

Integer programming is used to solve the container size (CSO) problem. There are a few assumptions made: (1) companies can pack up to 95% of the container volume. (2) All shipments are made through FCL. (3) Required containers (of the various sizes as determined by CSO) are always available. (4)

The weight of the shipment does not impact the carbon footprint of the containers (which is the industry carbon accounting method for ocean freight).

Carbon Emission Factors

The amount of carbon emission per container kilometer (KM) on container ships is a complex calculation based on many factors such as efficiency of the ship, fuel used, ship cruising speed, tidal conditions and actual route taken. For example, the older ships are less fuel-efficient and hence emit more carbon dioxide than the newer ships which emit between 20-40% less carbon dioxide. Actual carbon emission of the same container shipped on different ships has large variances. For the purpose of our optimization model, instead of using the actual carbon emission number, we found that a comparison factor is sufficient to compare the options of using different sizes of containers. We use a pre-determined carbon emission ratio for each of the three sizes of container. In this way, we assume that given the same shipping conditions (e.g., vessel used, route, and speed), the only factors affecting the carbon footprint are the type and number of containers used for the shipment.

The carbon emission factors we considered are as follows: the 40-foot standard container emits twice the amount of carbon dioxide of a 20-foot standard container and a 40-foot high-cube container emits 10% more carbon dioxide than a 40-foot standard container. Therefore, in our model we shall use the ratio of 1: 2: 2.2 for 20S: 40S: 40HC. This ratio shows that for ocean shipments, the 20-foot standard and 40-foot standard containers actually have the same carbon footprint per cubic meter. With the same carbon footprint per cubic meter, the shipment volume becomes the main determining factor in selecting which type of container is most appropriate.

In our data set, each row (a data point) is a shipment with an associated shipment volume from a port of origin to a port of destination. CSO is applied on each row of shipment volume. If a shipment is being consolidated, CSO is also applied on the consolidated volume.

Container Size Optimization (CSO) Model

The following variables will be used in CSO model:

- i = Type of container size, 1 for 20S, 2 for 40S and 3 for 40HC, ∀ i=1,2,3
- j = Port of loading, ∀ j=1,2,3…n
- k = Port of discharge, ∀ k=1,2,3…m
- C_i = Carbon Emission per container KM for each container size
- Q_{jk} = Shipping distance between port of loading and port of discharge in KM
- V_i = Volume for each size of container
- S_{jk} = Volume to be shipped on each trade lane (j,k), where trade-lane is a pair of unique port of loading and port of discharge
- E = Maximum excess volume set to 10m^3 for this model

Decision variable:

- X_{ijk} = Number of containers of size i for port of loading j and port of discharge k.

The objective function is to minimize:

$$\sum_{i=1}^{3} C_i \sum_{j=1}^{n} \sum_{k=1}^{m} X_{ijk} Q_{jk}$$

Subject to:

$$\sum_{i=1}^{3} V_i X_{ijk} \geq S_{jk} \qquad \forall j,k \qquad (1)$$

$$\sum_{i=1}^{3} V_i \; X_{ijk} - \; S_{jk} \leq \; E \qquad \forall \, j,k \qquad (2)$$

$$X_{ijk} \; \in \; Z^{+}$$

The problem is to find the best mix of containers with the objective of minimizing the total carbon footprint. Total carbon footprint is the summation of the emission factors of the shipments.

Constraint 1 ensures that the required volume is met by mandating that the optimized volume across the containers be equal or larger than the required volume for each trade lane represented by j and k. Constraint 2 takes into account to minimize excess volume of the optimized solution. Set to an arbitrary upper limit of $10m^3$ for this model, the problem will be solved when the optimized containers selected have a total sum of less than or equal to $10m^3$ of excess volume. The reason for including such a constraint is to ensure that the model provides a solution with minimal excess space. We note that there is a possibility that this constraint cannot be met and results in no solution.

Consolidation of Shipment within Country (CSC) Model and Assumptions

Mixed-Integer programming is used to solve CSC. The intuition for this optimization is to enable shippers to consolidate shipments at one port of loading and in doing so, increase the capacity fill per container in order to reduce their carbon footprint. The model takes into consideration all shipments which are heading to the same port of discharge. It is possible that the selected port of consolidation is one close to where the goods are produced, or a port that is purely used for consolidation. For example, goods are produced in A and B, but they can be consolidate at port E. Consolidation port is one which gives the lowest trucking and shipping carbon footprint to the port of destination. There are 2 sets of decision variables, the first set involves binary decisions on whether a particular shipment should be shipped directly or consolidated, and the second set of decision variables is to determine the optimal container sizes and number of each container size required while minimizing the overall carbon footprint.

The additional carbon emissions that have to be taken into account for the consolidation model are the carbon emissions that stem from trucking the goods between original and consolidation locations. Similar to shipping, the exact carbon emission per cubic meter per kilometer (KM) for trucking is influenced by the fuel efficiency of the truck, the type of truck, and the fill capacity. For the purpose of comparisons, a fixed factor is proposed for our optimization model. Based on industry input, we used an emission factor (no unit) of 0.011 for trucking a volume of $1m^3$ per KM.

The additional variables that have to be taken into account are:

- The trucking distance between cities
- The trucking carbon emission for $1m^3$ per KM

There are a few assumptions made for CSC:

- The original trucking distance between supplier/manufacturer and the original port of loading (before consolidation) is negligible and hence set to 0
- Production schedule of goods can be shifted to accommodate the additional time required for trucking the goods to the port of consolidation.
- There is no additional time required for loading and unloading the goods from the truck
- The goods are transported via Less-than-Truck-Load (LTL) and hence the resulting trucking carbon emission is dependent purely on the volume of the goods. As the goods are transported via LTL to port of consolidation, it makes sense for CSO to be applied after CSC to determine the optimal mix of containers to be selected for the final consolidated shipment.
- Transportation is always available for trucking between two locations

The following variables are used in CSC model:

i = Type of container size, 1 for 20S, 2 for 40S and 3 for 40HC, ∀ i=1,2,3

j = Port of loading, ∀ j=1,2,3…n

ĵ = Port of consolidation, it will be one of the port of loading , ∀ ĵ=1,2,3…n

k = Port of discharge, ∀ k=1,2,..,m

C_i = Carbon Emission per container KM for each container size

V_i = Volume for each size of container

T = Trucking carbon emission for $1m^3$ per KM

$P_{jĵ}$ = Trucking distance between supplier/manufacturer and port of consolidation in KM

Q_{jk} = Shipping distance between port of loading and port of discharge in KM

$Q_{ĵk}$ = Shipping distance between port of consolidation and port of discharge in KM

S_{jk} = Volume to be directly shipped from each port of loading to one port of discharge

$R_{jĵk}$ = Volume to be trucked from supplier/manufacturer to port of consolidation and consolidated volume to be shipped to port of discharge (i.e., let the volume to be the same as S_{jk})

D_k = Total volume expected at port of discharge

Decision variables:

X_{ijk} = Number of containers of size i for port of loading j and port of discharge k

$Y_{iĵk}$ = Number of containers of size i for port of consolidation ĵ and port of discharge k

f_{ijk} = Binary decision variable for consolidation at port ĵ

$$f_{jĵk} = \begin{cases} 1, & if\ consolidate \\ 0, & otherwise \end{cases}$$

g_{jk} = Binary decision variable for direct shipping

$$g_{jk} = \begin{cases} 1, & if\ direct\ shipping \\ 0, & otherwise \end{cases}$$

The objective function is to minimize carbon emission from direct shipping and consolidated shipping (ocean transport and trucking from each city to port of consolidation):

$$\sum_{i=1}^{3} C_i \sum_{j=1}^{n} \sum_{k=1}^{m} X_{ijk}\, Q_{jk} + \left\{ \sum_{i=1}^{3} C_i \sum_{ĵ=1}^{n} \sum_{k=1}^{m} Y_{iĵk}\, Q_{ĵk} + \sum_{j=1}^{n} \sum_{ĵ=1}^{n} \sum_{k=1}^{m} T\ P_{jĵ}\, R_{jĵk} f_{jĵk} \right\}$$

Subject to:

$$1 - \left(\sum_{ĵ=1}^{n} f_{jĵk} + g_{jk}\right) = 0 \qquad (3)$$

$$S_{jk}\, g_{jk} + \sum_{ĵ=1}^{n} R_{jĵk} f_{jĵk} = S_{jk} \qquad (4)$$

$$\sum_{j=1}^{n} S_{jk}\, g_{jk} + \sum_{j=1}^{n} \sum_{ĵ=1}^{n} R_{jĵk} f_{jĵk} = D_k \qquad (5)$$

$$\sum_{i=1}^{3} V_i X_{ijk} + \sum_{i=1}^{3} V_i Y_{iĵk} \geq S_{jk}\, g_{jk} + \sum_{j=1}^{n} R_{jĵk} f_{jĵk} \qquad (6)$$

$$f_{jĵk} \in \{0, 1\}$$

$$g_{jk} \in \{0, 1\}$$

$$X_{ijk} \in Z^+$$

$$Y_{iĵk} \in Z^+$$

In the objective function, the first term is the total carbon emissions for direct shipping. The second term considers the carbon emissions due to trucking the goods for consolidation and the ocean freight carbon emissions from the port of consolidation to port of discharge.

Constraint 3 ensures that for each shipment within the consolidation problem can only be either shipped directly or consolidated at the port, and it is a mutually exclusive event (i.e. a shipment has to be shipped directly or consolidated – no partial shipment is allowed). Constraint 4 denotes total volumes shipped directly and consolidated through the loading port is the same with the total supply. Constraint 5 ensures that the total volume that the port of discharge receives is equal to the total volume to be sent directly and from multiple loading ports to the same port of discharge. Constraint 6 ensures that the required volume for each trade lane for direct shipping plus any consolidated volume is met by the optimal number of containers of each size required.

Findings

Our data from the real-world company consists of shipments between the period of April 2009 and December 2013 (4.5 years). In this data, 53% of the shipments originated from 10 different ports in China and majority of the finished goods were shipped to 14 ports in U.S. As both source and destination countries are large countries with multiple sea ports across different geographical locations, we found opportunities to apply CSC and CSO methods.

In order to perform consolidation, shipments from different cities need to be heading towards the same port of discharge. We found that 97.5% of the shipments arrived at 4 major ports J, K, L, M (names of ports being masked out for data protection purposes). We assume that shipment arrival dates (at destination port) cannot be changed due to business needs. In order to consolidate, there must be same-day shipments to the same destination port. We found a total of 380 possible consolidation scenarios in our data set. For the shipments with only a single shipment for the day, only CSO is applied. Among the CSO scenarios, we considered only those shipments that require more than one container, i.e., shipments with total volumes greater than 71.78m^3. Shipment with volumes smaller than 71.78 m^3 is trivial as the selection of right container size is a straightforward choice. In our data set, we found 837 cases of single shipments satisfying the volume required for CSO.

Experiment Execution

The experiment was executed in 3 steps. In the first step, we solved single shipments for container size optimization using the CSO Integer programming model. Secondly, we solved the shipments with multiple single-day shipments using the CSC Mixed-integer programming model. Finally, for the consolidated shipments, we applied CSO to the final consolidated volume to find the optimal mix of container sizes required. All problems were solved using AIMMS optimization software.

Experiment Results

Out of the 837 problems in step 1 of our experiment using CSO model, 228 of them could not be solved within the maximum excess volume of 10m^3. The group of 228 problems was solved by relaxing the excess volume constraints. Our results revealed a total of 13.4% reduction of carbon footprint from almost 80% of shipments (total of 665 shipments). Of the 665 shipments that had carbon footprint reduction, there was a 15% reduction in container requirements in terms of number of TEU (see Table 2). Putting the savings into perspective, through the use of a carbon calculator provided by (BSR and CCWG, 2014), assuming that a 20-foot standard container (a TEU) emits 63 grams of CO2 per TEU kilometer per container KM and the average shipment distance is 10,000KM, the company would have reduced a total of 488 thousand KG of its carbon footprint, which is the equivalent of taking off 95 cars off the road for a year (YouSustain, 2016).

Container size	Original container requirements (in TEU)	Optimized container requirements (in TEU)	% Change
20-foot standard	368	602	64%
40-foot standard	2128	1824	-14%
40-foot high cube	2611.4	1907.4	-27%

Total	5107.4	4333.4	-15%

Table 2: Reduction of 15% container requirements after CSO optimization

In step 2, we solved the 380 problems from 8 China ports of loading to the 4 destination ports J, K, L and M. Our results revealed that 98.7% of shipments (375 out of 380) had the potential of reducing its carbon footprint by consolidating. For the purpose of isolating the performance of CSC, we tested two more scenarios on the 380 problems. In the first scenario, we apply CSO to individual shipments only (step 1 only). In the second scenario, we applied CSC followed by CSO (step 2 and 3). We tabulated the results in Table 3, showing that CSC provides an additional savings of 12.1% in carbon footprint on top of the savings achieved by CSO.

Port of Discharge	**Sum of Carbon Emission with only CSO**	**Sum of Carbon Emissions with CSO and CSC**	**Total % Change**
J	15,454,364.44	13,440,729.98	-11.70%
K	12,736,442.30	11,086,992.43	-11.50%
L	5,287,460.03	4,216,647.81	-12.30%
M	848,984.38	634,536.57	-28.10%
Total	34,327,251.14	30,328,543.04	-12.10%

Table 3: Additional 12.1% reduction in carbon emission provided by CSC

Sensitivity analysis on carbon emission factor for trucking

We anticipated that the carbon emission factor for trucking may affect the performances of CSC. Therefore, we performed a sensitivity test to show the differences if the carbon emission factor for trucking is varied between 0.005 and 0.25. Table 4 shows a summary of our sensitivity test with different trucking emission factors and the results. Only 1 scenario of a decrease from the baseline of 0.011 (based on real-world estimation by a LSP) was taken because at 0.005 the model suggests that all shipments should have some form of consolidation since the emission from trucking is negligible.

We found a positive correlation between the trucking carbon emissions and the number of shipments that were consolidated. As the trucking carbon emissions increase, number of direct shipments increases, the number of full consolidation decreases. Mixed shipping started with a reasonable increase and then maintain somewhat constant. Overall, total percentage of trucking emissions decreases with increasing trucking emissions due to reduction in consolidation.

Trucking Carbon Emission Factor	**Total % Carbon Emission Reduction**	**Direct Shipping**	**Full Consolidation**	**Mixed Shipping**	**% of Trucking of Total Carbon Emissions**
0.005	14.80%	0	377	3	2.90%
0.011 (Base)	12.10%	2	375	3	4.80%
0.05	4.90%	153	189	38	2.20%
0.1	3.70%	199	141	40	1.80%
0.15	3.10%	232	111	37	1.40%
0.2	2.70%	249	96	35	1.30%
0.25	2.40%	271	76	33	0.90%

Table 4: Sensitivity test with different trucking emission factors

The sensitivity analysis confirms our intuition that trucking emissions affect the decision to consolidate. The potential for consolidation diminishes with increasing trucking emissions. Consolidation represents an opportunity to reduce the total carbon footprint, but it is not without tradeoffs. One of which is that production scheduling may need some changes in order to accommodate trucking time required for consolidation. Truck deliveries can also be challenging for some geographical regions for the uncertainty in maintaining quality of products and keeping to shipping schedules.

Conclusion

This paper has shown that there are opportunities for companies to reduce their supply chain carbon footprint. We proposed two optimization models to reduce carbon footprint by more efficient use of ocean freight containers. With container size optimization (CSO), which minimizes carbon emission by selecting the ideal container sizes, we showed with a real-world dataset that company has the potential to reduce 13.4% of their carbon footprint. Considering consolidation shipment within country (CSC) provides an additional opportunity of 12.1% reduction in carbon emission for the case company. We believe that the method and optimization model can be applied to another data set with similar observations such as large percentages of shipments (with multiple shipments on the same day) from multiple ports in the same country to a few major ports. To further this research, we recommend additional real-world considerations such as production schedules, trucking cost and constraints to be considered before making decision on shipment consolidation.

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IMPROVING EFFICIENCY OF TEA VALUE CHAIN: A CASE STUDY OF THAI TEA COMPANY

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Introduction

One of the main challenges in managing supply chains for most manufacturers is the uncertainty in contractual achievement to customers (Per, 2009). A value chain analysis is a method of studying and analyzing how value's product can be added in activities (Michael, 1985)

To ensure that value chain will improve, manufacturers required to work closely with their customers (Jari and Dennis, 2006). Moreover, the ASEAN Economic Community (AEC), which will become effective on 2015, focuses on three policies, i.e., people, peace and prosperity. In short, the AEC will transform ASEAN into a region with free movement of goods, services, investment, skilled labor, and free flow of capital. The formation of the AEC gives opportunities to business expansion of Thai food industry. It also presents challenges and brings more revenue to Thailand. This paper analyzes the activities within the value chain of tea product using a case study of a Tea Company in Northern Thailand.

Food industry is supported by the Thailand Economic and Social Development Plan. The food industry in Thailand has high contribution which gives the economic potential of the food industry in ASEAN. Over the next 15 years, the ASEAN population is expected to grow up to 350 million. Most of them will have greater purchasing power (FIA, 2014). The food industry also contributes to other supporting industries, including packaging, such as cans, which leads to employment and higher income. The food industry is an industry with the potential to produce for domestic consumption and for export to other countries. Thailand has a steady background in agricultural production including many qualified workers. Furthermore, the manufacturing that uses modern technology can develop a product to meets the needs of the market. Thailand aims to increase competitive advantage in this food industry to stay on top in providing sufficient and quality food.

Tea is a popular beverage for a long time. The agricultural output of the tea leaves derived through different processes lead to the appearance of different flavor teas. The culture of tea and drinking tea is unique in several countries. For Thailand, tea has been a popular drink tea from European country and china. Future trend of tea market will continue growing because consumption behavior of people emphasize in healthy. The nutrients in tea are useful as an antioxidant.

This paper presents a case study of a Tea Company in Northern Thailand. The Company became a pioneer of Thailand's tea industry in 1941 before transforming into an international tea organic plantation as it is known today.

Literature Review

Several issues relating to this study have been reviewed as follows; value chain management and tea industry in Thailand.

Value Chain Management (VCM)

Originally, the Value Chain concept, proposed by Michael E. Porter, shows how activities create value for the customer and how managed activities can create competitive advantage [8]. The core of Porter's work is the idea of linking the boundary between activities. Porter considers that as a part of a business strategy, active management and improvement of these linkages is important as costs can be eliminated (Kate and Mark, 2006). Value chain analyses are used to comprehend socioeconomic and power relationships in the production chain from the initial starting material to a final product. It takes a financial view of the sequential value creation process in a network of firms (Anthony *et al*., 2012). The value chain can be used to understand how to plan and improve efficiency in industrial operations and practices as well as to strengthen the academic premise on the economics and optimality of the business value chains (Pekka *et al.*, 2010). Moreover, value chains can be applied in food industry to develop and improve the efficiency that brings benefits for wide range of producers and consumers (Jesse and Clare, 2010) and improve demand management (David and Andrew, 2009).

Nowadays, the organic product value creation grows through a well-coordinated supply chain. It was aware and responsive to consumers' personal values and agri-food value chain from a consumer or from a supply chain perspective (Luciana *et al*., 2011). In this research, we can apply value chain management to use with a case study to improve efficiency in company that creates the opportunity for competitive advantage (Alison and Rajbir, 2010).

Tea Industry in Thailand

Food industry uses raw material from agricultural sector such as livestock, fisheries and crops. Technology of food processing and preservation is used to produce large quantities of food products.

The tea supply chain tends to be complex, with many actors, producers, collectors, traders/brokers and packers involved (IFAD, 2014). The value chain with a wide range of stakeholders and activities are involved in transforming tea leaves to the beverage for consumer. Likewise, transforming the tea industry into a sustainable economic sector presents an extraordinary challenge to all its stakeholders. Cooperation between producers, governments, traders, processors and retailers is necessary to improve the efficiency of people involved from the beginning of the tea supply chain.

In recent years, there has been a growing concern about fair trade and safe working conditions for producers and employees as well as sustainability and natural resource management. The principles of organic agriculture are wide ranging and include concerns for safe food production, for environment, animal welfare and for issues of social justice (Angela *et al*., 2000).

Thailand has a large agricultural production area, being 45 percent of the entire country, Thailand ranks among the top of the world's food producing countries in several food categories. The fast-growing demand for food is increase by the world's population trend that the limitless expansion of the consumer market. Thailand exports approximately three million metric tons of food to various countries, valued at one billion US dollars (IFAD, 2014). Therefore, Tea Company is an organic manufacturing that was chosen as a case study to be a guideline for improving efficiency. It will be used as preliminary data for other industries.

Case Study's Diagnosis based on Value Chain Concept

The concept of value chain will help to understand the roles of each activity in the company's supply chain (Figure 1). Overall the management of the supply chain can identify elements of the activities that will be affected by internal and external factors along the value chain. There are the 5 primary activities and 4 supporting activities.

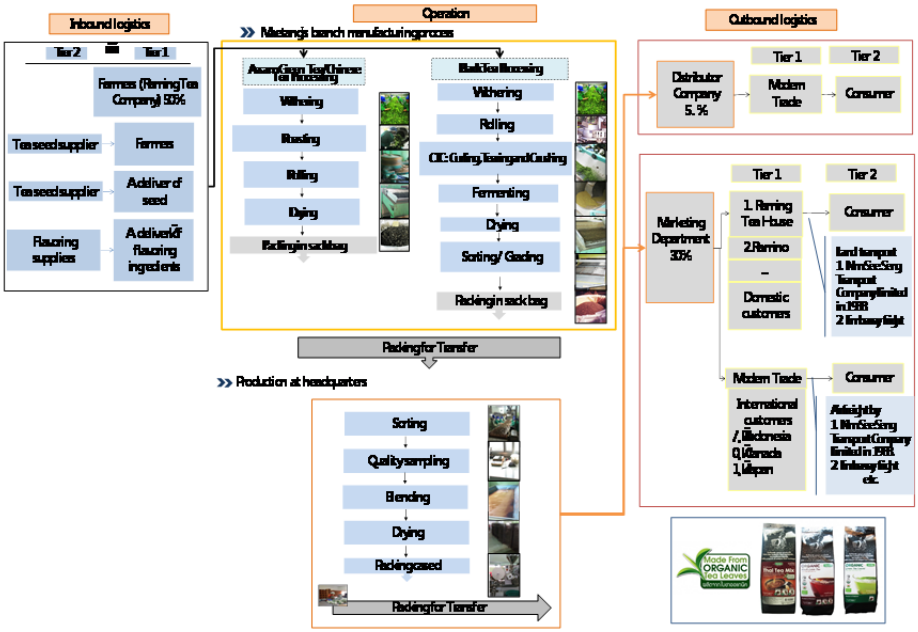

Figure 1: Tea supply chain of case study

The analysis of the current state

These activities of the company was analyzed by using value chain analysis shown in table 1

Activities	Issues
Inbound Logistics	Most tea leaves were planted by company. Some of the tea leaves are imported from Vietnam and Chiang Rai that will affect the quality and taste of the tea.
Operations	The production type of company is Mass Production / Mass Customization. The steps in production are complex and consist of many small steps in order to obtain products such as tea, dried tea leaves extraction. This process requires staff to sort leaves, find bud's tea leaves or other foreign matter. The flavor of the tea from different process is not constant. Therefore, sometimes it needs to adjust flavor that require further processes and long lead time.
Outbound Logistics	Currently, the brand of the company has been exported to Europe, Japan and Indonesia accounted for 20 percent and domestic customers accounted for 80 percent.
Marketing and Sales	The company has market planning unit that has begun a project to expand the market to neighboring countries such as Burma. However, AEC market is small. Therefore, the company will begin the project to expand the market in this area.
Service	The company is an OEM manufacturer of goods to customers which individual customers will have different needs. Service after sales is not included because the products are a consumer product.
Procurement	The source of tea production from domestic and foreign countries has different quality.

Activities	Issues
Technological Development	The company has developed the products in their research and development unit. For example, technology in package is used to speed up the packaging.
Human Resource Management	The company began as a community, producing tea leaves, with almost six hundred villagers, mostly Lahu and hill tribe and sub-contracter with farmers to plant tea and coffee plantation.
Firm Infrastructure	The company production consists of 2 plants, The first plant pre-processes to obtain dry tea leaves with warehouse for the storage of fresh tea leaves. The plant is on the mountain. Often, there is a power outage that makes the production interruptions. The second plant is only for packaging process

Table 1: The analysis of the current state

The analysis of the current production has used FMEA (Failure Mode & Effect Analysis) to perform a risk assessment within the manufacturing process to identity weaknesses or deficiencies which may affect the product or products. The risk was calculated for each block using FMEA analysis. FMEA is a systematic process meant for reliability analysis [12]. It improves operational performance of the production cycles and reduces their risk level [10]. The risk was calculated as ratio of three coefficients: severity of failures (S), probability of occurrences (O) and detection (D). Each coefficient was assigned value in the range from 1 to 4 and the risk priority number (RPN) was calculated which is shown in simple equation (RPN = S x O x D). The results of FMEA have been rating priority by production supervisor and quality control supervisor which shown in table 2.

Process	Defects / problems	Outcome	Cause	Current State	Evaluation			
					S	O	D	RPN
Sorting	The contamination of old tea leaves, rods and unknown materials exceed standard.	The output quality is not up to standard.	Inbound materials are not up to standard.	There are 8 employees.	3	4	2	24
Sorting	The process of sorting is unevenly volume.	Unstable performance in manufacturing	Inbound materials are not up to standard.	No performance measurement in production.	1	2	3	6
Sorting	Sorting volume does not meet the requirements of production.	Production capacity does not meet the requirements.	There are defect that need sorting again in the process.	Repeat sorting process and adjust the speed to slow down.	1	2	3	6
Sampling Inspection	The volume old tea leaves, rods and unknown material excessive into other processes.	The output quality is not up to standard	---------- Not a current problem ----------					
Blending	The ingredients do not meet the formula.	The output quality is not up to standard	---------- Not a current problem ----------					
Drying	Raw materials have moisture more than	The output quality is not up to	---------- Not a current problem ----------					

Process	Defects / problems	Outcome	Cause	Current State	Evaluation			
					S	O	D	RPN
	standard.	standard						
Packing	Machines have stumbled damage.	Production capacity does not meet the requirements.	The maintenance is not scheduled with no spare parts.	There are only replacing the spared parts when needed.	2	3	3	18
Packing	Many waste generated in the production process (package damage).	Production capacity and production costs increase.	Some parts cause machine malfunctions.	Modify / Repair parts by the maintenance department	1	2	1	2
Packing	Package quality is low.	The output quality is not up to standard	---------- Not a current problem ----------					

Table 2: FMEA result on company's operation process.

After a risk assessment by FMEA it was found that the process of sorting tea leaves and packing have defects or problems that occur on many issues. The results will be evaluated by Risk Priority Number (RPN) to prioritize the issue. The RPN will show how to select problems to improve. For other process in activities that are not a current problem, this is because the companies are in between improving process.

Results and discussion

The preparation of standard tea leaves sorting processes.

Tea sorting process is the first step in the production process of the tea drying at the headquarters. This process sort white tea (tea's buds), old leaves, tea's rods and unknown materials (hair rope, thread rock band, leaves, etc.) from the tea leaves for preparation prior to the next process, the blending.

Raw dried tea from all sources must be sorted by machine with a sorting conveyor. The machine vibrates to sort out white tea. Then a conveyor transports tea material and sorting staffs will sort old leaves, tea's rods and unknown materials. The characteristics of the material shown in Figure 2.

Figure 2: Sorted material

After sorting process the quality inspection department will conduct random quality control of 100 grams in every hours of operation. The standard sampling quality tea leaves after sorting is shown below.

Type of material removed	Standard sampling quality inspection (Samples per 100 grams)
Old tea leaves	< 3%
Rod of tea leaves	< 2%
Unknown materials	0%

Table 3: Standard sampling quality for tea leaves after the sorting.

If the sample quality is not up to standard, the process must repeat again to prevent non-standard tea leaves to the next process.

The diagnostics in sorting process with 8 working staffs found problems in the following two issues.

Issues of sorting standard

- There is no standard procedure for sorting clearly. Staff will pick old tea leaves, rods and unknown materials in conveyer into a container (cup) which placed above the conveyer. Staffs usually use one hand to pick up while other hand was not working.
- No specific functions of each position. Staffs will divide among themselves as who will pick up or sort what type of material.

Issues of conveyer speed, uneven material

- The dried tea leaves come from different sources. Some had tea leaves and rods in large quantities. Staff will adjusts conveyer speed to slow down sorting and random testing.
- Conveyer speed was scheduled for raw materials from different sources as follows.

Dried tea leaves	Conveyer speed
Source GPP	11
Source GCR	10
Source GWP	8
Organic tea leaves	13

Improvement in sorting process.

There is currently no standard in the process of sorting the tea leaves. Staffs work with one hand which makes the process not effective. The experiment designs a reasonable and advisable adjustment of the ergonomics of vision at work. This angle is normally 15-30 degrees (measured from the horizontal).

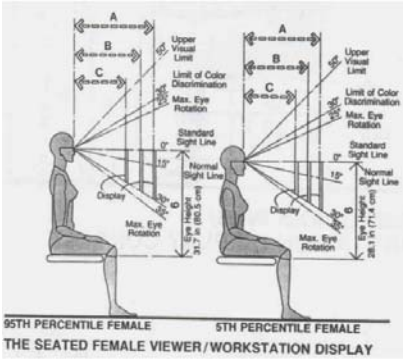

Figure 3: The seated female viewer/workstation display
source: Panero and Zelnik, 1979 : 291

Design an experiment to improve sorting process.

Original sorting process: Use one hand to pick up then took the hand motion toward to put it into a container on the side of the conveyer.

The process of sorting trial 1**:** Use one hand-pick then use other hand helping. The goal is to reduce hand motion.

The process of sorting trial 2**:** Use one hand to sort out. Another hand hold container.

.

No.	Name	Conveyer speed	Trial	Type Sorting	weight (g) experiment			Average weight (g)
					1	2	3	
1	Suntra	8	Original	Rods	101.8	73	96.5	90.43
2	Suntra	8	Original	Old leaves	337.8	535.5	589.2	487.5
3	Suntra	8	Trial 1	Rods	109.8	92.5	101.5	101.27
4	Suntra	8	Trial 1	Old leaves	540.8	602.8	669.2	604.27
5	Suntra	8	Trial 2	Rods	112.1	119.3	114.4	115.27
6	Suntra	8	Trial 2	Old leaves	802	863.5	862	842.5

Table 4: The results of experiment

The experiment compares the trials. The results of trial 2 is better than trial 1. It can sort 115.27 grams of rod tea (better than the old method by 27.47%) and the average weight of a handful of tea leaves is the 842.5 grams (better than the old method by 72.82%)

Figure 4: Comparison of sorting rods tea and old tea leaves (before – after)

Increase productivity by adjusting conveyer speed to suit the material.

The standard of sorting process also includes speed adjustment of the conveyor speed. The experiment tests the speed of conveyer from current speed, up by 1 in each experiment to see if the quality is acceptable. Moreover, the quality control is stricter by 10% to ensure the output of the process.

Type of material removed	Standard sampling quality inspection (Samples per 100 grams)	The criteria used in trials (Samples per 100 grams)
Old tea leaves	< 3%	< 2.7%
Rod of tea leaves	< 2%	< 1.8%
Unknown materials	0%	0%

Table 5: Standard samples and the criteria used to adjust the conveyer speed.

No.	Conveyor speed	Sample quality after sorting (100 grams)			Quality criteria
		%Old tea leaves	%Rods of tea	%Unknown materials	
1	11	2.2	0.8	0	□
2	12	2.7	1.1	0	□
3	13	3.6	1.5	0	□
4	12.5	2.7	1.2	0	□

Table 6: Experimental results from variable speed conveyor and random quality after sorting.

The experimental varies speed of conveyor from the original speed of 11 to the new speed of 12.5. This experiment can increase the yield of sorting 45 kg per day from 382.5 Kg/day to 427.5 kg/day (up 17.76%)

Conclusion

The risk assessment is used to identify weaknesses or deficiencies of manufacturing process by FMEA the process of sorting tea leaves is the most concern. The problem is the contamination of old tea leaves rods and unknown materials that exceed standard and makes output quality low. Therefore, this approach may increase accuracy of sorting process by introduce sorting process standard with conveyer speed adjustment. The result of improvement can increase efficiency of employee. It can increase the yield of sorting drying tea leaves 11.76% (from 382.5 kg/day to 427.5 kg/day).

Acknowledgements.

Supports from Chiang Mai University via the Excellence Center in Logistics and Supply Chain Management (E-LSCM), are appreciated. Financial support from The Thailand Research Fund (TRF) through the Research and Researcher for industry (RRi) and Raming Tea Co., Ltd. The findings of the research is come from researcher, the Thailand Research Fund and the company does not necessarily agree.

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INCREASING EFFICIENCY IN INVENTORY SYSTEM BY BARCODE TECHNOLOGY IN SPORTSWEAR TAILORING FACTORY

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Introduction

Textiles and Garment industry has vital importance in the economy, and is considered a necessity for human survival. It also relates for many industries with raw materials such as industrial buttons, zippers, labels, weaving, knitting, dyeing, processing and garment. Such role provides massive contribution to economy by providing employment and income to a country. Applying scientific management concept of value creation in the textile and apparel industry can increase value for the investors by elevating the business from upstream to downstream in the supply chain system. This paper considers value creation in the industry by implementing demand forecasting methods and introducing diversification of products to meet consumer preference. Authors speculates that by implementing of such strategies, it will result in economies of scale and further returns for the industry.

The case study factory produces a variety of series, types and size of sportswear. Furthermore, the productions are mainly made to stock and sometimes made to order. The finished goods are stocked in warehouse. Then, the sportswear are transferred to packaging department and prepared for distribution. To check the quality per customer requirements, the manual process is done by operators. This affects in error in process and non-conformed product for customer. Thus, these effect customer unsatisfactory. Penalty and re-shipment increase manufacturing cost.

This paper aims to apply the technology to reduce error. The example are RFID and Barcode that are widely-known technology. Therefore, this paper analyses the processes by using value chain management concept with application of information technology. There are five sections in this paper. The existing literatures review on value chain management and information technology are reviewed in section 2. The methodology are presented in section 3. Additionally, this section will present the technology development for improving efficiency. The results are later discussed in section 4. And finally, section 5 are conclusion and discussion.

Literature Review

This paper considered the issues relating to the concept of value chain approached in the textiles and information technology.

Value Chain Management (VCM)

The concept of competitive advantage and how firms can manipulate management activities was introduced by Porter (Michael, 1985). Manufacturing companies can create value by acquiring raw materials and processing them to more valuable products. Retailers bring together a range of products and present them in a way that's convenient to customers, sometimes supported by services such as fitting rooms or personal shopper advice (Céline, 2006). The operation strategy of value chain in clothing has been development in design process to be applied in textile and garment industry to

develop and improve the efficiency that brings benefits for wide range of producers and consumers (Patricia, 2006) and improve demand management in highly diverse textile (Margaret *et al.*, 2004].

Information Technology Applied in Inventory System

Barcode technology have been widely applied in automatic identification and tracking throughout the textiles and fashion supply chain (Vassiliki *et al.*, 2001). The sportswear tailoring factory is highly diverse and heterogeneous definition. Many type of raw material and finished good are involved. Barcode technology works by scanning print barcode label with barcode reader (Wong, 2014). Nowadays RFID is deployed mainly to support the following operations (Siu *et al.,* 2009): the handling process; tracking work-in-progress; receiving operations; shipping operations; tracking products; tracking inventories; monitoring and sorting of merchandise; counting stock and picking merchandise; tracking containers; shipping; locating products; and store management (Hau-Ling *et al.*, 2012). However, a cost–benefit for RFID tags is still an open issue (Ngai, 2012). In general, literature on an analytical assessment of the RFID technology is fairly limited, mainly focusing on the inventory function and the effect of inventory discrepancy. The inventory ratio was stood out as the indicator (Kok *et al.,* 2008) showed contradictory outcome. Suggestion from many earlier researcher were given on return of investment (ROI) (Korrakot *et al,* 2007).

The literature review shows that the value chain activities discussed the problem by each activity. The barcode technology is applied in the process of inventory for development and implementation of a system is presented. Finally the barcode technology can support completely and the technology has become increasingly the system in the factory.

Methodology

This section presents research methodology to implement technology for improving efficiency of the case study factory. There are three steps comprising of (1) Identifying and understanding the activities, (2) Suggesting the solutions by applying technology and (3) Developing and implementing the technology.

Step 1: Studying Process Activities by Using Value Chain Management.

This step describes how to study process of the case study factory by using value chain management. Value chain management can help understand the roles of supply chain activities in the organizations. There are two main business activities comprising of primary activities and support activities. Firstly, primary activities consist of five activities that are inbound logistics, operations, outbound logistics, marketing and sales, and services. These activities relate with main activities to transform inputs into outputs for customer. On the other hand, support activities are firm infrastructure, human resource management, procurement and technology development. The problems of this case study factory are error in processes and non-conforming products that need to identify key activities for process improvement.

Step 2: Design an Application by Applying Information Technology Concept.

The problems are identify with in key activities of business processes. Then this step attempts to find improvement solutions. To reduce error, an application is designed, applying information technology concept. MS Excel software is easy to use and application to other application.

Step 3: Implementation

The application is used with barcode. It can reduce error in focused activities. Then, the previous results and the implemented results are compared to measure efficiency of the implementation. Examples of measurement are process times, manufacturing costs and numbers of error.

Result and Discussion

This section presents the results and discussion. For primary results, the process activities of the case study are studied. The company receives purchase orders from customer that are called “Picking Note”. Then, operators arrange products from warehouse following picking note. Next, the products are packaged with ID codes to identify products. After that, the products are checked again with picking note by operators to confirm product. Finally, the products are delivered to customer. Process flow of the case study is shown in Figure 1. The case study factory is suggested that the main problem is error from operators in packaging department.

To find solution for process improvement, an application is designed by applying technology to check the accuracy of the product. MS Excel software is used to design barcode system. The structure of the application process consists of three parts that are input process, processing and output process.

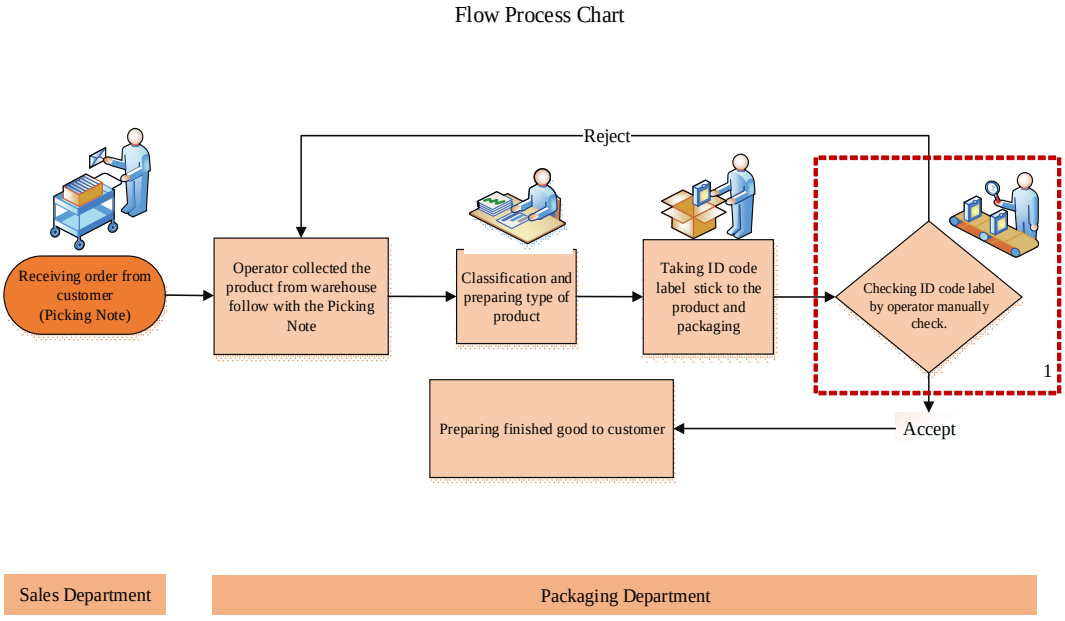

Figure 1: The flow chart of operations operator before improvement.

Input process concerns ID-card data of picking note that are types of product and barcode, then related with data analysis to confirm products with picking note and packing list. The output process shows the results of the check. There are seven status of check comprising of not sufficient, shortage, over picking, product is over, correct and completely, product is completed and wrong picking product as shown in Fig.2 then display of application shows the details of products.

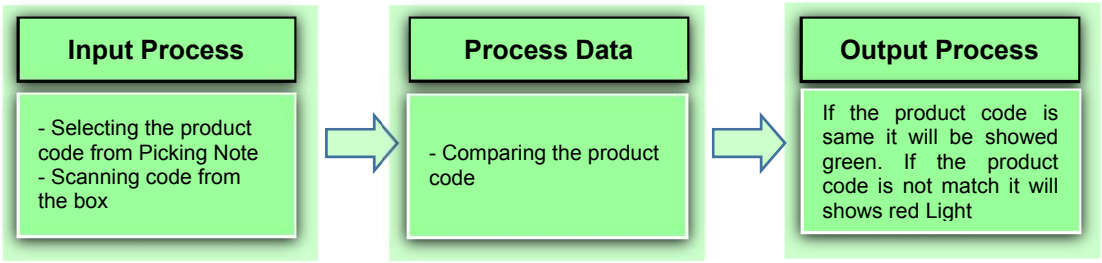

Figure 2: The structure of program.

Program will check the accuracy of product as following, the symbol is shown in table 1 as following,

Figure	>>Short<<	-1	<<Over>>	1	Complete	0	Pick ผิด!!!
Description	Status shows that item required is not sufficient	Status shows that product is shortage	Status shows that product is over picking	Status shows that product is over	Status shows that product is correct and completely	Status shows that product is completed	Status shows wrong picking product

Table 1: Symbols of product status

Displays of the application shows the detailed of products and the result as shown in Fig 3. The application of barcode scanner and barcode sticker label are essential equipment.

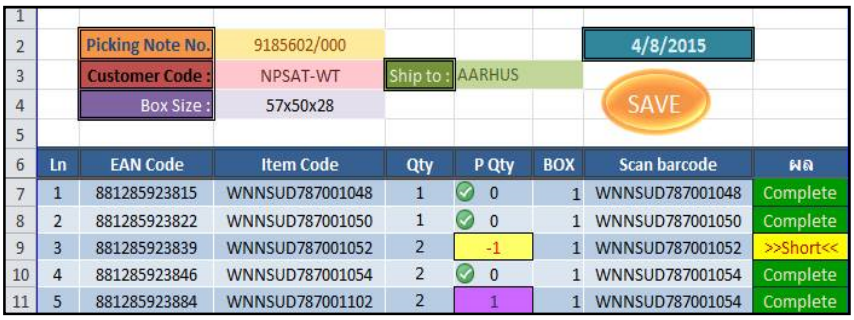

Figure 3: Display of the program

After implementation, error products and error processed are reduced while the application can check the ID number and correct products before shipping. The result found that time to check products, mistake of shipment and cost of damage delivery are reduced. Table 2 shows comparative results between before and after implementation. The application can work with 100% accuracy.

List	**Before**	**After**	**% Improvement**
1. Time to check product (Minutes/order)	30.15	18.25	39.49%
2. Mistake of shipment (Times)	4	0	100%
3. The damage delivery (Baht/Month)	36,000	0	100%

Table 2: Comparing before and after improvement list

The detailed of barcode sticker label is shown in Fig. 4 and Fig. 5.

Here, the factory will benefit from the barcode technology. The program works with great efficiency. It can check the product correctly. It can reduce errors by 100%.

Figure 4: Barcode scanner and barcode sticker label.


Figure 5: Product are ready to delivery to customer.

Conclusion and Discussion

This paper discussed an application of information technology, i.e., barcode technology. It can be applied to the small industry. This application can check the products for increasing efficiency in inventory system.

The result of this case study factory is the application of barcode technology to verify the finished goods that are delivered from factory to customer. The application detects faulty goods before delivery to customers. It saves 432,000 Thai baht/year. Moreover, time is reduced by 39.49%, shipment of good are corrected by 100% and the damage delivery is reduced 100%.

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LAST MILE FULFILMENT USING AUTOMATED PARCEL LOCKER SYSTEM: SERVICE EXPECTATIONS OF E-MERCHANTS

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Introduction

Reports have stated that Singapore consumers spent $1.1 billion on online shopping in 2010, and grew 30% to $1.4 billion in 2011. By 2015, e-shoppers will be spending an estimated $4.4 billion (Lim *et al*., 2015). The trend in the increasing amount spent and transactions numbers of online shopping is expected to continue in the coming years, and thus it translates to more and more parcels that will be required to be delivered to these consumers (Soon, 2016). As such, this evolution has led to an increasing focus on how to fulfil this final leg of the supply chain, which is to deliver the parcels to the consumers, which is also known as the "last mile" (Morganti *et al*., 2014).
The last mile is usually considered the one of the most expensive and yet least efficient aspect of the entire supply chain from the supplier to the end consumer (Gevaers 2011). One of the greatest challenges about this final delivery to the home consumer is the possibility of failed delivery. If the recipient is not around and there is no one else at home to receive the parcel, the delivery company might have to bring the parcel back and make another delivery trip after contacting the recipient, or they can deliver it to the nearest post office if it is a registered post. These processes are considered very inefficient and time-consuming, and it can incur unnecessary costs to either the supplier of the purchased item, the delivery company and/ or the consumer. As such, the Deputy Prime Minister of Singapore, Tharman Shanmugaratnam has mentioned that there will be a nationwide parcel locker system in Singapore to solve this problem (The Straits Times, 2016).

There have been increasing reports and articles about the use of such parcel lockers in different countries and by different companies (Colliers International, 2015), that focuses on the trends, advantages, economics and suitability of such lockers for different goods and in different communities. Most of these reports are presented from the perspective of the consumer, or the service provider, or the authority that is building the infrastructure. There is very little literature that focus on the perspective of the e-merchants or the suppliers of the items sold, on how they view such parcel lockers as a method of fulfilling their consumers' demand, and what other considerations or obstacles that they have when it comes to using such lockers.
This paper is thus written to ensure that the provider of such parcel locker systems can address the concerns of the e-merchants, and their expectations, in order to roll out a successful automated parcel locker system.
To accomplish this aim, we reached out to these e-merchants, or any of these suppliers that sell their items online, who has engaged a service provider to complete the last mile delivery of their items to the consumer, through an online survey. This service provider must also be a provider of the parcel locker systems, so that we will be able to understand why their clients choose to or not to use their lockers. Through the survey findings and interviews with the service provider, we gained insight into the issues faced by these e-merchants and made recommendations that will be valuable to any service provider of automated parcel locker systems.

Related Literature on Automated Parcel Locker system

Automated Parcel Lockers are an alternative to the traditional door-to-door parcel deliveries from the businesses to their customers. These lockers can be used by businesses to reduce costs on the last mile delivery as the traditional service providers can reduce the number of delivery trips, including failed delivery and re-delivery trips, as well as through consolidation of different delivery destinations

into fewer locker locations. For the customers, it allows them to receive their parcels without having to wait for the delivery personnel and avoid any other problems due to human factors.

Such parcel lockers are becoming increasingly popular (Colliers International, 2015) in Europe, US and Asia. Some of the examples of parcel lockers installed worldwide include InPost in Poland, Packstation by DHL in Germany, and Amazon in the US. In Asia, startups such as PopBox from Indonesia and established companies such as PCCW in Hong Kong, have also rolled out these parcel lockers to meet the increasing demand of online consumers.

In Singapore, there are currently 3 main companies offering automated parcel lockers for the last mile delivery, namely SingPost, Ninja Van and Yamato Asia (The Business Times 2016). Each of these companies operates these lockers for their own clients, and if they were to have their own set of lockers in all of the neighbourhoods throughout Singapore, there would be a huge duplication of efforts and resources.
Thus, the Singapore government will unveil their plans for a nationwide "large scale deployment of common parcel lockers" soon, in order to optimize the usage of such lockers. (Channel NewsAsia, 2016).

	SingPost	Ninja Van	Yamato Asia
Number of lockers	136	21	29
Location of lockers	Shopping Malls, Community Centres, Post Offices, Educational Institutions, Sports Complexes, etc.	Shopping Malls, Educational Institutions and campuses, etc.	At selected 7-Eleven stores island-wide
Services provided at the lockers	Collection of parcels Returns of parcels Posting of parcels Renting of lockers	Collection of parcels	Collection of parcels

Table 1: Comparison of parcel lockers in Singapore
Source: https://www.mypopstation.com/, https://collect.ninjavan.co/en-sg, http://www.yamatosingapore.com/courier/7-connect-locker/ (accessed 28 Jun 2016)

Methodology

The survey was developed together with a logistics service provider, which provides both door-to-door courier delivery services as well as parcel locker systems, to understand the concerns of e-merchants from various industries, and their views on using these lockers. The survey was then sent out to the clients of the service provider electronically for them to respond, where 59 responses were captured. This ensures that the respondents come from a pool of e-merchants who have had an opportunity to use the parcel lockers, as we are interested to understand their concerns and resistance, if any.
Subsequently, interviews with experts in the logistics industry were conducted based on the results from the survey as part of this qualitative research, in order to capture and record the insights and perspectives of the e-merchants.

Findings

Awareness of parcel lockers:
Among the 59 respondents, 61% reported that they have heard of the parcel lockers, but merely 30.6% of them have used these lockers. The main reason cited was that there was a lack of

awareness (62.5%) on the usage of these lockers, and thus the e-merchants typically chose the traditional method of engaging the service provider to do a door-to-door delivery service.
More has to be done to educate these e-merchants on the usage of these lockers, including the business model and user interfaces, in order to convince them to move away from the traditional method.

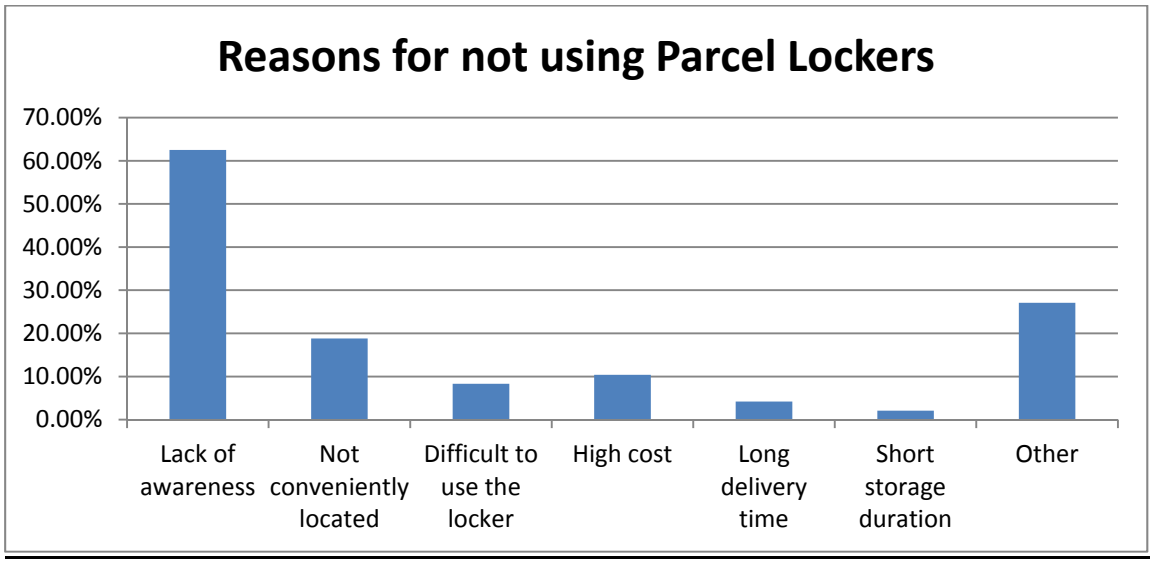

Figure 1: Reasons why e-merchants are not using parcel lockers

Cost of usage:
The cost of using the lockers remains an important factor to the successful rollout of the parcel lockers. As shown in Figure 2, having a reasonable cost (64.4%) is the greatest incentive in influencing the decision of the e-merchants as to whether they will use the lockers as the last mile delivery method.

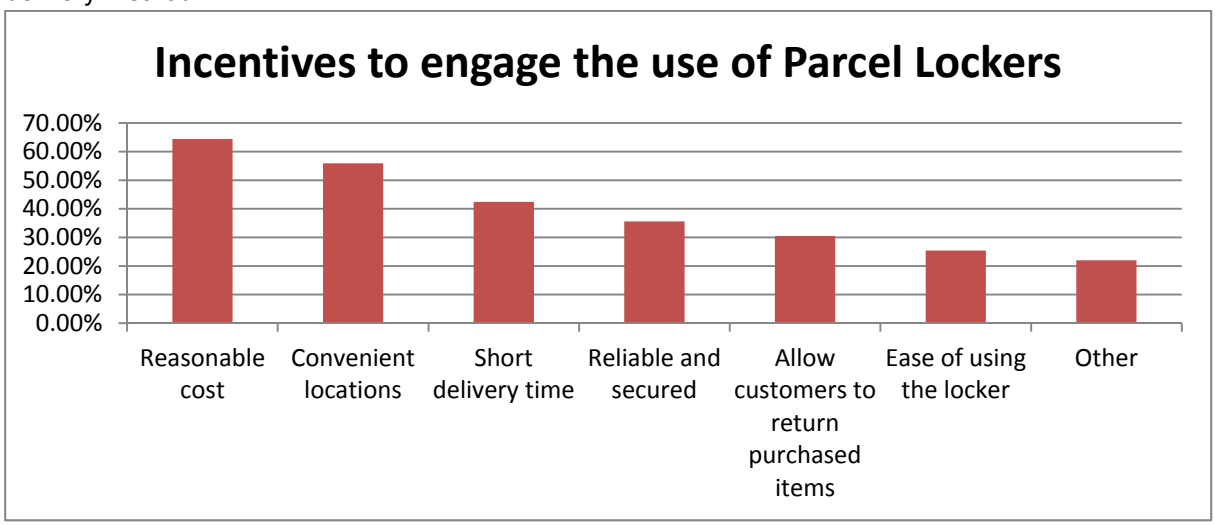

Figure 2: Incentives to use parcel lockers

Assuming that the service provider charges $5 for a parcel door-to-door delivery, most of the e-merchants (67.8%) agreed that the cost of delivery to a parcel locker should be between $1 and $3, which is less than the current traditional delivery charge.

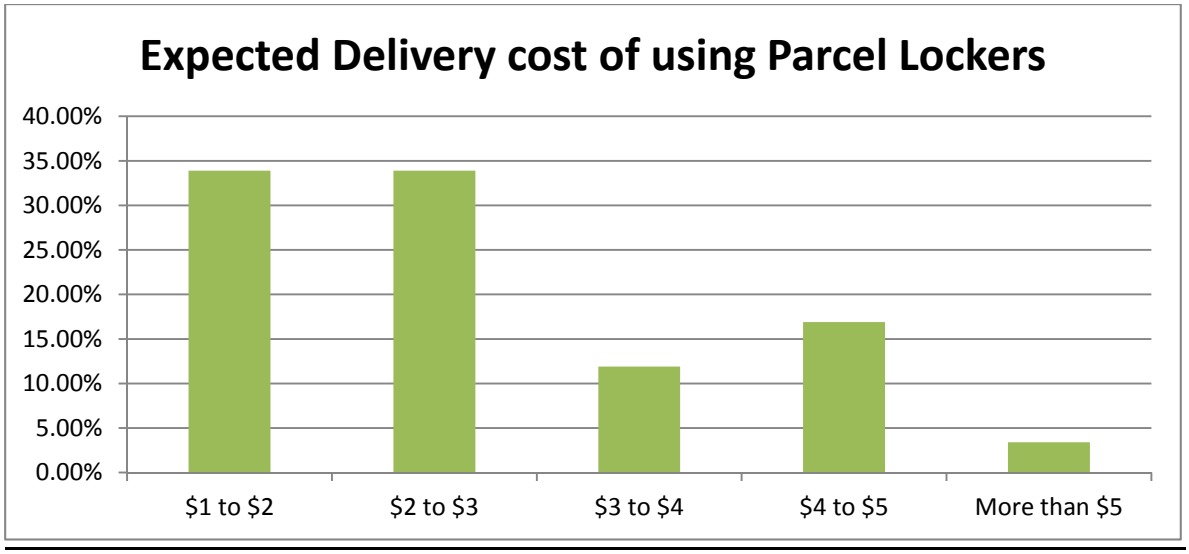

Figure 3: Expected delivery cost of parcel lockers

Convenience of lockers:
As shown in Figure 2, more than half of the respondents agreed that the convenience of where the lockers are located is an important factor to encourage usage as well.
Currently, most of these lockers can be found in shopping malls, community centres, sports complexes, educational institutions, and near to MRT stations and bus interchanges. Typically, the e-merchants are not complaining about the current locations of these lockers, as shown in Figure 1, as less than 20% of them gave the reason that they do not use the lockers due to inconvenient locations.

Certainty of delivery:
Choosing between the certainty of delivery to the consumer and the convenience of the delivery to the consumer, 66.1% of the e-merchants surveyed chose the certainty of delivery. 22% of them felt that the convenience of the delivery is more important, while 11.9% of them felt that other reasons such as the timeliness and quality of the delivered product is more important.
This resonates with the findings that out of those who had used parcel lockers before, 63.6% of them "Somewhat Agree" that these lockers help to solve the problem of failed delivery to their customers.

Accessibility to boxes:
One of the questions that e-merchants have is the possibility of them accessing these parcel lockers to open up and drop off their customers' parcels. Currently, some of the lockers can only be opened up by the service providers to deposit the parcels, and for the customers to open up and retrieve via a mobile app or entering certain codes.
If the e-merchants are able to deposit the parcels by themselves, it might help to reduce their order fulfilment cost.

Integration of systems:
One of the main concerns that these e-merchants has is the integration of the systems between their own backend system, and that of the parcel locker service provider, as well as any other marketplace that they might be using, such as Groupon and Zalora. The e-merchants would want to ensure that they have the ability to track when the parcels have been delivered to the lockers, when the customers have been informed to pick up the parcels, and when they actually do pick them up. But they would not want to spend too much resource to implement this part of the integration of systems.
There is still scepticism from the e-merchants about the system status updates from such delivery methods, which eventually will affect the payments and verifications between all the parties involved.

Service level:
There are concerns about the service levels in the case of using parcel lockers. Although most of the e-merchants feel that the parcels would be collected by the customers within 3 days, one of the questions raised is what if the customers are really not able to collect the parcel by then? Is there an option to increase the storage duration, would the e-merchant or the customer have to pay extra charges, could the customer say that he had not been informed that his parcel had arrived – these are some other doubts that e-merchants feel that should be addressed before they feel confident in adopting the use of the lockers.

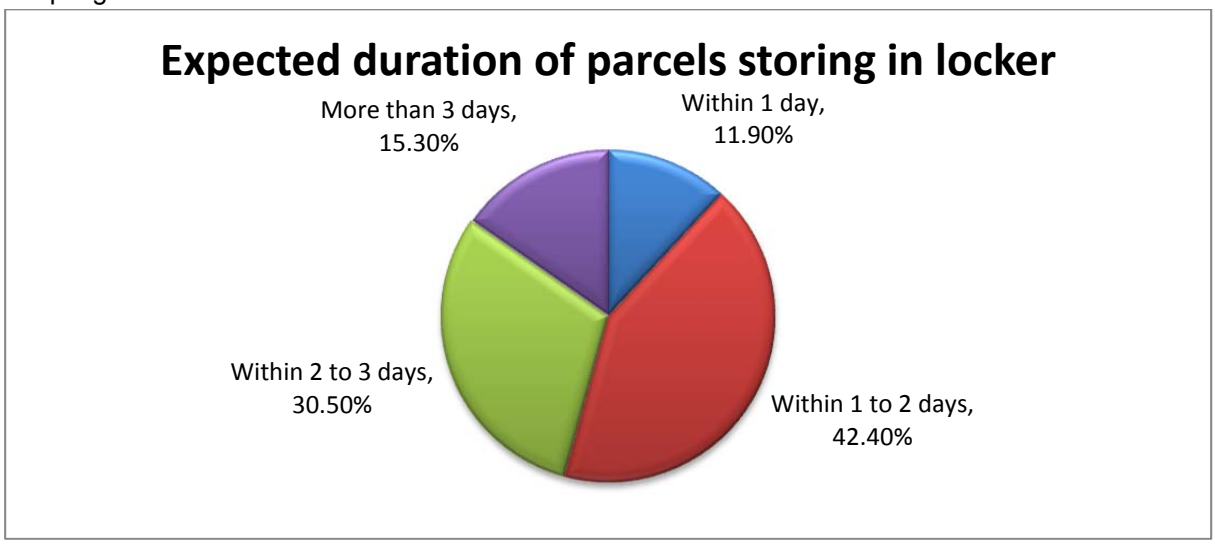

Figure 4: Expected duration of usage of lockers

Reliability and security:
Among those who had used the parcel lockers before, generally most of them would agree that these lockers are reliable and secured. What the e-merchants would be concerned with is how fast the service provider can drop off the parcels at the lockers upon confirmation by the customer, and how fast the customer will be informed that his parcel has arrived.

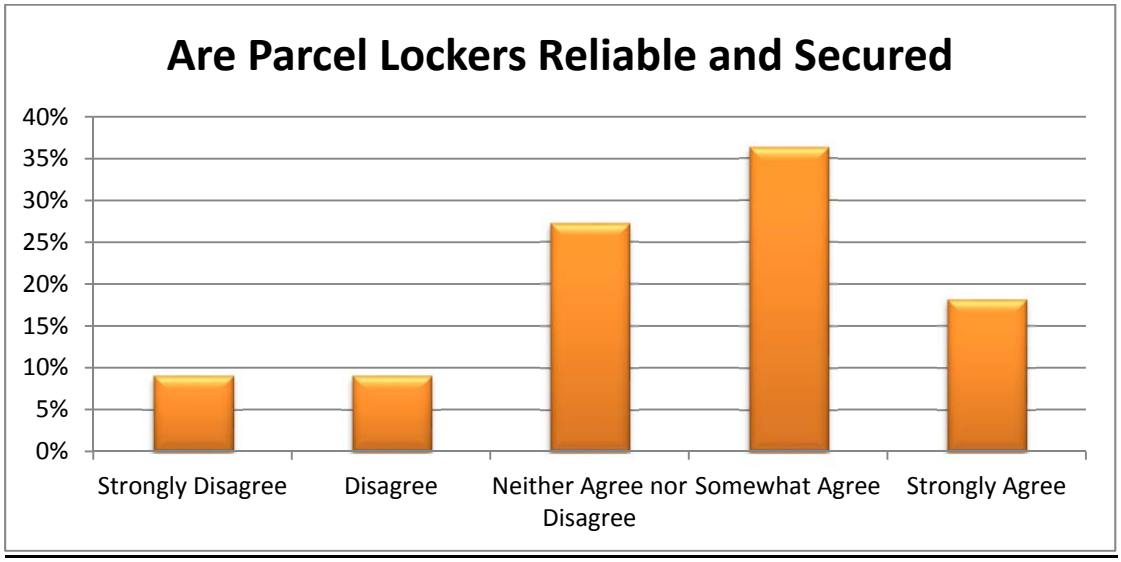

Figure 5: Sentiments about the reliability of the locker

Returns of goods:
68.3% of the e-merchants feel that they will be willing to consider using the parcel lockers for their customers to return goods to them, in the case of wrong sizes, defects of items, etc.
For those e-merchants who do not wish to use the lockers for the returns, one of the reasons they quoted include the fact that if customers are able to do the returns too conveniently, it may lead to abuse of the system. The e-merchants are also unable to access the condition of the returned items and may incur additional costs and inconvenience, either for themselves or for the customers.
Some of the e-merchants are also doubtful of the reliability of the system for tracking purposes and ease of use of the lockers for this additional service.

Conclusion

The overall view of the e-merchants show that they are open towards using automated parcel lockers to fulfil the last mile delivery to their customers in Singapore. This is in line with what the Singapore Government will be rolling out in the near future. They agree that the lockers are reliable and secure, and will help in reducing the number of failed deliveries. However, to make this scheme successful, there are still certain issues to be addressed.

Firstly, there needs to be further educating of the e-merchants on the usage of these lockers, such as how they function, what the lockers can and cannot be used for, how will the transactions be effected, and how will they know when the parcels have been deposited and when the parcels have been collected. They will also need to be assured on the ease of using the lockers by their customers, and the ability to track the status of their deliveries at any time, and without compromising on their service level.

Secondly, the cost of using these lockers should not be higher than the delivery cost of the traditional door-to-door delivery. It is important to note that backend integration of the e-merchants' systems and that of the automated parcel lockers may also serve as a stumbling block, especially if they are not compatible with the API from the lockers and require additional upgrades.

Thirdly, access to the lockers should not be limited to the service providers. E-merchants are also looking for creative ways to make use of the lockers, such as making their own deposits into the lockers and allowing customers to make returns through the lockers. The e-merchants also feel that while the lockers are useful, it may not meet everyone's requirements, especially when some of them sell furniture which is too large for the lockers, or some of them who sell fresh food but the lockers are not equipped with temperature control.

Further research can be conducted to understand the operating costs of the lockers to determine a fair pricing that e-merchants will be willing to pay for their usage. It would also be beneficial to all parties if more feedback can be gathered from customers who had experience in using the parcel lockers, and incorporated into the findings.
All these information will help the provider of the parcel lockers to build a more successful business model, particularly when this system is still considered relatively new in Singapore, and not many customers have had the opportunity to try it out yet.

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LOGISTICS SERVICE PROVIDER PERFORMANCE MEASUREMENT: A CONCEPTUAL FRAMEWORK

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Introduction

According to Mentzer and Konrad (1991), the evaluation of performance is a vital managerial function. There are many reasons as to why firms measure their performance. Some examples found in the literature are to see progress, identify success, report performance, evaluate performance, confirm what is already known, reveal what is not known, understand operating processes, assist operational personnel, identify problems and bottlenecks, form new objectives and targets, determining future courses of action and to confirm priorities (Gunnasekaran et al. 2004; Holmberg, 2000; Kennerley and Neely, 2003).

The purpose of this paper is to provide a comprehensive and innovative performance measurement framework for a logistics service provider. The framework is supported in a thorough revision of the existing literature regarding performance indicators system, with particularly significant domain in the field of logistics and freight transport.

This paper is separated into 2 main sections. The first section will discuss the systematic review methodology of the logistics performance measurement literature for logistics service provider combined with a citation network analysis approach. Then, the findings of the review will be presented through the use of the Pajek software and conclusions will be derived. While the 2nd section, a conceptual theory building is used to develop a framework representing a theory of logistics service provider performance measurement.

The Systematic Review Methodology

This manuscript follows the guideline provided by Gopal and Thakkar (2012) as well as Hemingway and Brereton (2009). Figure 1 describes how the articles were selected, evaluated, analysed and interpreted.

The objective of this systematic review methodology will help identify the research streams related to performance measurement in the logistic and supply chain context. The first stage of the review process involved the identification of papers and research reports that were concerned with logistics and supply chain performance measurement. The authors identified electronic databases and websites that could provide potentially relevant articles. The following databases were searched: Emerald, Science Direct, Taylor & Francis, Springer, ABI/Inform, Scopus and Wiley Online Library. However, some journals are available in more than 1 database, such as IJPDLM which is published in Emerald but available in ABI/Inform. To ensure that there has no duplicated journals, ABI/Inform and Scopus were selected as the main database in this systematic review.

The period of publication of the journal articles is from 2005 to 2015. 2005 was chosen as the starting point for the review because it was the year that had the highest number of hits when keywords such as “Logistics” or “Supply Chain” or “Performance Measurement” were selected. Nonetheless, earlier literature was also included.

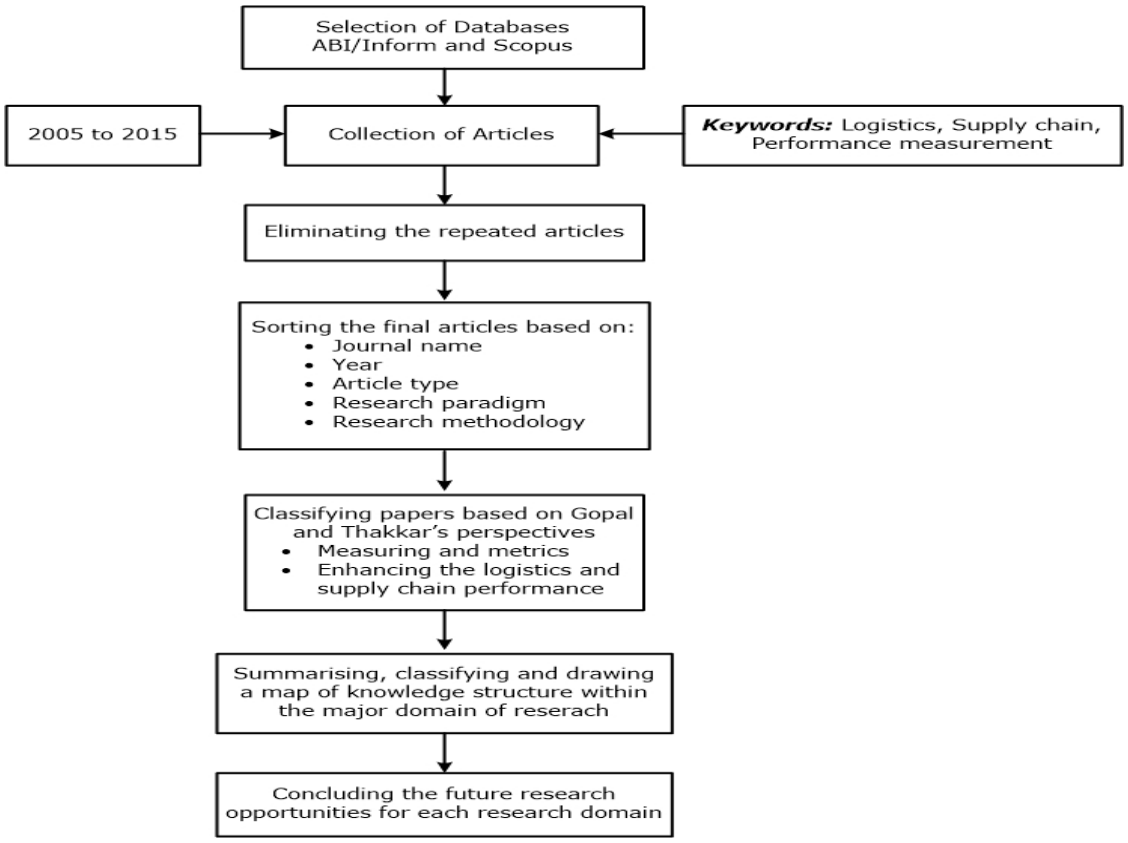

Figure 1: Review methodology
Source: adapted from Gopal and Thakkar (2012) & Hemingway and Brereton (2009)

There are three main keywords used in this review “logistics performance measurement”, “supply chain performance measurement”, “logistics and supply chain performance measurement” and equivalent keywords are also used for covering all the potential relevant papers. Table 1 summarises the keywords and the search results. This table shows the number of article identified.

Keywords	**Equivalent keywords and search strings**	**Number of articles**	
		ABI/Inform	**Scopus**
Logistics Performance Measurement	Logistics Performance Assessment; Logistics Performance Evaluation	269	2408
Supply Chain Performance Measurement	Supply Chain Logistics Performance Assessment; Supply Chain Logistics Performance Evaluation	530	948
Logistics and Supply Chain Performance Measurement	Logistics and Supply Chain Performance Assessment; Logistics and Supply Chain Performance Evaluation	76	132

Table 1: Search keywords and results (2005-2015)
Source: The Authors

In total 153 articles published in 99 journals were discovered. In order to reduce the number of potential papers related to logistics and supply chain performance measurement, the 153 abstracts were screened and 38 abstracts were determined based on their suitability for inclusion in the systematic literature review.

The next step was the analysis and interpretation of the selected articles by focusing on the authors, year of publication, research context (country and industry), objective, methodology, article type, data collection method, data analysis method, contributions and classification dimension according to Di Fan et al. (2014). The last step was focused on understanding the structure of the research domains by following the guideline of Main Path Analysis (MPA) (Colicchia and Strozzi, 2012) with the Pajek software 4.01 (De Nooy et al., 2005).

Classification of Research Domains

According to the authors initial finding, logistics and supply chain performance can be divided into two categories: (1) Supply chain measures and metrics and (2) Enhancing the supply chain performance. The 38 articles were further scrutinized on such perspective. It was observed that there were 16 papers related to enhancing logistics and supply chain performance while 22 papers focused on supply chain measures and metrics.

In the enhancing supply chain performance perspective, sub-themes were observed such as performance measurement practices for logistics and supply chain (Wagner, 2008), quality performance measurement (Shokri et al., 2013), logistics and supply chain performance improvement (Keebler and Plank, 2009), performance measurement development (Martin and Patterson, 2009), performance measurement tools (Chia et al., 2009) and impact of measurement system on firm's performance (Wong et al., 2014) as shown in figure 2.

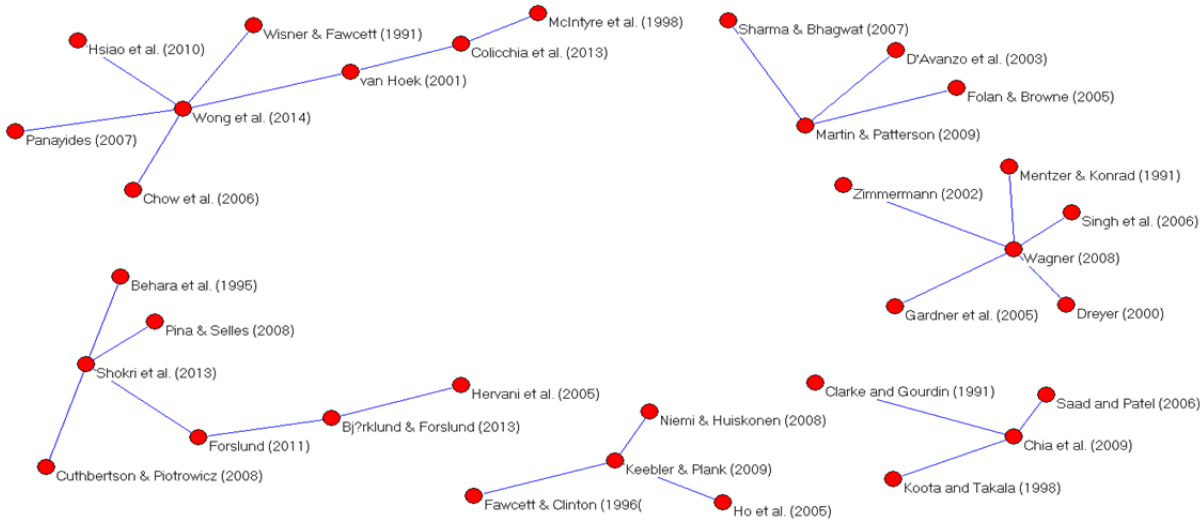

Figure 2: Citation network of the articles in enhancing the supply chain performance perspective.
Source: The Authors

22 papers looked into logistics and supply chain measure and metrics perspective (Gunasekaran et al. 2004; Neely et al., 1995; Beamon, 1999) which explored supply chain metrics as shown in figure 3.

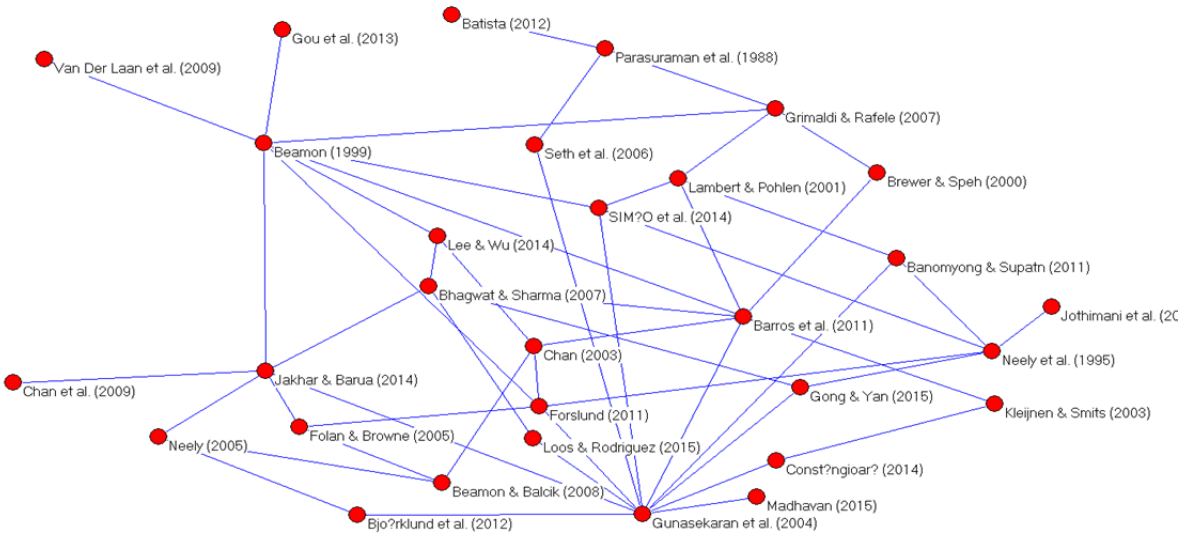

Figure 3: Citation network of supply chain metrics literature
Source: The Authors

Research Streams Path Analysis

Figure 2 and Figure 3 illustrated the structure of two research domains which are enhancing logistics and supply chain performance as well as supply chain metrics by following Main Path Analysis (MPA) approach (Colicchia and Strozzi, 2012), the authors used the citation network as the key to link each article with Pajek software 4.01 (De Nooye et al., 2005).

Reviewing supply chain performance enhancement

There are six research clusters within this domain. The first stream is related to the scope of performance measurement in logistics and supply chain which was proposed by Mentzer and Konrad (1991), Dreyer (2000), Zimmermann (2002), Gardner et al. (2005), Singh et al. (2006) and Wagner (2008). It is about the scope of performance measurement path. The second cluster is focused on total quality aspect which was proposed by Behara et al. (1995), Shokri et al. (2013) and Bejorklund and Forslund (2013) where they measured the probability of manufacturing a product or creating a service through the six sigma concept or zero defects to measure customer satisfaction. The next research cluster is an efficiency and efficacy in logistics and supply chain management proposed by Fawcett and Clinton (1996), Ho et al. (2005), Niemi and Hulskonen (2008) and Keebler and Plank in 2009.

The next cluster is related to KPIs in logistics and supply chain performance measurement which is proposed by D'Avanzo et al. (2003), Folan and Browne (2005), Sharma and Bhagwat (2007) and Martin and Patterson (2009). The next identified cluster focused on methodology of performance measurement as proposed by Clarke and Gourdin (1991), Koota and Takala (1998), Saad and Patel (2006) and Chia et al. (2009). The last stream is the impact of measurement system on firm's performance as discussed by Wong et al. (2014). The starting point of this cluser came from Wisner and Fawcett (1991) who identified basic characteristics of world-class manufacturers.

Reviewing supply chain measure and metrics

This research domain presents only one cluster with three articles that have the most citations. The first article named “Measuring Supply Chain Performance” by Beamon (1999) who proposed a supply chain performance measurement stream. This article was used as a reference for developing the performance measurement system by many practitioners and scholars such as Grimaldi & Rafele (2007), Van Der Laan et al. (2009), Barros et al. (2011), Forslund (2011), Gou et al. (2013), Jakhar & Barua (2014), Lee & Wu (2014) and SIMÃO et al. (2014).

The second most cited article entitled “A Framework for Supply Chain Performance Measurement” by Gunasekaran et al. (2004) who proposed a supply chain performance modelling/framework stream. This article was used as an important reference to asssess performance by scholars such as Seth et al. (2006), Banomyong and Supatn (2011), Barros et al. (2011), Forslund (2011), Bjorklund et al. (2012), Constăngioară (2014), Jakhar and Barua (2014), SIMÃO et al. (2014), Madhavan (2015), Loos and Rodriguez (2015) and Gong and Yan (2015).

The last seminal paper is entitled “Performance measurement systems design: a literature review and research agenda” by Neely et al. (1995) who proposed a performance measurement framework. This paper was cited by academics and practitioners such as Banomyong and Supatn (2011), Forslund (2011), Jothimani et al. (2014), Simao et al. (2014) and Gong and Yan (2015) in their development framework.

Beside of using systematic review, the authors still perform the traditional review about LSP performance measurement and found that

- Knemeyer, et al. (2003) study the perspective of a customer. If the customer perceives that the LSP focuses on the interaction between the companies and is concerned with winning and keeping the customer, the relationship can be strengthened.
- Stank et al. (2003) examine how relational, operational and cost performance relate to customer satisfaction, loyalty and market share.
- The internal business perspective translates the customer perspective into what the company must do in order to meet its customer’s expectations. But the targets for success keep changing; and thus innovation is needed. For LSP s innovations can include additional activities, regions, transport modes and communication systems e.g. RFID or WebServices (Chapman et al., 2003 , Lemoine et al., 2003).
- Financial indicators measure if the company’s strategy, implementation and execution contribute to bottom-line improvement

Proposed Conceptual Framework

The literature overview presented in the previous section supports the view that there are different points of view (both internal and external) on the company’s performance. The internal point of view is represented by management and employees within the company. The external point of view shows the perspective of the customer and the society.

The authors introduce the concept of performance measurement – the integration of environmental, social, economic and others criteria that allow service providers to achieve long term sustainable viability – to the logistics literature. Then a proposed framework of logistics performance measurement and develop performance indices based on logistics service provider’s perspective. The authors conclude by discussing managerial implications and future research directions, including the further development and testing of the framework.

Point of view / Horizon	Internal		External	
	Management	Employees	Customer	Society

Table 2: LSPs performance measurement point-of-view
Source: The Authors

The vertical axis divides the performance indicators in long-term and short-term. This distinction has been previously used in other research (e.g. Gunasekaran et al, 2001) and is accepted as a meaningful division that the decision makers find applicable.

Point of view / Horizon	Internal		External	
	Management	Employees	Customer	Society
Long-term				
Short-term (operations)				

Table 3: Performance indicators perspective
Source: The Authors

An extra extension has been added for the management point of view, the KPI scheme has been further split in four categories: Effectiveness, Efficiency, Satisfaction, IT utilisation and innovation.

Point of view / Horizon	Internal		External	
	Management	Employees	Customer	Society
Long-term				
Short-term (operations)				

Refinement of management point-of-view

Effectiveness	Efficiency	Satisfaction	IT utilisation&innovation

Table 4: Management point-of-view
Source: The Authors

After that the KPIs for LSP performance measurement were listed as follow.

Internal perspective - Management point of view		
Effectiveness		
Revenue ↑ Profit margins ↑ Capacity utilization ↑ Km per day ↑ Labour productivity ↑ Price ↑ Turnover per km ↑ Number of deliveries ↑ Benefit per delivery ↑ Trips per period ↑ Perfect order fulfilment ↑	Total number of orders ↑ Number of customers ↑ Number of new customers ↑ Number of regular customers ↑ Number of profitable customers ↑ Continuous improvement, rate ↑ Product range ↑ Plan fulfilment ↑ Total loading capacity (for trucks) ↑ On-time delivery performance ↑	Long term plans availability / development ↑ Market share width ↑ Number of markets that have been penetrated ↑ Successful contacts – % of successful deals out of the initial offers ↑ Effectiveness of distribution planning schedule ↑ % of orders scheduled to customer request ↑ % of supplier contracts negotiated meeting target terms and conditions for quality, delivery, flexibility and cost ↑ Competitive advantage ↑
Efficiency		
Total distribution cost ↓ Labour utilization ↑ Overhead percentage ↓ Overtime hours ↓ % Absent employees ↓ Salaries and benefits ↓ Controllable expenses ↓ Non-controllable expenses ↓ Customer service costs ↓ Order management costs ↓ Inventories ↓ Number of trucks in use ↑ Total delivery costs ↓	Average fuel use per km ↓ Average delivery re-planning time ↓ Marketing costs ↓ Failure costs ↓ Prevention costs ↓ Appraisal/Inspection costs ↓ % of failed orders ↓ % of realized km out of planned km ↑ Performance measurements costs ↓ Human resource costs ↓ Variable asset costs ↓ Fixed asset costs ↓ Information system costs ↓	Overhead/management/administrative costs ↓ Quality of delivery documentation per truck/driver ↑ Effectiveness of delivery invoice methods ↑ % orders / lines received with correct shipping documents ↑ % product transferred without transaction errors ↑ Item/Product/Grade changeover time ↓ Order management costs ↓ Supply chain finance costs ↓ Total supply chain costs ↓ Total time in repair (for trucks) ↓ Ratio of realized orders vs. requested orders ↑ Average delivery planning time ↓
Satisfaction		
Attrition of drivers ↓ Morale, motivation of personnel ↑	On-time delivery performance ↑ Number of customer complains ↓ Overall customer satisfaction ↑	% of orders scheduled to customer request ↑ Overall employees satisfaction ↑ Overall society satisfaction ↑
IT and innovation		
Information system costs ↓ Up-to-date performance information availability ↑ Utilization of IT equipment ↑ IT training costs ↓	Number of new products in the range ↑ % of information exchange through IT ↑ % of employees with IT training ↑ Availability of IT equipment ↑	% of information management assets used / production assets ↑ % of invoice receipts and payments generated via EDI ↑ Average time for new products development ↓ Average costs for new product development ↓
Internal perspective – Employee's point of view		
Km per trip ↓ Working conditions ↑	Weight to (un)load per labour hour ↓	Salaries and benefits ↑
External perspective – Customer's point of view		
Transportation price ↓ Insurance price ↓ Primary services price ↓ Goods safety ↑ Product variety ↑ Response time ↓	Transparency for a customer ↑ Possible types of communication ↑ Available types of goods insurance ↑ Order size flexibility ↑ Timeliness of goods delivery↓	Services variety ↑ Order configuration flexibility ↑ Possibility to change order details ↑ Additional services price (priority transportation) ↓ Contact points (number of people to contact) ↓
External perspective – Society's point of view:		
Level of CO2 emission ↓ Society satisfaction ↑ Wasting resources ↓ Recycling level ↓ Employees satisfaction ↑ Disaster risk ↓	Solid particles emission ↓ Taxes to the national treasury ↑ Participation in charitable actions ↑ Reputation of a company ↑ Road maintenance costs ↓ Number of available work places ↑	Competition level among similar companies ↑ Care for animals/children around ↑ Use of innovation technologies ↑ Development of innovation technologies ↑ Cooperation with other companies ↑

Summary

This paper used the systematic method to review 38 articles from 28 journals and 2 databases. Subsequently, these 38 articles are classified into 2 main research domains based on Gopal and Thakkar (2012). The authors analyzed main path analysis (MPA) by following the guideline from Colicchia and Strozzi (2012) and used citation network as a key to link each article and conducted by Pajek software 4.01 (De Nooye et al., 2005) in each research domain.

The analysis shows that there are six research streams in the enhancing supply chain performance domain and three seminal papers in the supply chain measures and metrics domain. This review also observed gaps in research areas related to each paths. The first path describe that many performance dimensions are taken into account. This is the same as in the fourth path which investigate the use of common measurement metrics in an attempt to determine which one(s) are most useful for measuring performance but not including the environmental and social perspectives.

Hence, future research efforts in both these paths should aim to better understand how to measure environmental and social practices.

The second path is a reflection on how quality management programs can be implemented effectively through performance measurement. The third path describe how diagnostic and assessment of logistics and supply chain performance can be done. However, there is a lack of benchmarking research to identify best practices. The fifth path describes various dimensions of performance but the measurement methods are restricted to single-firm case studies. The last path of enhancing supply chain performance domain is limited on how to utilise integrated measures that can highlight the contribution of corporate goals such as Economic Value Added. Finally, the three seminal papers by Beamon (1999), Gunasekaran et al. (2004) and Neely et al. (1995) must be referred to when reviewing supply chain measure and metrics.

This paper is part of ongoing research. Then this proposed conceptual framework will be empirically validated, to prove this framework into accepted and validated model. Results encourage researchers and practitioners to be more highlight the importance of framework development over other factors like developmental strategies, success factors etc which had been the prime focus of earlier researches.

Based on this research, new performance measurement conceptual framework is proposed for existing logistics paradigms. The detailed analysis presented in this research paper offers a set of characteristics and structure that industry as well as academia could use it as a guidance framework to measure logistics service provider performance.

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MANAGING STOCKOUT AND OVERSTOCK OF IMPORTED GROCERY PRODUCTS IN A SUPERMARKET CHAIN

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Introduction

The profitability of the supermarket business is dependent on its sales revenue and efforts to keep operating costs low. It is important for supermarkets to maintain a high level of customer satisfaction by ensuring that the products are made available to customers at the right place, at the right time, at the right quantity and at the right price. Supermarket chains are often concerned with managing out-of-stock (or stockout) and over-ordering of grocery products as demand forecasting for such products can be very challenging.

The costs of stockout (when goods are unavailable) and overstock (when excess goods are accumulated) for a supermarket business can be high. Stockouts lead to immediate loss of sales as customers shop for products or alternatives elsewhere, loss of follow-on business, and loss of goodwill and reputation in the longer term. Overstocking leads to higher holding costs as more storage space is needed, locks up scarce resources as the capital cannot be used elsewhere, contributes to ageing inventory (e.g. inventory held for more than 90 days), and leads to higher disposal costs when the product shelf life expires. Both stockout and overstock situations can adversely impact the profitability of the supermarket business.

This paper examines the stockout and overstock of imported grocery products in a supermarket chain in Singapore. The supermarket chain has over 120 outlets providing a wide range of grocery products sourced from all over the world. The chain has a fresh food distribution facility and a distribution centre (or centralised warehouse) for efficient logistics support. It proactively seeks new supply chain relationships with overseas grocery suppliers to provide more product variety for its customers and keep prices competitive. Products with good saleability in overseas markets are often introduced to the local market despite the potential uncertainty of customer demand for these products. The supermarket chain also diversifies its supply sources to manage the risks involved in bringing in these products into the market.

Finding the right balance of inventory levels for imported grocery products is not easy. Competition in the supermarket industry in Singapore is very intense and supermarket chains have to source for products world-wide to secure competitive prices through bulk purchases. Various promotions and festive occasions throughout the year require imported grocery products to be brought in larger bulk to cater to increased demand. Festive season products tend to be expensive, non-returnable and usually cannot be sold after the festive period.

Therefore, it is important for inventory planners to manage the inventory levels well and strive to make good order forecasts so as to cater to demand during normal and promotional periods. This study attempts to find answers to the following research questions:

- What are the main causes of stockout and overstock of imported grocery products?
- How can the order forecasting of these products be improved to minimise stockout and overstock situations?

Literature Review

According to Gruen et al. (2002), about 47% of stockout incidents can be attributed to store order and forecasting, while 28% is due to upstream causes and 25% is due to store replenishment. Other contributing factors can include container delays and late replenishment order from supermarkets. Gruen et al. (2002) reported that about 31% of consumers would purchase an item from another store when the item is unavailable at the store. Besides the direct or indirect loss of potential sales at the supermarket outlet, there is the issue of customer dissatisfaction.

Aburto and Weber (2007) noted that improving the forecasting accuracy of a supermarket can help to reduce stockout incidents while allowing the supermarket to keep its inventory level low. They advocate that solving the stockout problem requires a reliable prediction of the stock's demand. However, they iterated that this is not easily achieved as sales can be dependent on various factors such as past sales, prices, advertising campaigns, seasonality, holidays, weather, sales of similar products, and competitors' promotions.

Overstocking can be a result of poor management of stock demand where inaccurate inventory data cascades from the warehouse to the stores (Hooi, 2013). It also occurs when a product has a stipulated selling period with unknown demand, where supermarkets deliberately overstock to hedge against uncertainty in the stock's demand (Tsay, 2001). This can happen at the level of the warehouse or retail outlet. When overstocking occurs at the warehouse, stocks are likely to be "pushed" to the supermarket outlets. If the outlet staff has poor management of its shelf spaces, these excess stocks have to be shifted to the storage room. Over time, this leads to high stock returns to the suppliers or stock disposal when products reach their expiry dates. All of these create higher logistical and administrative costs.

Many studies have looked at improving order forecasting, yet it is still a challenge for many supermarkets to make accurate forecasts on orders. This is because order forecasting is highly contextual and is easily affected by various ordering processes and replenishment policies specific to the supermarket business (Chopra and Meindl, 2016). There is never a 100% accurate forecast, but many are striving to obtain an order forecast as accurate as possible.

Methodology and Data

We used the case study method (Saunders et al., 2012) to investigate the stockout and overstock situation at this particular supermarket chain. Qualitative and quantitative data was obtained to address the research questions. To understand the main factors that caused stockout and overstock, we had discussion with the procurement and inventory managers. The cause-and-effect analysis was applied to identify the root causes. We examined the current process for ordering imported grocery products and then attempted to improve the order forecasting process.

Figure 1 shows the current process for ordering imported grocery products. For a new product, the procurement manager gathers necessary information (e.g. price and profit margin) and presents to the ranging committee that meets on a weekly basis for approval. The committee makes a comparison of the new product with existing items. If the product is rejected, no follow-up action is required and the supplier is informed of the reasons for the rejection. If the product is approved, the procurement manager informs the inventory planner to add the new approved items with the existing ones under the same supplier (where applicable) to obtain updated order quantities for the next order. Once the order quantities have been approved, the inventory planner triggers a new order to the supplier.

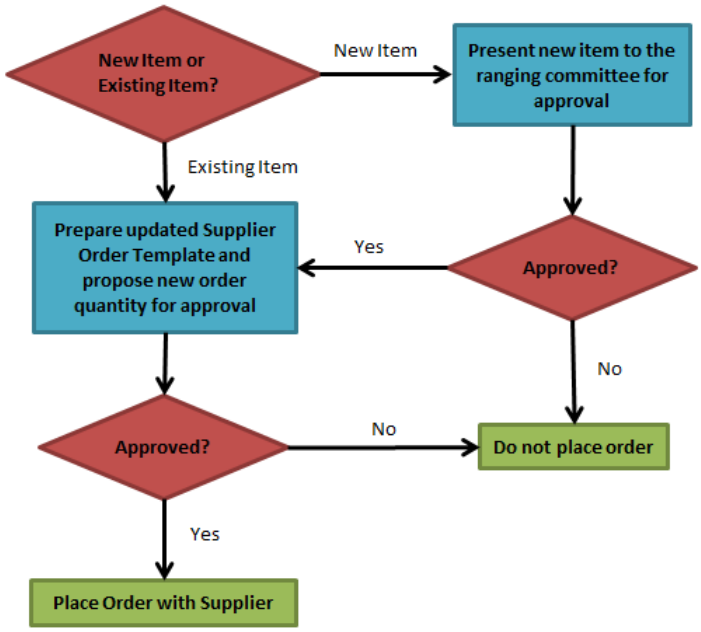

Figure 1: Current process for ordering imported grocery products

The following information was examined to provide a better insight into the ordering process:

- *Monthly Write-Off Report*: This report is used by inventory managers to monitor the monthly write-offs at the warehouse level. Write-offs can be due to damaged products, seasonal products that cannot be sold after the festive period, and stocks past their expiry date.

- *Point-of-Sales (POS) Data*: Data is extracted from the intranet based on various specifications such as by individual store, individual supplier, and items by the respective retail formats.

- *Supplier Ordering Template*: Available on a daily basis, this Excel-based spreadsheet is used by the inventory planner (imports) to help make important decisions on ordering. It consists of up-to-date descriptions and specifications of products under a particular supplier.

- *Temporary Not Available (TNA) Report*: Available on a weekly basis, this report informs the supermarket outlets on products currently unavailable and arrival date of the next shipment.

- *Warehouse Stock Expiry Report*: This report consists of all the items current made available in the warehouse sorted from the earliest expiry date to the latest. This report is useful for monitoring product shelf life and gives the inventory planners time to react.

- *Supplier Product Quotation List*: This list contains product specification and pricing information from suppliers when there are new item proposals for procurement managers to consider.

- *Warehouse Stock Inventory Report*: This report provides an overview of products in the warehouse and supermarket outlets. It includes detailed information on product listing, classifications and inventory level.

Table 1 shows an example of the supplier ordering template for seven different flavours of instant noodles from a certain supplier based on average monthly sales from December 2014 to February 2015. The supermarket wants to place a new order SL003/15 to arrive in Singapore on 16 April 2015. It is important to ensure up-to-date and correct data provided by the suppliers is reflected in the spreadsheet. Table 2 describes the various columns of the spreadsheet.

PURCHASE ORDER & INVENTORY

Supplier: ABC PTE LTD (71300)

Proposed Date: 16-Mar-15

						16-Mar-15	16-Mar-15				INCOMING ORDER				
											16-Apr-15				
											SL003/15				
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
S/NO.	SKU	PRODUCT DESCRIPTION	P/S	DC	SHELF LIFE UPON ETA (MTHS)	WH88 SOH (CTNS)	STORE SOH (CTNS)	TOTAL WH & STORE SOH (CTNS)	AVG MONTHLY SALES (Dec - Feb '15) / MTHS (CTNS)	MOS BASED ON WH SOH (MTHS)	MOS BASED ON WH + STORE SOH (MTHS)	PROPOSED ORDER QUANTITY (CTNS)	ESTIMATED AVAILABLE STOCKS IN WH @ POINT OF ETA (CTNS)	MOS BASED ON WH + NEW SHIPMENT (MTHS)	ESTIMATED AVAILABLE STOCKS IN WH & STORE @ POINT OF ETA (CTNS)	MOS BASED ON WH + STORE + NEW SHIPMENT (MTHS)
1	13010470	ABC INST NDL-RST BEEF 5S 100G	6	88	5	993	153.8	1146.8	1684.4	0.6	0.7		0	0.0	0	0.0
2	13010471	ABC INST NDL-HOT BEEF 5S 101G	6	88	5	869	171.0	1040.0	1445.3	0.6	0.7		0	0.0	0	0.0
3	13010473	ABC INST NDL-CHK MUSH 5S 98G	6	88	5	370	140.5	510.5	931.7	0.4	0.5		0	0.0	0	0.0
4	13028845	ABC INST PRWN NOODLES 5S 96G	6	88	5	156	62.3	218.3	361.2	0.4	0.6		0	0.0	0	0.0
5	13055590	ABC P.VEG PORK RIBS 5S 119G	6	88	5	0	140.7	140.7	363.2	0.0	0.4		0	0.0	0	0.0
6	13028841	ABC INST B/NDL MROOM CHK 103G	12	88	5	109	46.5	155.5	293.8	0.4	0.5		0	0.0	0	0.0
7	13042403	ABC INST B/NDL-RST BEEF 105G	12	88	5	83	42.9	125.9	307.4	0.3	0.4		0	0.0	0	0.0
												0				

PREPARED BY: LAU KIAT HONG / DATE

ADDITIONAL INFO:

Order lead time : 1 month

Table 1: Sample input from the supplier ordering template

Col	Description	Spreadsheet Computation	Source / Remarks
A	Stock Keeping Unit (SKU)	-	-
B	Product Description	-	Supplier product quotation list
C	Carton Pack Size	-	Supplier product quotation list
D	Distribution Centre/Warehouse	-	-
E	Product Shelf Life (months)	-	Supplier product quotation list
F	Warehouse Stock-on-Hand or WH SOH (cartons)	-	Stock inventory report
G	Store Stock-on-Hand or Store SOH (cartons)	-	Stock inventory report
H	Total Stock-on-Hand or Total SOH (cartons)	= (Column F + Column G)	-
I	Average Monthly Sales (cartons)	-	Point-of-Sales (POS) data
J	WH SOH Months of Supply (months)	= (Column F / Column I)	-
K	Total SOH Months of Supply (months)	= (Column H / Column I)	-
L	Proposed New Order Quantity (cartons)		Input from inventory planner
M	Estimated Available Stocks in WH (cartons)	=IF((Column F) - (((Column L - Start Date) / 30days)*Column I) > 0, (Column H + Column L) - (((Column L - Start Date) / 30days)* Column I), Column L)	-
N	WH SOH + New Shipment MOS (months)	= (Column M / Column I)	-
O	Estimated Available Stocks in WH & Store (cartons)	=IF((Column H) - (((Column L - Start Date) / 30days)*Column I) > 0,(Column H + Column L) - (((Column L - Start Date) / 30days)* Column I), Column L)	-
P	WH SOH + Store SOH + New Shipment MOS (months)	= (Column O / Column I)	-

Table 2: Description of supplier ordering template

Results and Discussion

Causes of stockout and overstock

Figure 2 shows the cause-and-effect diagram for identifying possible factors that contribute to stockout and overstocking situations. The fishbone diagram was grouped into six categories, namely: HQ, Suppliers, Stores, Warehouse, Procedures and Customers. For each category, potential causes leading to stockout and overstocking were surfaced. After discussion with the procurement and inventory managers, the root causes were identified as:

- *Suppliers - Long Lead Time - Distance*: Lead times for imported products sourced overseas vary greatly. An order for a US-based supplier requires a lead time between 2.5 to 3 months, while an order for an Asia-based supplier needs a lead time of 1 to 1.5 months. Any delays in placing new orders or a shipment delay would affect downstream replenishment at the stores.

- *Stores - Displays - Fail to Replenish Timely*: Failure to replenish products onto the store shelves while products sit idle in storage room is another cause. Products must be replenished timely and checked at regular intervals to ensure as many products are made available to customers.

- *Customers - High Demand - Promotion*: Goods are likely to move faster due to special pricing given during promotions for a particular product. Before a promotion, sufficient stocks need be placed to cater to high customer demand. Inventory levels at the store are likely to be low or out-of-stock after the promotion. In the event of a last-minute cancellation of a promotion, the store would be flooded with stocks and leading to insufficient space for sales display.

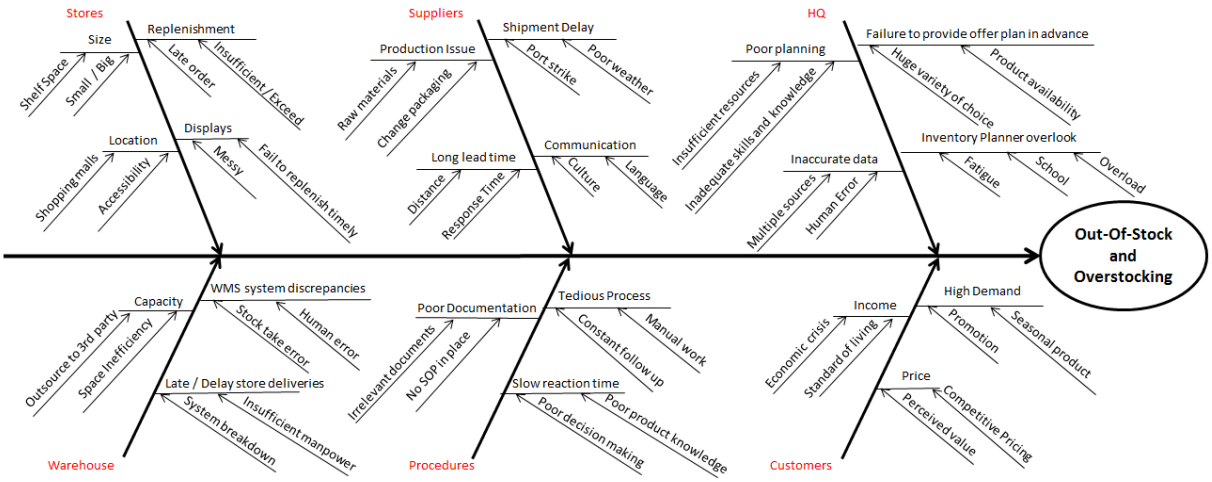

Figure 2: Cause-and-effect diagram for stockout and overstock

Effect of the supplier ordering template on write-offs

We used data from the monthly write-off reports to determine whether the supplier ordering template was an effective tool to minimise write-offs of unsold goods after the festive season and products past their expiry dates. Write-off amounts tend to be higher after festive seasons as well as after the year-end stock takes at the stores and warehouses. The supplier ordering template was implemented at the supermarket at the end of 2013.

Figure 3 shows the monthly write-off value of imported grocery products for FY2013 to FY2015. Comparing the figures for FY2013 and FY2014, it can be seen that there was a marked reduction in annual write-off value, i.e. a savings of about $405,000. We reckon that the supplier ordering template could have played an important role in providing as timely and accurate information as possible for inventory planners to place their orders to suppliers.

Between FY2014 and FY2015, there was an increase in the annual write-off value of about $80,000. We attributed this to the expansion of the import business with an increase in new products introduced to the market and the corresponding increase in write-offs.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
FY2013	$304,890.42	$ 88,275.64	$206,103.17	$ 65,036.52	$110,584.05	$76,387.82	$65,414.88	$43,433.85	$61,561.35	$33,583.98	$ 54,536.09	$79,493.80	$ 1,189,301.57
FY2014	$ 62,540.67	$105,086.76	$106,829.41	$ 83,228.57	$ 56,708.96	$72,981.82	$36,712.43	$62,768.13	$79,745.56	$62,524.44	$ 28,347.99	$26,337.31	$ 783,812.05
FY2015	$ 70,445.21	$ 73,160.17	$131,429.99	$115,631.53	$ 67,216.52	$42,060.14	$37,417.55	$63,503.85	$50,472.27	$47,715.79	$101,244.20	$63,729.91	$ 864,027.12

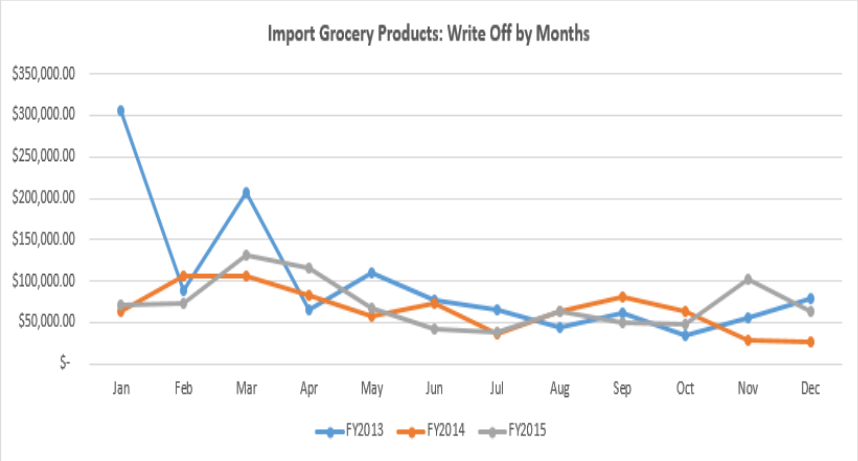

Figure 3: Monthly write-off value of imported grocery products, 2013-2015

Improving the order forecasting process

Microsoft Excel Solver was incorporated into the supplier ordering template in an attempt to improve the ordering forecasting process by optimising the order taking into account the average monthly sales, Months of Supply (MOS) and current inventory levels. The following settings in Solver were used (Figure 4):

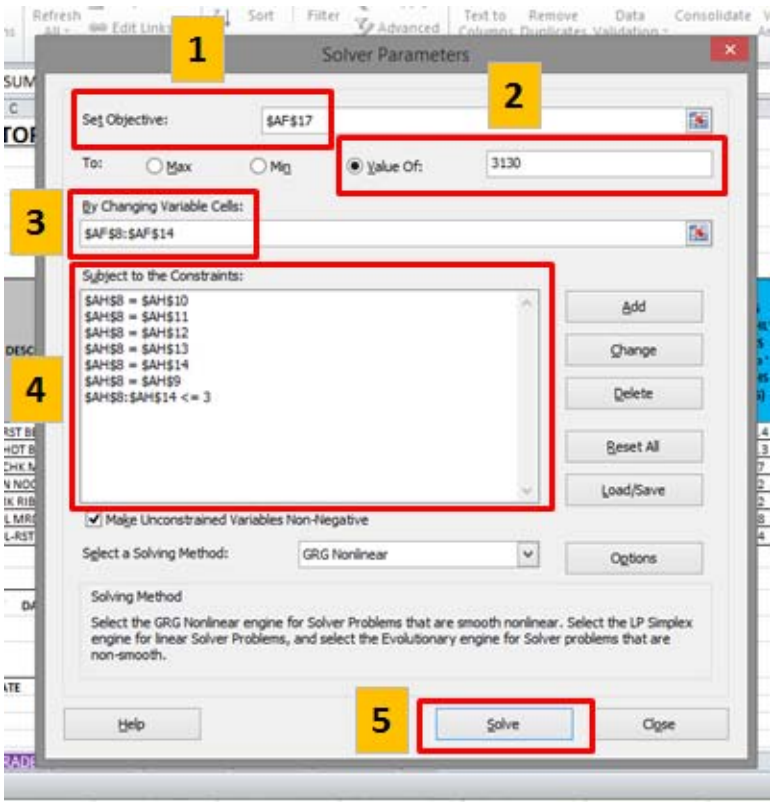

Figure 4: Excel Solver Parameters

1. Set objective cell to be the total quantity of the order.
2. Choose “Value Of:” option and input the maximum order quantity (in cartons) for a 40-foot full container load (FCL).
3. Select Changing Variable Cells to be the cell for Solver to determine the optimum order quantity for each item.
4. Set the following constraints:
   - Optimum order quantity must be a integer.
   - Months of Supply (MOS) for each item should be the same to ensure optimum stock holding across all items.
   - MOS should not exceed 3 months where it will be deemed as ageing inventory.
5. Click “Solve” to determine the optimum order quantity.

Using the example input of Table 1, Solver was applied to derive the order quantities for the new order SL003/15. Figure 5 shows the sample output. The MOS (based on Warehouse + Store + New Shipment) of 0.6 months (column P) was optimised across all the items. The proposed order quantities are shown in column L.

PURCHASE ORDER & INVENTORY

Supplier: ABC PTE LTD (71300)

Proposed Date: 16-Mar-15

											INCOMING ORDER				
						16-Mar-15	16-Mar-15				16-Apr-15				
											SL003/15				
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
S/NO.	SKU	PRODUCT DESCRIPTION	P/S	DC	SHELF LIFE UPON ETA (MTHS)	WH88 SOH (CTNS)	STORE SOH (CTNS)	TOTAL WH & STORE SOH (CTNS)	AVG MONTHLY SALES (Dec - Feb '15) / MTHS (CTNS)	MOS BASED ON WH SOH (MTHS)	MOS BASED ON WH + STORE SOH (MTHS)	PROPOSED ORDER QUANTITY (CTNS)	ESTIMATED AVAILABLE STOCKS IN WH @ POINT OF ETA (CTNS)	MOS BASED ON WH + NEW SHIPMENT (MTHS)	ESTIMATED AVAILABLE STOCKS IN WH & STORE @ POINT OF ETA (CTNS)	MOS BASED ON WH + STORE + NEW SHIPMENT (MTHS)
1	13010470	ABC INST NDL-RST BEEF 5S 100G	6	88	5	993	153.8	1146.8	1684.4	0.6	0.7	979	979	0.6	979	0.6
2	13010471	ABC INST NDL-HOT BEEF 5S 101G	6	88	5	869	171.0	1040.0	1445.3	0.6	0.7	840	840	0.6	840	0.6
3	13010473	ABC INST NDL-CHK MUSH 5S 98G	6	88	5	370	140.5	510.5	931.7	0.4	0.5	541	541	0.6	541	0.6
4	13028845	ABC INST PRWN NOODLES 5S 96G	6	88	5	156	62.3	218.3	361.2	0.4	0.6	210	210	0.6	210	0.6
5	13055590	ABC P.VEG PORK RIBS 5S 119G	6	88	5	0	140.7	140.7	363.2	0.0	0.4	211	211	0.6	211	0.6
6	13028841	ABC INST B/NDL MROOM CHK 103G	12	88	5	109	46.5	155.5	293.8	0.4	0.5	171	171	0.6	171	0.6
7	13042403	ABC INST B/NDL-RST BEEF 105G	12	88	5	83	42.9	125.9	307.4	0.3	0.4	179	179	0.6	179	0.6
												3130				

PREPARED BY: _____

LAU KIAT HONG / DATE

ADDITIONAL INFO:

Order lead time : 1 month

Mixed 40" - 3130 cartons

Figure 5: Sample output showing the order quantities obtained using Solver

Conclusions and Recommendations

Out-of-stock and overstock of goods are major issues of concern for supermarkets that provide a large variety of products to customers. This is especially so for imported products where lead time and accurate order forecasts are needed to ensure products arrive in time whenever customer wants it to ensure high customer service standards. The objectives of this study were to investigate the factors that cause stockout and overstocking of imported grocery products for the case of a supermarket chain in Singapore as well as to find ways to improve the order forecasting process.

We studied the flow of goods from warehouse to the supermarket outlets and its processes to identify potential causes of stockout and overstock situations. Based on discussions with the procurement and inventory managers of the supermarket, the cause-and-effect analysis identified six categories that contributed to stockout and overstock. The possible factors were narrowed down to three main ones: (i) long supplier lead time, (ii) failure to replenish at the stores, and (iii) high customer demand as a result of promotions.

Overstocking can lead to increased write-off costs and ageing inventory. We reported the use of an Excel-based supplier ordering template to help the inventory planner make important decisions on ordering. There was a marked reduction in the total write-off value the year after the supplier ordering template was implemented. We explored the use of Solver to perform order forecasting in a more efficient instead of manual input of the order quantities. However, achieving an optimum inventory level is a challenging task. It is important to ensure the ordering processes are handled with well to build customer loyalty and increase customer satisfaction through quality products and services.

Due to time and resource constraints, it was not possible to gather more detailed for an extensive investigation. Further work can look at conducting surveys with end customers at the supermarket outlet level to gather their response when they encounter out-of-stock situations rather than obtaining information from secondary sources. More studies can also be done to explore ways of increasing the frequency of stock replenishment and improving shelf displays to maximise the space utilisation so as to improve stockout situations.

Another area for future work can be to explore the use of auto-replenishment systems for imported grocery products using sophisticated technologies and software where orders are auto-generated by the system and sent to suppliers. This can provide the supermarket chain a competitive advantage by reducing the order lead time and increasing work productivity.

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PERFORMANCE – BASED LOGISTICS SERVICE BUSINESS MODEL UTILIZING CLOUD COMPUTING

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Email: sllam@ntu.edu.sg

Introduction

In the contemporary business environment, competition in the consumer markets is largely between supply chains and depends on how well service providers manage their supply chains (Lam, 2013). Manufacturers continually strive to differentiate themselves from their competitors not only in terms of products and services but also their supply chains. These manufacturers as shippers expect logistics service providers (LSPs) to provide high quality services such as on time deliveries, fast and consistent transit times, wide networks, and accurate invoicing (Conaway, 2011).

Currently in the market, third-party and fourth-party logistics providers (3PL and 4PL, respectively) attempt to coordinate complementary services and act as a single contact point for shippers (Tezuka, 2011). We refer them as LSPs in general in this paper. The supply chain process is complex involving various logistics operators/ second-party logistics providers (2PLs). During the integration process, LSPs do not provide all the logistics services by themselves and they often have to engage 2PLs for operations which are not part of their core businesses (Tezuka, 2011). The 2PLs' service quality can directly affect the reputation and performance of the integrators (Bask, 2001). Therefore, it is crucial for LSPs to assess and monitor 2PLs' performance. This leads to a need for having a mechanism to evaluate logistics operators' performance (Dibenedetto, 2007).

Supply chains are further complicated by information distortions and holdup problems because individual entities often only focus on their own objectives and goals, resulting in higher total logistics costs (Lam and Bai, 2016). With a background of a challenging marketplace, the study aims to develop a performance-based intelligent logistics service business model for LSPs which enhances their capability in logistics service offering and improves supply chain performance by utilizing Internet of Things (IoT) network and cloud computing.

After the introduction, section 2 provides a brief literature review. Section 3 illustrates the new business model. Section 4 provides a conclusion and future research directions.

Literature review

This study refers to the evolving concepts of logistics performance in the literature. The management of LSPs and 2PLs is a key issue in supply chain management (SCM) as they are major players in the supply chain processes bringing products and services to end customers (Bask, 2001). LSPs play an important role in improving supply chain performance through collaboration and the integration of logistics activities (Panayides and So, 2005). A body of literature has examined the parameters for logistics performance evaluation (e.g. Jharkharia and Shankar, 2007; Kayakutlu and Buyukozkan, 2011). While reliability, cost efficiency, and responsiveness have been widely acknowledged in the literature, little can be found addressing sustainability as a performance indicator for LSP, even sustainability is increasingly important in SCM (Lam and Dai, 2015).

The concept of Performance-Based Logistics (PBL) states that payments to service providers should be based on their success in delivering desired outcomes (Randall *et al*., 2010). In accordance with Berkowitz *et al*. (2003), under the practice of PBL, the actual service delivered by LSPs should be measured against predetermined performance standards by customers. PBL is increasingly

implemented in practice such as in highway construction and operation, and high speed rail operation (Devries, 2005).

IoT and cloud computing are widely recognized as a paradigm shift in the way IT services are developed, deployed, scaled, updated, maintained and paid for (Marston *et al*., 2011). Recent studies suggest that cloud-based IoT technologies would enhance logistics and supply chain performance (Hall et al., 2012; Li *et al*., 2013; Wang *et al*., 2006). However, limited literature can be found on how cloud-based IoT works in logistics and supply chains. Our research contributes by developing a new performance-based logistics service business model enabled by IoT and cloud computing.

Performance-based logistics service business model

Given the challenges faced by the industry as noted in the introduction, the cloud-based IoT business model developed in this study is designed to tackle these industry concerns. The idea is to automize those processes which can reasonably be automized in order to improve information flows and supply chain planning. Data and information gathered by RFID technology will provide intelligence for LSPs to fulfill such purposes. Based on literature review, interviews, latest industrial practices and our own analysis, we develop a new business model aiming to enhance LSPs' functionality in supply chain planning so as to contribute to supply chain performance (see Figure 1).

The key parties are the LSP and those 2PLs. All parties and functions are linked to the cloud platform. The LSP operates the service models and assumes the leading and central role in supply chain planning. It engages different 2PLs to provide one-stop logistics services and is responsible for cargo, information and financial flows. Two interrelated models namely the dynamic service evaluation model and the performance-based pricing model are proposed to facilitate the supply chain planning. The goal is to align user evaluations with service providers' performance (Althuizen *et al*., 2012). Based on the measured data, the overall performance is ensured by applying two service level evaluation models: first, to evaluate the historic performance of partners for contracting and, second, to evaluate the actual service level of partners during operations. 2PLs are paid based on their performance levels, which are measured against certain performance criteria. All the processes including service fee calculations and analytics should be computerized to minimize human errors and to ensure efficiency.

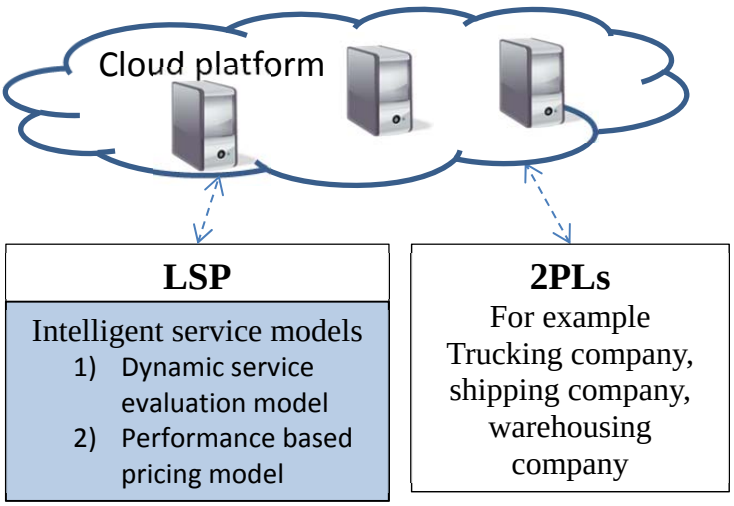

Figure 1: Performance-based logistics service business model

Source: Author

Conclusions

This paper presents an original contribution by developing a performance-based logistics service business model which enhance LSPs' capability in logistics service offering and improve supply chain performance by utilizing IoT networks and cloud computing. In the approach, the LSP serves as the single contact point for shippers and assumes the leading role in supply chain planning with innovative logistics service evaluation and pricing mechanisms. The distinctive feature and major benefit of deploying cloud-based IoT is that cargo status can be reflected directly without human intervention. Also, the analytical outcomes provide market intelligence for LSPs.

To the best of our knowledge, this is the first attempt towards addressing objective logistics performance evaluation by using cloud-based IoT. This overcomes the concern of subjective evaluation in the existing literature. This study contributes to develop the concept of Performance-Based Logistics. PBL is a relatively new concept in logistics. More research can be performed, for example, to empirically investigate LSPs' and 2PLs' behaviour if PBL is adopted. Security of the cloud-based IoT networks is crucial for the implementation of the new decision framework. Future research can be done to analyse security risk and its impact on the decision framework.

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REDUCING EXCESS INVENTORY IN A HIGH-MIX LOW-VOLUME MANUFACTURING SETTING

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Introduction

Providing customers with a wide variety of products and services has been a characteristic of some manufacturing and service industries. Increased customisation generally leads to varied proliferation of a given part and often requires Original Equipment Manufacturers (OEMs) to hold inventory of a wide range of variants of a given part. This study investigates the case of an OEM which supplies batteries to its worldwide customers in the electronics industry.

This operating environment is characterised by high-mix, low-volume manufacturing, i.e. about 90% of its products are customised according to customer's requirement while the balance of about 10% belongs to trading and direct retail items. The customisation strategy resulted in at least 20% of the critical components in the product's bill of material to be unique to the end product. The company faces high operating cost due to excess inventory coverage and stock obsolescence. To align with the company's strategic focus of cost efficiency, it is essential for the company to reduce the excess inventory cost.

The manufacturing activities of this OEM such as production, R&D and quality activities are carried out at its assembly plants on Batam Island, Indonesia, located 20 km off Singapore's south coast. The planning, customer service, sales and marketing functions are centralised at its regional office in Singapore. The company uses the SAP R/3 system to integrate the systems in Batam and Singapore to facilitate information flow between the plants. Real-time information overcomes the distance barrier in information and allows the planners to have timely information for material planning and master scheduling.

This paper examines the issues of excess inventory and stock obsolescence at this high-mix low-volume OEM using Lean Six Sigma's DMAIC (Define-Measure-Analyse-Improve-Control) approach. The objectives of this paper are three-fold. First, we seek to examine the item category with the highest impact to overall inventory. Second, we identify the main causes of excess stock. Finally, we determine the possible improvement solutions to reduce excess stock. The following research questions (RQs) were developed to guide the study to achieve the three objectives.

RQ1: What are the items with highest impact to overall inventory?
RQ2: What are the root causes of excess inventory?
RQ3: How can the company reduce the current levels of excess inventory?

Figure 1 shows the scope of study that was focused on the material planning and procurement activities within the company's order-to-cash cycle. The activities of both phases were taken into account in the root cause analysis of RQ2 as they were activities considered to have the most impact on the inventory levels.

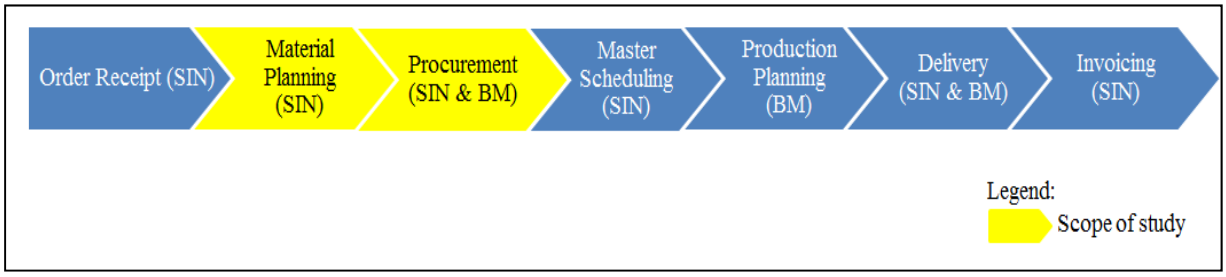

Figure 1: Scope of study in relation to the OEM's order-to-cash cycle

Literature Review

The review of existing literature relevant to the study were broadly summarised into two groups: techniques for identifying item categories with the greatest impact to overall inventory and Lean Six Sigma tools for determining the main causes and viable solutions to address the issues of excess inventory and stock obsolescence.

Market competition has forced many companies to focus on eliminating waste in the form of time, effort, defective units, and inventory in manufacturing-distribution systems (Larson and Lusch, 1990; Schonberger and Ansari, 1984). Ted Farris reported that 66% of the cash-to-cash improvements since 1986 in the majority of industry segments have come from reductions in days of inventory (Trunick, 2005). Farris noted that improvements to operations resulted in a reduction in the amount of inventory held within the company, leading to reduction in incidents of stock obsolescence.

Pattinson (1974) controlled excess and obsolete inventories by developing a suspect inventory list. He processed the suspect inventory list by shortlisting the high cost items which contributed 50% or more to the inventory value. As our aim was to achieve the greatest reduction of inventory value and stock obsolescence, this category management approach was most suited with our objectives and was considered useful in generating improvement solutions for multiple items with similar characteristics. Pattinson highlighted that the analysis of usage volume should ideally be based on future demand in the next 12 months. Since this information is not readily available, companies often use sales figure from the past 12 months as a proxy of the projected usage. We used Pattinson's approach to address RQ1. We focused on identifying the groups of items with the largest impact on the inventory value based on two variables: level of excess stock and stock value.

Many companies have developed and implemented Lean Six Sigma approaches in their pursuit for continuous improvement. Kumar and Sosnoski (2009) provided detailed discussion of the five Lean Six Sigma phases: Define, Measure, Analyse, Improve and Control (or DMAIC). Our study looked at the application of the concepts and tools under the 'Analyse' and 'Improve' phases, namely the cause-and-effect diagram, and the interrelationship digraph.

Doggett (2004) pointed out that the cause-and-effect diagram was easy to use and allowed flexibility in identifying problem-solving solutions through brainstorming. He also highlighted the interrelationship digraph as a structured tool for problem solving since it can show relationships of multi-variables which contributes to the problem. Crandall and Crandall (2003) supported the use of the cause-and-effect diagram to identify the main causes of excess inventories.

Notable cases on how companies have applied the Lean Six Sigma framework in their pursuit of continuous improvement and customer value enhancement are Fujitsu and Xerox. Fujitsu (2007) used visual management tools and kaizen as key elements of its lean programme. Xerox (Fornari and Maszle, 2004) considered enhancing customer value as the central focus when aligned its goals for its lean six sigma projects.

Methodology

We adopted the case study method (Yin, 2003) to conduct an empirical study of the inventory issues faced by this OEM that produces batteries for the consumer electronics industry. As most items are unique to the end product, the company finds it difficult to use the components for production of other battery models, resulting in stock obsolescence and high operating cost due to excess inventories. There is an urgent need for the company to reduce excess inventory and improve its cost efficiency.

Quantitative and qualitative data for this study were extracted from the case company through a mix of random and systematic sampling. They included:

- Stock coverage (or stock turnover in days) report is generated by the company's SAP system; this indicator is used to measure the level of excess stock
- Stock value percentage (the value of each stock item against the overall inventory) is generated by the company's SAP system
- Monthly rolling forecast of selected items from customers
- Ideas from brainstorming sessions with the company's Material Requirements Planning (MRP) controllers or planners
- Management's performance expectations and targets

Results and Discussion

The findings were grouped into three sections in response to the three research questions.

Items with highest impact to overall inventory

The item category with the most impact to the inventory was determined by using the multi-variate weightage method. The importance of each item category was weighted with a score based on two decision variables: stock value percentage and stock coverage. For each item, a score ranging from 0 (least important) to 10 (most important) was assigned to each item based on the company's perspective of its relative importance to stock value and stock coverage. The scores for stock value and stock coverage were then combined to obtain the total weighted score.

This allowed us to segregate the item categories into three levels of importance (high, medium and minimal) while taking into account the impact of the two variables. From the analysis, the category with the highest impact was the LIC cell category which had 8,307 days of stock coverage and contributed to 60% of the overall inventory value.

Root causes of excess inventory

Following a brainstorming session with the OEM's planners which enabled useful ideas to be generated, we applied the cause-and-effect diagram to identify the possible causes of excess stock for the LIC category. Figure 2 illustrates the 19 causal factors grouped into the six major categories: material, demand forecast, man, measurement, procedure and environment.

We then applied the interrelationship digraph to establish the relationship between the causal factors and determine the most likely root cause of the problem. Figure 3 depicts the relationship of these causal factors. High buffer stock, high risk of obsolescence, high purchase quantity and inconsistency of measurement methods were the most likely outcomes which led to the problem of excess inventory for LIC cell category.

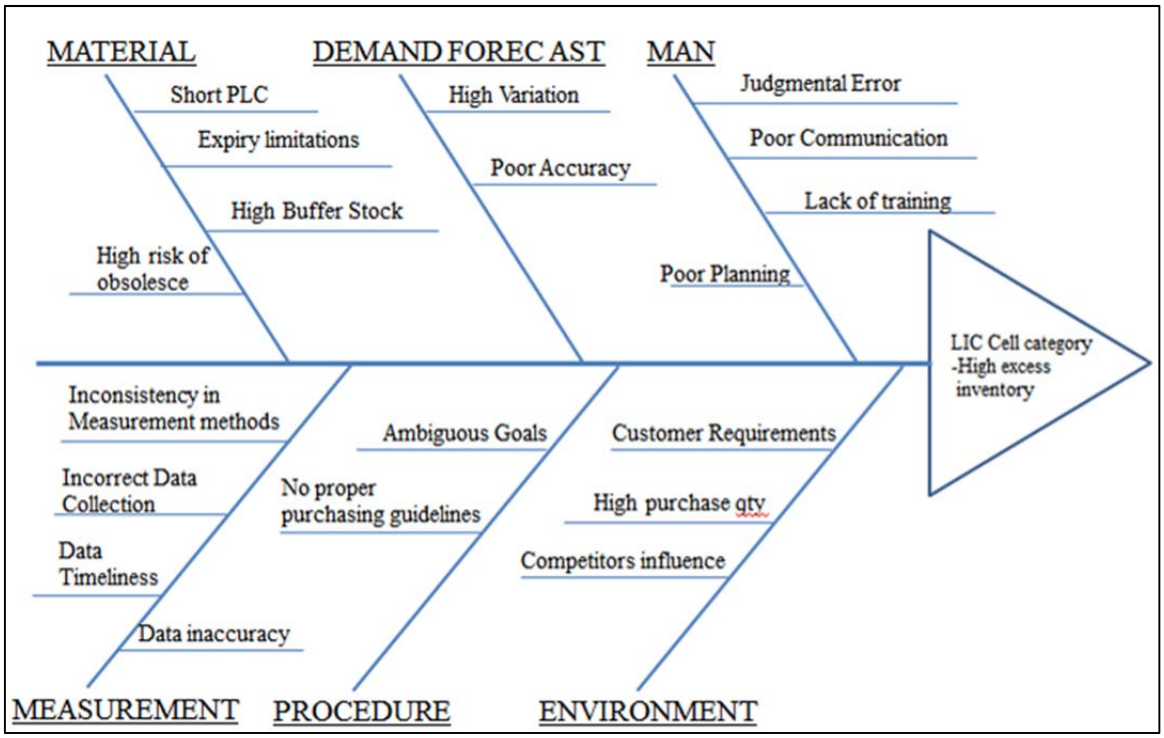

Figure 2: Cause-and-effect diagram for excess inventory

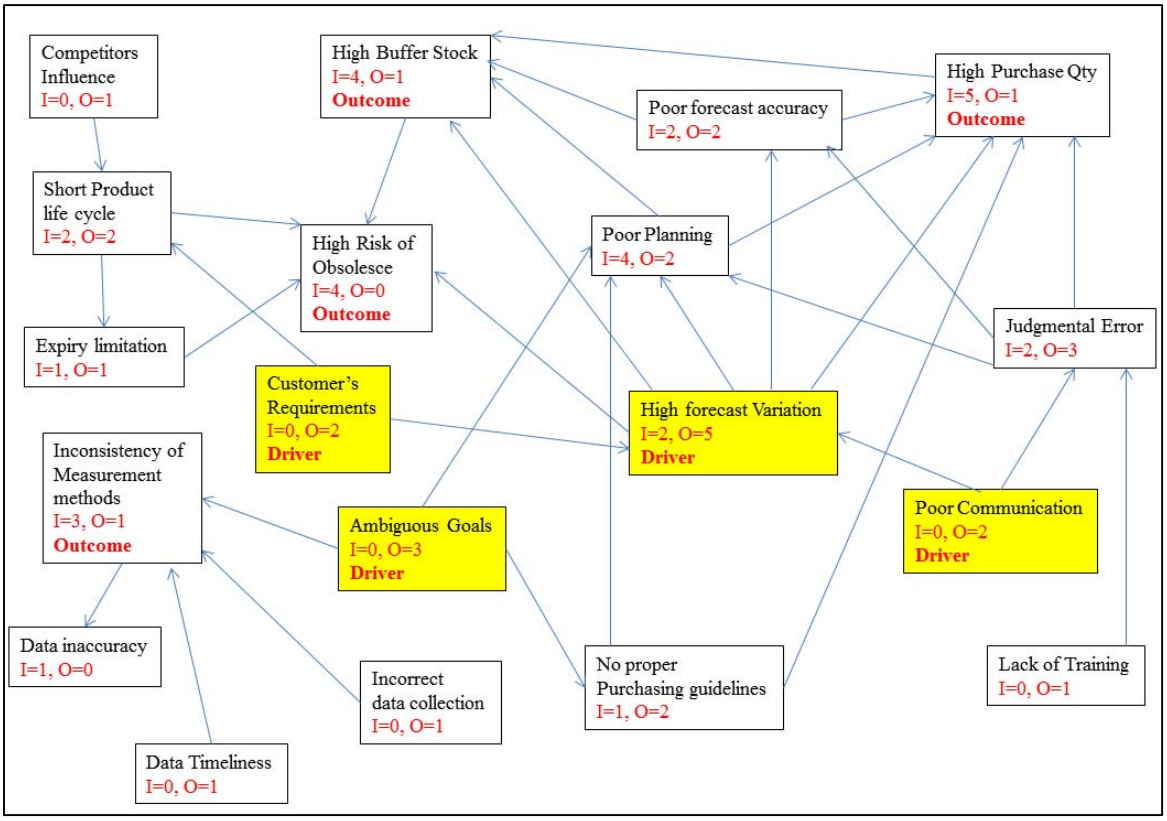

Figure 3: Interrelationship digraph of causal factors

The drivers (root causes) for these outcomes were identified as volatile customer's requirement, high forecast variation, ambiguous goals and poor communication.

- *Root cause #1 Customer's requirements*: Increasing speed of innovation and shortened product life cycles have contributed to high demand volatility in the electronics sector. OEMs have to fit the changing market by customising to volatile customer demand. However, such flexibility comes at a cost to the OEM as this often resulted in high forecast variation and liabilities such as stock obsolescence and excess inventory.

- *Root cause #2 High forecast variation*: Over a six-month period, we found that there were variations of about 5% to 106% for each forecast version done by the product manager. This meant that the forecast for the same period varied across every forecast version. As material planning and purchases for LIC cells are dependent on forecast figures, large variations of forecast resulted in excess or shortage of materials.

- *Root cause #3 Ambiguous goals*: The management sets goals and KPIs for each functional department. However, there were situations when objectives and goals were not aligned. For instance, the planners were not clear whether they should cater to additional stock for order fulfilment or reduce inventory level. Therefore, ambiguous goals led to inconsistency of measurement methods, poor planning and no proper purchasing guidelines.

- *Root cause #4 Poor communication*: Two types of communication were identified in our observations: internal and external communication. Poor internal communication occurred when information did not flow across functional departments in a timely manner. Poor external communication occurred when sales personnel did not communicate frequently to obtain latest updates from customers. Both led to poor judgment in decision making and contributed to high forecast variations.

Possible solutions to reduce excess inventory

After the root causes were identified, another brainstorming session was conducted with the OEM's planners to gather ideas on possible solutions to reduce excess inventory. Table 1 summarises the improvement ideas that were generated.

Root Causes	Description	Possible Improvement solutions
1. Customer's Requirements	- Frequent changes in customer's requirements. - Root cause for short product life cycle and high forecast variation.	#1. Establish close communications with customer through bi-weekly meetings #2. Adopt long term liability contracts with customer
2. High Forecast Variation	- Variation between 5% - 106% for each forecast version - Root cause for high buffer stock, high purchase quantity, poor forecast accuracy, high risk of obsolesce and poor planning.	#3. Establish matrix for demand planning #4. Establish weekly sales and operations meeting #5. Adopt forecasting system #6. Adopt Collaborative planning, forecasting and replenishment (CPFR)
3. Ambiguous Goals	- Unclear management objectives and goals. For example, what to measure and what is the priority? - Root cause for inconsistency of measurement methods, poor planning, no proper purchasing guidelines	#7. Top management to review and re-establish corporate goals and guidelines #8. Establish bottom up feedback system #9. Adopt Visual Management
4. Poor Communication	- Poor internal and external communication. - Root cause for judgmental error and high forecast variation	#10. Internal communication: Top management to re-establish and control information flow between functional departments - External communication: Same as idea #1

Table 1: Summary of root causes and possible solutions

Figure 4 shows the impact/effort matrix to assist in prioritising the improvement solutions that could mitigate the excess inventory problem at this OEM. Solutions within quadrant 1 were the 'quick wins' which yield the highest impact with the least amount of effort. The remaining solutions within quadrant 2 were 'major projects' which required further study.

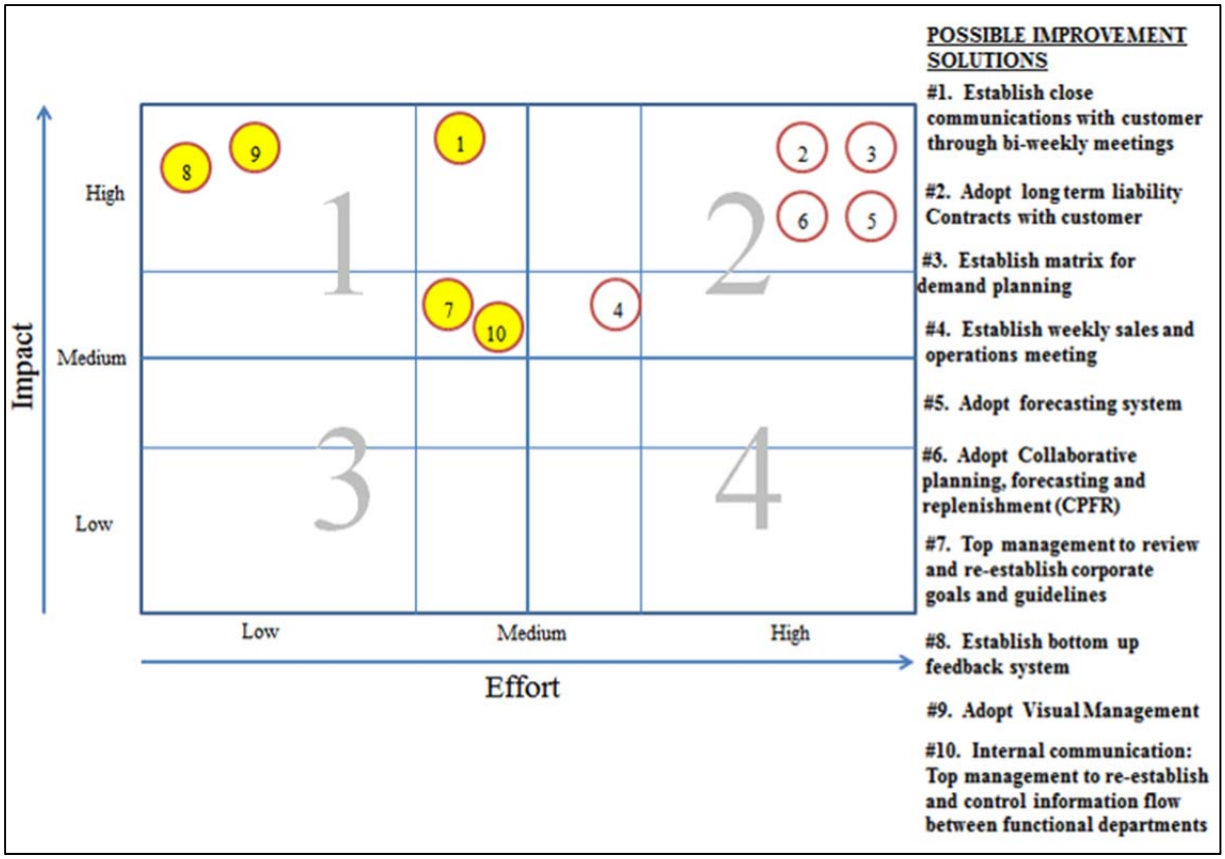

Figure 4: Impact/effort matrix for possible solutions

The following solutions were considered Priority 1 High Impact-Low Effort:

- *Solution #8 Establish bottom-up feedback system*: This solution is the easiest to implement and yields the highest impact. Establishing a bottom-up feedback system allows employees to request for information regarding the company's goals and to seek clarity on potential issues quickly, e.g. when the planner is not sure if keeping additional stock for order fulfilment or lean inventory is more important. The company's web-based intranet can serve as a platform for employees to submit their feedback to the management for review.

- *Solution #9 Adopt visual management*: Visual tools "provide quick and effective controls as it is easy to understand by employees" (Myerson, 2012) as demonstrated by the success of Fujitsu's lean project. Management can use visual management tools to develop control charts and encourage prompt action from employees. For example, order fulfilment, forecast and inventory level charts can be updated on a daily or weekly basis and displayed at a visible place for all employees. This allows all employees to be very clear of the management goals and whether they are performing in accordance to the management's objectives.

The following solution was considered Priority 2 High Impact-Medium Effort:

- *Solution #1 Establish close communications with customers through bi-weekly meetings*: This solution aims to keep the company abreast of customers' requirements and plans that affect the company's product lifecycle and demand forecast. It requires minimal to medium effort to gather cooperation from customers and sales personnel for bi-weekly meetings. The OEM can gather the voice of the customer (VOC) and understand customers' requirements in order to take timely actions. VOC was the basis to align Fujitsu's lean objectives to customer's needs. VOC can also allow the OEM to ensure customers' interests are not affected while the company attempts to reduce excess inventory.

The following solutions were considered Priority 3 Medium Impact-Medium Effort:

- *Solution #7 Top Management to review and re-establish corporate goals and guidelines*: Setting clear directions and aligning strategies with corporate goals can enable the company to keep up with the competition as well as eliminate and improve non-value added processes. Such a performance excellence process backed by strong management support contributed to the success of Xerox's lean six sigma projects. For instance, the OEM can identify the key customers for order fulfilment so that the planner can cater for additional stock to ensure no stockout situations for these customers.

- *Solution #10 Internal communication - Top management to re-establish and control information flow between functional departments*: Poor internal communication exists when information does not flow timely across the different functional departments. This can be due to a silo mentality where functional departments are either unwilling to share information with other departments or they forget to circulate the information. Top management can establish monthly meetings with the mid-management team to drive the importance of information sharing and resolve possible conflicts between departments. Improved communications can reduce the impact of forecast variations as actions can be taken in advance.

Conclusions and Recommendations

The purpose of this study was to underscore how a leading Original Equipment Manufacturer (OEM) of batteries can make use of Lean Six Sigma's DMAIC (Define-Measure-Analyse-Improve-Control) approach to address issues related to excess inventory and stock obsolescence. The case study focused on the 'Analyse' and 'Improve' phases of the DMAIC approach. Quantitative and qualitative data were extracted from the OEM for analysis.

We identified the item category with the highest impact to overall inventory through a scoring system based on two weighted decision variables - level of excess stock and stock value. The result from the evaluation of the total score revealed LIC cell category as the one with the highest impact on inventory with a stock coverage of 8,307 days and contributed to 60% of overall inventory value. Drawing from this finding, we focused on reducing excess inventory of the LIC cell category so as to achieve greater result on the overall inventory value.

An analysis of root causes was performed specifically for the LIC cell category. The cause-and-effect diagram identified 19 causal factors grouped into six categories. These factors were further analysed by establishing the interrelationship diagraph between the factors. By doing so, we identified four root causes of excess stock situation of LIC cell category: (i) customer's requirements, (ii) high forecast variation, (iii) ambiguous goals, and (iv) poor communication.

We recommended strategies to establish an improved inventory management and control system for the long run. The impact/effort matrix was used to determine the best improvement solutions to prioritise for implementation. The matrix identified five 'quick-win' solutions: (i) establish bottom-up feedback system, (ii) adopt visual management, (iii) establish close communications with customers through bi-weekly meetings, (iv) top management to review and re-establish corporate goals and guidelines, and (v) top management to re-establish and control information flow between functional departments.

Overall, the findings from the study can serve as a guide on the techniques that can be applied to a high-mix low-volume manufacturing setting to reduce excess stocks and improve operating cost in the long run.

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SOUTH FLORIDA PORTS - THE BATTLE FOR THE SEA IS WON INLAND?

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Introduction

Capacity increase only at ports facilities without improvements in ports' inland access is not enough for the entire container transport chain to function properly since sea flow generates almost proportional inland flow (Parola and Sciomachen, 2005). While bigger vessels help carriers to reduce voyage cost, these saving are increasingly outweighed by higher port and landside costs (WCN, 2016a). With constantly growing container transports, efficiency of rail and flexibility of road are increasingly needed for inland access to/from the ports. Competition requires ports to focus on their inland access (Roso et al, 2015; Rodrigue et al, 2010) on the demand for services in its traditional hinterland (Bask et al, 2014, Andersson et al, 2016) and also on development in areas outside their immediate market (Rodrigue et al, 2010). Many container ports around the world are involved in implementation and/or development of inland intermodal terminals/dry ports/inland ports to improve their inland access in order to increase their competitive advantage but also to increase the terminal capacity and consequently productivity. Such developments have been observed in China (Beresford et al., 2012), Australia and New Zealand (Roso, 2013), India (Ng and Gujar, 2009), the United States (Rodrigue et al, 2010, Roso et al., 2015), Asia (Hanaoka and Regmi, 2011), Russia (Korovyakovsky and Panova, 2011), and Europe (Flämig and Hesse, 2011; Henttu and Hilmola, 2011; Monios, 2011, Bask et al, 2014).

However, container ports in South Florida: Port Miami, Port Everglades and Port of Palm Beach keep their container volumes stable or slightly increase without particular engagement in development of their inland access or hinterland expansion. Therefore, the purpose of this paper is to explore why these seaports are not involved in implementation or don't have any particular collaboration with inland ports while many other ports around the world have to work on inland access through collaboration with inland intermodal terminals.

Research approach

For the purpose of this study an extensive analysis of relevant literature was conducted as well as face-to-face semi-structured interviews with relevant actors of the seaports management. Literature related to intermodal transportation, container seaports, and inland intermodal terminals/dry ports/inland ports were reviewed. In accordance with recommendations by Stuart et al. (2002) and given the exploratory nature of the study, semi-structured interviews were chosen to explore the issues as the same allowed the interviewees to introduce new issues and the interviewer to follow up topics more fully. The interviewees were given in advance a checklist of issues/question that were planed to be discussed during the interviews. Face-to-face interviews were conducted with managers of three seaports in the south of Florida: Port of Miami, Port Everglades and Port of Palm Beach. These ports have been chosen geographically, i.e. all three are situated very close to each other (less than 100km in between) in south Florida; and all handle containers, more than 100.000TEU a year.

In order to insure validity, the triangulation with multiple means of data collection has been used (Stuart et al. 2002). Apart from having face-to-face interviews and site visits at seaports' terminals, secondary data were drawn from internal company reports, newspaper articles, presentations,

reports, and websites. Some additional e-mail correspondence was also conducted in order to clarify and fill the gaps in data as well as to validate the findings from the interviews.

Seaport inland access and inland ports

The ownership and management of ports shift from dominance of publicly owned and operated ports to a "landlord" port model in which port authorities cede control of the business of port operations to private firms (Roso et al. 2015). The separation of port authority and service provision increases port efficiency and enhances service qualities as competition among multiple service providers within a port is introduced (Van Reeven 2010). Seaports as important nodes in the transport chain have replaced their earlier narrow focus on cargo handling with a wide range of logistic activities, giving them a more active role. There has been a trend in organizational and technological changes towards offering door-to-door transport solutions rather than port-to-port (Paixão and Marlow 2003). This trend has enlarged the seaports' hinterland and therefore created a competition among neighboring seaports. That competition requires from the seaports to focus not only on improvements within the seaport area but also on their inland access via functional inland intermodal terminals. The emergence of inland intermodal terminals connected to seaports took place in several regions around the world and yet there is no definitive consensus on how such facilities should be labeled, with terms such as dry port being advocated (Rodrigue et al, 2010). A dry port is an inland intermodal terminal directly connected to seaport(s) by rail, where customers can leave/pick up their standardized units, as if directly at/from the seaport (Roso et al, 2009). A dry port also offers transshipment services, as any conventional inland intermodal terminal does, and the value-added services such as storage, consolidation, depot, track and trace, maintenance of containers, and customs clearance that are usually available at seaports (Roso et al, 2009) and as such emphasizes higher level of integration with seaports, i.e. movement of seaport's interface inland. In this paper term inland port for the facility having dry port characteristics will be used, as the one is more common and therefore more appropriate in North America. Inland ports are planned, set and operated by wide variety of actors ranging from public to private interest (Rodrigue et al, 2010). Inland ports that have a higher level of integration with the seaport have a higher chance of success, simply because of integration or lack of competition between them (Roso, 2013).

According to Roso (2013) implementation of an inland port brings a competitive advantage to the seaport since it expands the seaport's hinterland, i.e., it improves the seaport's access to areas outside its traditional hinterland by offering shippers low-cost and/or high-quality services, such as e.g. New Zealand's case of Tauranga's inland port. The implementation of the dry port is not the only factor in relieving seaport congestion (Henttu and Hilmola, 2011) or improving seaport inland access (Hanaoka and Regmi, 2011); however, it is a significant component in improving seaport productivity. With dry port implementation CO2 emissions should decrease (Henttu and Hilmola, 2011; Roso, 2013), congestion at seaport terminals and seaport city roads should be avoided, and the risk of road accidents reduced (Roso et al, 2009). Besides these general benefits to the environment due to shift from road to rail, inland ports mostly offer seaports a possibility to increase the throughput without physical expansion at the site (Roso et al, 2009). Furthermore, market-driven Outside-In development of inland intermodal terminals (dry ports) that generates higher level of integration with the seaports has been seen as very successful and very likely contributing to viability of rail on short distances Roso (2013).

South Florida Ports

The State of Florida, a peninsula located in the south-eastern corner of the US and only 90 miles from the island of Cuba, covers a total area of 58,560 square miles and has an estimated population of 19 million (Florida Chamber Foundation, 2013). Its twelve international airports are a major gateway for visitors and air cargo from the Caribbean and Latin America. Forty percent of all US exports to Latin and South America pass through the State. A total of $132 billion in two-way trade to 225 trading partners took place at Florida ports in 2013. With 60,000 exporting businesses, Florida businesses account for one in five US exporters (ibid). Despite the number of small exporters, a large consumer

market, and a tourism industry that attracted 87 million visitors in 2011, the State has a relatively small manufacturing sector and has been a net importer of freight (Florida Chamber Foundation, 2013; State of Florida, 2016).

While the State of Florida currently has 14 deep-water ports, most are not natural. An extensive continental shelf and a system of barrier islands and reefs, particularly in the southern part of the state, limited access. A hurricane in 1835 opened up a small natural waterway in the barrier islands around Biscayne Bay allowing access to Miami. Although a channel into Miami was built in 1912, the port itself was not established until 1960. Port Everglades was opened three decades earlier (1927) after the removal of a rocky barrier and blasting to create a suitable basin for the harbour and is currently the deepest United States port south of Norfolk, Virginia. It became the State's first Foreign-Trade Zone in the 1970s. The Port of Palm Beach was established in 1935 but saw only limited cruise ship activity until the 1950s when efforts were made to establish freight service to Cuba (Kaye, 2015, Port Everglades, 2016)

Recognizing the potential impact of the expansion of the Panama Canal, a shift in US growth to the Southeast, and the potential opening of trade with Cuba, the State of Florida began to invest in strategic transportation projects to position the state as a global hub for trade and investment. The State of Florida ranked number one in container traffic among nine southern states in 1990, however, two decades of growth in the states of Georgia, Texas, Virginia, and the Carolinas has outpaced Florida with the State of Georgia alone increasing its market share by 11.4% over this period. To answer these challenges, the FDOT (2010a) with the Florida Seaport System Plan called for the development of at least one seaport with 50 feet of water and on-dock rail, expanded capacity at seaports to serve containers, break-bulk, and bulk markets, improved landside connectivity including the development of high-capacity long-distance rail and truck corridors, and expanded distribution centre capacity. Ten Florida ports handle container traffic with the top four ports being Miami, Everglades, Jacksonville, and Palm Beach. Of these ports, Miami, Everglades, and Jacksonville are considered to be major cargo gateway ports.

The Florida rail system is comprised of 2,786 miles of mainline track that is owned by 15 operating line-haul railroads. These include two Class 1 railroads (CSX Transportation and Norfolk Southern Corporation and one Class II railroad (Florida East Coast Railway (FECR)). CSX and Norfolk serve the Eastern US and connect Florida to the national rail network. CSX is the largest operating railroad in the Florida with an extensive rail network in the Panhandle, and Northern and Central Florida. Norfolk does not have an extensive network in Florida, but they do have a haulage agreement with FECR between Miami and Jacksonville. FECR owns 386 miles of track along the Eastern coast of Florida, making it the second largest network in Florida. FECR provides exclusive rail service to the Ports of Palm Beach, Everglades, and Miami (FDOT, 2010b).

The State of Florida has identified eight locations for inland ports. These are Americas Gateway Logistics Center, Central Florida Intermodal Logistics Center, Southwest Florida Intermodal Logistics Center, South Florida Intermodal Logistics Center (Belle Glade), South Florida Logistics Center (Coral Gables), North Florida Intermodal Park, Crawford Diamond Industrial Center, and the US Sugar and Hilliard Bros Airglades Airport (Garcia, 2014). In South Florida, the key inland ports open and/or in development are South Florida Logistics Center, Americas Gateway, US Sugar, and Airglades. Flagler Global Logistics (South Florida Logistics Center) was founded in 1892 by Henry Flagler and located just south of the Port of Miami in the City of Coral Gables. It provides warehousing, consolidation/deconsolidation, refrigerated cargo, and Foreign Trade Zone services as well as links to FEC and other transportation (Flagler Global Logistics, 2016). Four developing inland ports – Airglades, Americas Gateway, South Florida Intermodal Logistics Center, and US Sugar – are located on the Southern shore of Lake Okeechobee These facilities are roughly 109 miles north of Miami Beach and 70 miles due west from Palm Beach.

Port Miami

Port Miami stands as US container port closest to the Panama Canal and in year 2015 handled 1,007,782 TEU mostly from Latin America and the Caribbean (Port Miami, 2016). The landlord port on 520 acres leases agreements with cargo terminal operators: Seaboard Marine, POMTOC and SFCT (ibid). The port handles wide range of cargo such as waste, machinery and textiles, which are top 3 export commodities; and apparel, furniture and fruit/vegetables, which are top 3 import commodities. Imports and exports are very balanced, 51 and 49% respectively.

The Port is a point of entry/departure for cargo and relies on its connections with other intermodal facilities such as the Miami International Airport (MIA), the FEC Hialeah Intermodal Facility, and the West Dade trade-related, freight forwarding and consolidation warehouses (Port Miami, 2016). At the port, landside access has been improved through the Port of Miami Tunnel that feeds truck traffic directly into the major interstate highway; and the Intermodal and Rail Service reconnection project - the port has on-dock rail (9,000 ft. of tracks on 3 sidings) which links the container terminals to national rail system that connects the port to 70% of the U.S. population in four days or less (Port Miami, 2016). However, only 10-12% of the total container volumes are transported by rail to/from the port. Additional dredging has deepened the port to 50 feet to prepare for Panama Canal opening and arrival of 14,000 TEU vessels. The U.S. Department of Commerce has granted Miami-Dade County the authority to establish Foreign Trade Zone No.281 that should expedite and encourage foreign trade commerce (Port Miami, 2016).

Port Everglades

The port currently leases 85% of its 500 acres of land area to various private entities for cargo and cruise services. Largest of the three ports; with almost 24 million tons of cargo: bulk, break bulk, petroleum and containerized, moved through Port Everglades in 2014 when the port also broke the one million TEU mark ranking it as the 11th leading container port in the United States and the top port in Florida, serving more than 150 ports and 70 countries (Port Everglades, 2015). The port handled 1,060,507 TEUs in year 2015 and kept its first container port in Florida position (ibid). The port is conveniently located just across from the international airport that brings additional cargo and cruise passengers but also limits the stacking of container for safety reasons. Dredging at Port Everglades has upgraded the channel, turning basin, and berthing while near-dock intermodal container transfer and highway and rail access has improved connectivity. The port has 12 container terminal operators handling fruit, vegetables, automobiles and apparel mostly to and from Central America, the Caribbean, South America, Europe and even the Far East. Export and imports are rather balanced, roughly 40 and 60 percent respectively.

FECR has completed 42.5-acre near-dock intermodal container transfer facility that transfers international and domestic containers between ship and rail (Port Everglades, 2015), which currently are approx. 10-15% of the total container volumes handled. The ICTF should reduce congestion on interstate highways and local roadways and reduce air emissions by diverting an estimated 180,000 trucks from the roads by the year 2027 (ibid). Furthermore the port is in the process of adding five new cargo berths and five new Super-Post Panamax cranes, along with dredging it main channel from 42 to 50 feet by 2017 (Port Everglades, 2015).

Port of Palm Beach

The landlord port provides cargo and cruise service to 30 tenants on its 162 acres of land; Tropical Shipping is a major container operator at the port and major carrier in the Caribbean (Port of Palme Beach, 2015). The 25th busiest container port in US is unique with its 650 000 tones a year of raw sugar moved by short-sea shipping to Baltimore, Maryland and NY (Ports&Harbour, 2014). In 2015 the port handled 271,277 TEUs; predominantly export about 80% and primarily destined to Caribbean (Port of Palme Beach, 2015). Cargo movement is facilitated through easy access to Interstate 95 and five miles long port-owned on-dock rail that connects directly to the FECR moving approx. 30,000 TEU by rail to and from the port. The port considers it non-union labor force as an advantage over

neighboring ports. The Port is an efficient container port,, but constrained by channel and berth issues as well as limited land availability (Florida department of Transportation, 2010). The Port's Master Plan calls for additional dredging, cooperation with the FECR and CSX, development of Intermodal Logistics Centers and improved highway links (CH2M Hill & Martin Associates, 2013). The Port, although small compared to the neighbors, recognized the need for expansion and proposed developing a local inland port in the past. The idea was well received and the Port, along with the Florida Department of Transportation worked on study to determine the optimal location but the project failed.

The battle for the sea is won inland, is it indeed?

Functional inland access to seaports is an important decision making factor in the development strategies of seaports; as well as a significant factor that affects shipping companies' port choice. A seaport's natural or immediate hinterland is no longer defined only by geographical distance but by competition with other seaports, i.e. by the quality of the service at the seaport terminals as well as at their inland facilities (Roso, 2013), in other words, for many seaports the battle for the sea is won inland. All three South Florida ports are conveniently located with easy access to Florida's interstate and highway systems and therefore manage container truck deliveries/pick ups without big delays or massive congestion problems. In particular Miami solved, at least temporarily, congestion problems with the road tunnel. And, all three have on or near-dock rail access that is used to move containers to/from the seaports but insufficiently, the potential is much bigger and needs to be released.

In 2015 Port Everglades topped its record in container trade; Port Miami hit new highs in cargo, while business at Port of Palm Beach was mainly flat. Port Everglades, for example, handled 5% more containers in fiscal 2015 than a year earlier mostly due to a new near-dock intermodal container transfer facility that encourages delivery of cargo that can be quickly and economically sent by rail to inland destinations north. To compare, Charleston Port recorded 14% growth and handled 1,9 million TEU in 2015 (SCP, 2016) mostly due to its inland port. The South Carolina Inland Port (SCIP) at Greer opened in 2013 is aimed at extending the Port of Charleston's hinterland; SCIP is situated 212miles from the port and is linked to the port by the Norfolk Southern main rail line that provides overnight double-stack container train service between Charleston and the Upstate (WCN; 2013). The initial capacity of the facility was around 40,000 containers/year but the port already realized that the facility could handle as many as 100,000 containers/year within few years (ibid). The success of this inland port encouraged the port to build a second such intermodal facility, at Dillon, but also demand for enhanced efficiency of international container movements between the Port of Charleston and growing markets in South and North Carolina (WCN, 2016b). Further comparison to Port of Savannah, the busiest container export port on East cost that has access to The Cordele Inland Port (Georgia Port Authority, 2016). The inland port also called The Inland Gateway offers a direct 200-mile rail route to the Port of Savannah container terminal Garden City Terminal with the goal to create and expand international markets (ibid). All three South Florida ports, particularly Miami, are relatively new and because of their location they have historically been ports of entry for Latin America and due to the location have taken these volumes for granted. While they were leading ports in 1990 (and have continued to post growth as container traffic has exploded), the ports north of them in Georgia, Virginia, and the Carolinas who have been strategic in their development of ports and inland ports have grown faster and overtaken them.

At least 15 port services can be carried out at inland ports and freed the space at ports and to add value to the business equation for shippers; such as e.g. storage, customs clearance, container cleaning, container repairs, inspection, quarantine, stripping and stuffing, empty container depots (Roso et al, 2015). Both Port Miami and Port Everglades state that ports can not fund inland ports without increase in container volumes; i.e. crucial is to have a single cargo mass or client to make such enterprise commercially viable. Furthermore, Port Miami asserts that federal funding support is important for such development. Nevertheless ssuccessful examples of inland ports implementation are evident already in South Carolina for Charleston port without Federal funding; South Carolina Port

Authority funded the project (SCA, 2016). Furthermore, around 23% of the total container volumes were transported by rail to/from the Charleston in 2015, which is almost as double as Miami and Everglades combined; intermodal volume has increases for 166% since 2011 showing a strong need for additional inland port facilities (WCN, 2016b). Increase in intermodal volumes and demand for shift from road to rail has been seen generally and the latest request from The National Industrial Transportation League that has reiterated its demand for open access on US railroads shows (WCN, 2016c), among others, the need for more goods on the rail.

Neighbouring ports are usually thought of as rivals but often there is a scope for cooperation too such as in a way that South Florida ports all strive to bring volumes and trade to Florida. However, Port Everglades operator King Ocean consolidated several Eastern Caribbean services that were previously calling at Miami, indicating some sort of competition; these services are anticipated to generate approximately 30,000 TEU/year additionally (Port Everglades, 2015). Port Miami weaknesses are the egress/ingress to the port, reputation for poor service, and the adversity for people to drive into the port (PPB ref). Nevertheless, Port Miami claims to be "Big ship ready!" since they've acquired 6 Post-Panamax cranes and deep dredged to -50 feet (Trade Numbers, 2015). Those features are crucial for Post-Panamax vessels to call at the seaport but not enough; improvements only in the maritime part of the transport sector are not enough for the entire transport chain to function properly (Roso et.al. 2015). Big ships, big problems! Introduction of big ships is good business for the shipping line with reduction of unit costs, but overall supply chain cost are increasing (WCN, 2016a). Lloyd's List reported that despite being theoretically able to handle ships of up to 14,000 TEU, the expanded canal is adopting a slowly-slowly approach to taking larger vessels, after changes in the US energy market are currently limiting demand and because ports on the US east coast are not yet ready to take anything much larger than 8,500 TEU (Lloyds loading list, 2016).

Conclusion

Competition usually requires ports to focus on their inland access and many ports tend to expand their hinterland through close links with inland intermodal terminals based on a higher level of functional integration. However between container ports in south Florida there was no hard competition so far, i.e. they all seamed to work on bringing the volumes to Florida from different markets in hinterland and foreland; all three are heavily involved in cruise business, and they had no particular capacity issues at their terminals or heavy congestion at the port gates.

The Panama Canal has linked the Pacific with the Atlantic for more than 100 years and soon it will be possible for significantly larger ships to pass through the canal and it is likely to mean one of the biggest changes for the global shipping industry. It is expected to bring an increase in cargo at ports of Florida's east and Gulf costs; the cargo from new bigger ships that can carry two to three times the container than the ships passing the canal before the expansion. Will the south Florida ports be able to manage those vessels? The challenge facing these ports is to increase their capacity and improve their inland access to meet the demand and to take advantage of increased volumes to compete with other ports. Port Miami has deep dredged to -50 feet and acquired Post-Panamax cranes and Port of Everglades is in the process of dredging it main channel to 50 feet and acquiring Post-Panamax cranes. According to Lloyds loading list (2016) ports on the Florida east coast are not yet ready to take anything much larger than 8,500 TEU. Maybe because capacity increase only at seaport facilities, such as deep channel drafts and appropriate port equipment, without improvements in seaports' inland access are not enough for the entire container transport chain to function properly?

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SUPPLIER SELECTION IN REAL ESTATE INDUSTRY USING FUZZY AHP AND FUZZY TOPSIS: A CASE STUDY IN THAILAND

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Introduction

Supplier selection is the process by which firms identify, evaluate, and contract with suppliers. The supplier selection process deploys a tremendous amount of a firm's financial resources. In return, firms expect significant benefits from contracting with suppliers offering high value. For this reason, the company will purchase the construction materials from the material suppliers they selected in order to ensure the building quality and cost control. The cost of the construction project could be broadly divided into three major groups, namely: materials, labor, and overhead. The materials can typically account for around 40% to 45% of the total cost in the construction industry. In addition, the labor cost in the construction industry is generally governed by the availability of workers within the proximity, only the construction materials can provide the greatest flexibility in seeking the lower cost for the construction companies. Therefore, an effective and efficient material supplier selection model which can help the company to select the "best" suppliers at the right cost, in the right quantity, with the right quality at the right time has a significant effect on the business success of real estate industry. The research on the supplier selection has a historical record. It is basically a multiple criteria decision making (MCDM) problem, which consists of three major stages: evaluation, prioritization, and selection of alternatives. This study aims to provide a user-friendly supplier selection model for real estate industry to select their best material suppliers effectively and efficiently. Supplier selection it is also possible to anticipate evaluation of the potential of suppliers to establish a collaborative relationship. Supplier selection is a decision process with the aim of reducing the initial set of potential supplier to the final choice, decision are based on evaluation of supplier on multiple quantitative as well as qualitative criteria.

Literature

Fuzzy set theory

Fuzzy set theory has been used for modelling decision-making processes based on imprecise and vague information such as the judgment of decision makers. Qualitative aspects are represented by means of linguistic variables, which are expressed qualitatively by linguistic terms and quantitatively by a Fuzzy set in the universe of discourse and respective membership function. Fuzzy set theory combined with multi-criteria decision making (MCDM) methods has been extensively used to deal with uncertainty in the supplier selection decision process, since it provides a suitable language to handle imprecise criteria, being able to integrate the analysis of qualitative and quantitative factors. The axiomatic bases of fuzzy set theory are manifold. We shall concentrate on the elements of the theory itself

Definition 1 If X is a collection of objects denoted generically by x, then a fuzzy set A in X is a set of ordered pairs:

$$A = (x, \mu_A(x) | x \in X) \quad (1)$$

Definition 2 A type m fuzzy set is a fuzzy set whose membership values are type m − 1, m > 1, fuzzy sets on [0, 1].

Definition 3 A probabilistic set A to X is defined by defining function $\boldsymbol{\mu_A}$,

$\boldsymbol{\mu_A}$: X × $\boldsymbol{\Omega}$ ∋(x, ω) →$\boldsymbol{\mu_A}$ (x, ω) ∈ $\boldsymbol{\Omega_C}$ (2)

and ($\boldsymbol{\Omega_C}$, $\boldsymbol{B_C}$) = [0, 1] are Borel sets.

Definition 4 A linguistic variable 2 is characterized by a quintuple (x,T(x),U,G, ˜M), in which x is the name of the variable, T(x) (or simply T) denotes the term set of x, that is, the set of names of linguistic values of x. Each of these values is a fuzzy variable, denoted generically by X and ranging over a universe of discourse $\boldsymbol{\mu}$, which is associated with the base variable u; G is a syntactic rule (which usually has the form of a grammar) for generating the name, X, of values of x. M is a semantic rule for associating with each X its meaning. M(X) is a fuzzy subset of U. A particular X, that is, a name generated by G, is called a term.

Definition 5 A fuzzy number M is a convex normalized fuzzy set M of the real line R such that

1. It exists exactly one $\mathbf{X_0}$ ∈ R $\boldsymbol{\mu_M}$ ($\mathbf{X_0}$) = 1 (x0 is called the mean value of M).

2. $\boldsymbol{\mu_M}$ (x) is piecewise continuous.

Definition 6 A fuzzy number ˜M is of LR-type if there exist reference functions L (for left) and R (for right), and scalars α > 0, β > 0, with

$\boldsymbol{\mu_M}$ (x) = L $\left(\frac{\boldsymbol{m-x}}{\boldsymbol{\alpha}}\right)$ for x ≤ m (3)

= R $\left(\frac{\boldsymbol{m-x}}{\boldsymbol{\beta}}\right)$ for x ≤ m = R (4)

Definition 7 The support of a fuzzy set A, S(A) is the crisp set of all x ∈ X such that $\boldsymbol{\mu_A}$ (x) > 0

The (crisp) set of elements that belong to the fuzzy set ˜A at least to the degree α is called the α-level set:

$\boldsymbol{A_\alpha}$ = {x ∈ X|$\boldsymbol{\mu_A}$≥ α} (5)

$\boldsymbol{A'_\alpha}$ = {x ∈ X|$\boldsymbol{\mu_A}$≥ α} is called strong α-level set or strong α-cut.

Definition 8 A fuzzy set ˜A is convex if

$\boldsymbol{\mu_A}$ (λ$\boldsymbol{x_1}$+ (1 − λ) $\boldsymbol{x_2}$) ≥ min {$\boldsymbol{\mu_A}$ ($\boldsymbol{x_1}$), $\boldsymbol{\mu_A}$ ($\boldsymbol{x_2}$)}, $\boldsymbol{x_1}$, $\boldsymbol{x_2}$ ∈ X, λ ∈ [0, 1]. (6)

Definition 9 For a finite fuzzy set A, the cardinality |A| is defined as

|A|= $\sum_{x\in X} \boldsymbol{\mu_A}$ (x) (7)

||A|| = $\frac{|\boldsymbol{A}|}{|\boldsymbol{X}|}$ is called the relative cardinality of A

Triangular Fuzzy Numbers (TFN)

Practices for the property developers, a supplier selection process involves indistinct needs and vague preferences such as reputation, relationship, etc. Such subjective, imprecise and uncertain information need to be translated into quantitative data for decision making. Fuzzy sets, which were first introduced by Zadeh, are one of the widely used methods to solve this kind of problem. It is specially designed to mathematically represent uncertainty and vagueness and provides formalized tools for dealing with the imprecise and intrinsic factors to many decision problems. In this study, one of the most widely used fuzzy set, i.e. triangular fuzzy set is employed to quantify the qualitative information. As a result, all the fuzzy variables are represented as Triangular Fuzzy Numbers A. The reason of using TFN method is because of its intuitive, easy to use, computational simplicity, useful in promoting representation and information processing in a fuzzy environment. According to Lam et al.

Fuzzy TOPSIS

This research is the case of Fuzzy AHP (Fuzzy Analytic Hierarchy Process), Fuzzy TOPSIS (Fuzzy Technique for Order Preference by Similarity to Ideal Solution). The Fuzzy TOPSIS method was proposed by Chen to solve multiple criteria decision-making problems under uncertainty. Linguistic variables are used by the decision makers. Define the ranking of the alternatives according to the closeness coefficient, CCi, in decreasing order. The best alternative is closest to the FPIS and farthest to the FNIS. Evaluations of the weight of the criteria and the ratings of the alternatives were made by the decision makers, according to the linguistic terms. Based on Chen, triangular fuzzy numbers (TFN) were used to specify the linguistic values of these variables.

In this study, all the qualitative information, i.e. the importance weights of decision makers and the ratings assigning to the candidates by of decision makers in accordance with the subjective criteria should be firstly decided. For the weighting, the five-point-scale can be defined as: Of little importance (VL), Moderately important (MI), Important (I), Very important (VI), Absolutely important (AI). For the rating, the five-point-scale can be defined as: Very Low (VL), Low (L), Medium (MI), High (H), and Excellent (EX), as presented in Table 1 and Table 2.

Linguistic terms	**Fuzzy triangular number**
Of little importance (VL)	(0.0, 0.0, 0.25)
Moderately important (MI)	(0.0, 0.25, 0.50)
Important (I)	(0.25, 0.50, 0.75)
Very important (VI)	(0.50, 0.75, 1.0)
Absolutely important (AI)	(0.75, 1.0, 1.0)

Table 1: Linguistic scale to evaluate the weight of the criteria.

Linguistic terms	**Fuzzy triangular number**
Very low (VL)	(0.0, 0.0, 2.5)
Low (L)	(0.0, 2.5, 5.0)
Good (G)	(2.5, 5.0, 7.5)
High (H)	(5.0, 7.5, 10.0)
Excellent (EX)	(7.5, 10.0, 10.0)

Table 2: Linguistic scale to evaluate the ratings of the alternative suppliers.

Linguistic judgments of the weights of the criteria and the ratings of the alternatives for the three decision makers involved in the selection process. The linguistic variables are converted into TFN. The parameters of the TFN resulting from the aggregation of the judgments, which represents the fuzzy decision matrix. Linguistic ratings of the alternative suppliers by different decision makers.

According to Chen, the Fuzzy Positive Ideal Solution (FPIS, A+) and the Fuzzy Negative Ideal Solution (FNIS, A−) were defined as

$$A+=\{v_1^+, v_j^+, \ldots, v_m^+\} \quad (8)$$

$$A-=\{v_1^-, v_j^-, \ldots, v_m^-\} \quad (9)$$

where $v_j^+=(1,1,1)$ and $v_j^-=(0,0,0)$.

The distances source of the ratings of each alternative from A+ and A–, calculated according to

$$d_i^+ = \sum_{j=1}^{n} d_v(v_{ij}, v_j^+) \quad (10)$$

$$d_i^- = \sum_{j=1}^{n} d_v(v_{ij}, v_j^-) \quad (11)$$

where d(.,.) represents the distance between two fuzzy numbers according to the vertex method. For triangular fuzzy numbers

Compute the closeness coefficient, CC_i, according to Eq. (12).

$$CC_i = \frac{d_i^-}{d_i^+ + d_i^-} \quad (12)$$

Fuzzy AHP

Chang 1996 proposed a Fuzzy AHP approach based on the extent analysis method, which is widely used in supplier selection problems. This method uses linguistic variables to express the comparative judgments given by decision makers. In the method proposed by Chang, each object, xi, is taken and extensive analysis is performed for each goal. Thus, extent analysis values for each object can be obtained. Compute the value of the fuzzy synthetic extent with respect to the i object according to

$$S_i = \sum_{j=1}^{m} M_{gi}^i \otimes \left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^i\right]^{-1} \quad (13)$$

Compute the vector W′, which is given by

$$W' = (d'(A_1), d'(A_2), \ldots, \mathbf{d}'(A_k))^T \quad (14)$$

assuming that

$$d'(A_I), = \min V(Si \geq Sj), \quad \text{for } i=1,2,..,k,\ j=1,2,\ldots,k,\ k \neq j \quad (15)$$

The normalized vector is indicated by

$$W = (d'(A_1), d'(A_2), \ldots, \mathbf{d}'(A_k))^T \quad (16)$$

where W is a non-fuzzy number calculated for each comparison matrix.

The linguistic terms presented were used by the decision makers to comparatively evaluate the weight of the criteria and the ratings of the alternatives. Following Chang, TFN were used to specify the linguistic values of these variables, as presented in Table 3**.**

Linguistic terms	Fuzzy triangular number
Equally preferable (EQ)	(1.0, 1.0, 3.0)
Slightly preferable (SP)	(1.0, 3.0, 5.0)
Fairly preferable (FP)	(3.0, 5.0, 7.0)
Extremely preferable (XP)	(5.0, 7.0, 9.0)
Absolutely preferable (AP)	(7.0, 9.0, 9.0)

Table 3: Comparative linguistic scale for ratings of alternatives and weights of criteria.

Comparative judgments of the weights of the criteria made by the three decision makers involved already converting into TFN. The results of aggregation of these fuzzy values are presented in and were obtained by the arithmetic mean of the judgments. Likewise, the fuzzy values of the aggregated comparative judgments of the alternative suppliers for each criterion made by the three decision makers.

Case Study

This real estate company has 9 important tasks and 41 main materials. We have group materials for 8 groups based on the material type and same supplier include Piling work process, Pile

Steel, Steel Grating, roof structure, roof material, Cement, Tiles, and Sanitary ware. In this research, we are interested in Piling work process material. In (Weber et al. 1991) the authors present a classification of all the critical published since 1996 a cording to the treated criteria, based on 74 papers, they observe that price, delivery, Quality and Production capacity and Location are the criteria most often treated in the literature. The quality of the selection model's final outcome has largely relied on the criteria it used and the weighting it assigned. Such steps are significant to ensure the selected criteria are critical to the real estate industry. Traditional qualitative measures of performance, such as quality, delivery time or cost, another measure of subjective evaluation. There are several criteria that must be considered in the selection process, both quantitative and qualitative lists some important criteria for supplier selection based on 30 papers, as presented in Table 4. And three expert interviews are a compliment prior to a quantity. The aim of these structured interviews is the viewpoint collector of several criteria, as presented in Table 5.

No.	Criteria	Frequency
1	Price / Material costs	19
2	Delivery / Lead time	16
3	Quality control and standards	16
4	Production Capacity	9
5	IT Software communication sophistication	9
6	Supplier's financial strength	8
7	Performance history	8
8	Communication openness	6
9	Problem solving	6
10	Flexibility	6
11	After Sales Support	6
12	Management and organizational framework	5
13	Reliability	5
14	Price Stability	5
15	Cooperation & Communication	4
16	Technical assistance & Support	4
17	Payment terms	4

Table 4: Importance criteria for supplier selection from literature review.

No.	Criteria
1	Price of the material
2	Quality of the material
3	Delivery of the material
4	Performance History

Table 5: Importance criteria from expert.

The fundamental criteria, which are the basic requirements imposed on the material are defined. In accordance with the literature sources, the price, delivery, quality, and services were the four main categories which were widely and traditionally used as the fundamental criteria in appraising the performance of suppliers. Define the specific selection criteria for the real estate industry. According to the literature sources, some of the specific criteria for the construction industry are summarized, the cost, delivery, and quality which was defined as the fundamental criteria above are also widely used in the construction material supplier selection process According to Ka-Chi Lame

et al. Some of the specific criteria for the construction industry were determined as follows: cost; deliver; quality; payment terms; past performance; reliability; flexibility; and technical characteristics.

We used the above criteria as starting point and literature criteria were further decomposed to sub-criteria to formulate a model able to supplier selection, as presented in Figure 1. Based on the determined selection criteria, the candidate suppliers' performance data (both quantitative and qualitative) are collected. For the quantitative data, e.g. unit price, freight terms, scrap rate, and production volume can be collected from the tender documents or suppliers' information directly. On the contrary, the qualitative data, e.g. reputation, flexibility, relationship, etc. is generated by the subjective judgments given by the Decision-maker

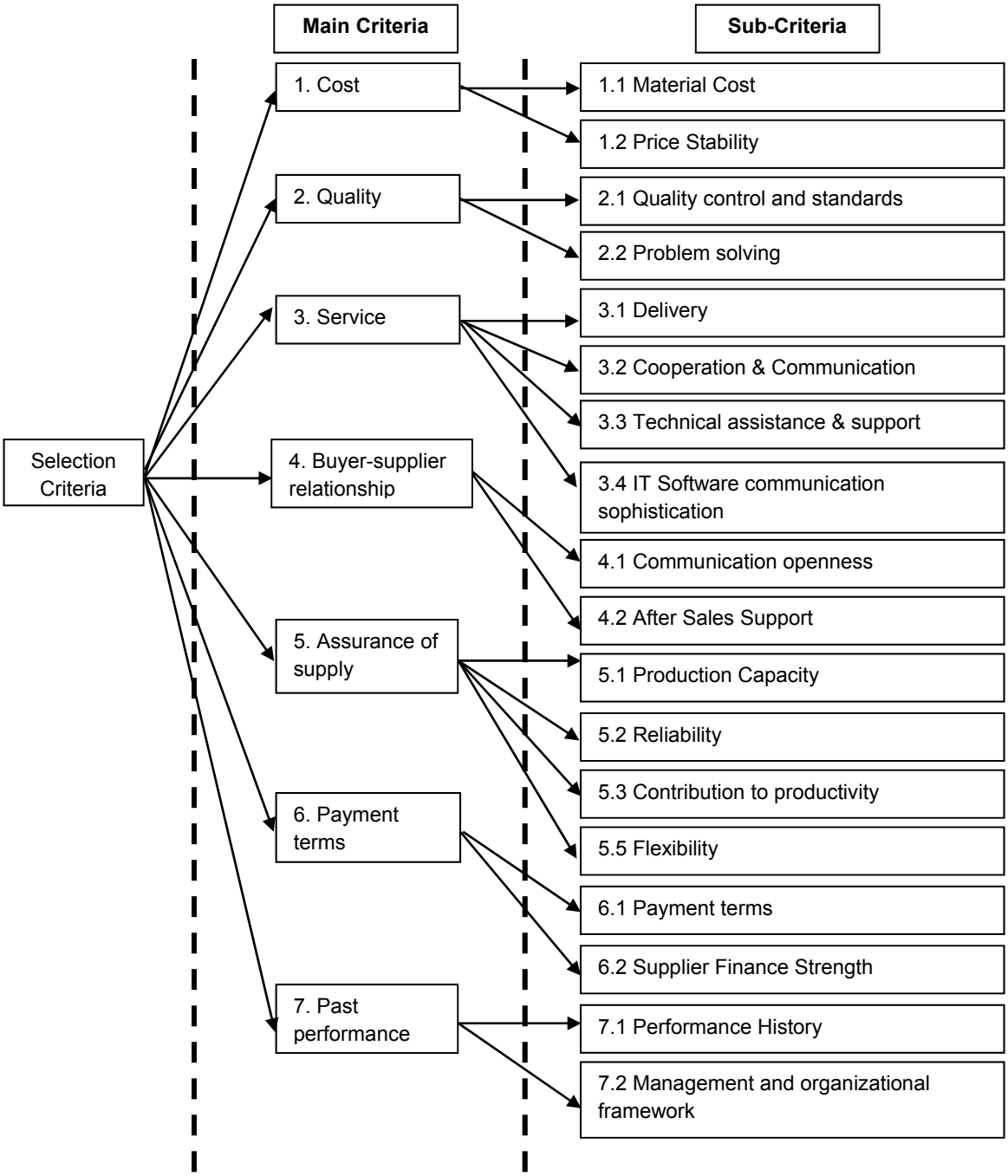

Figure 1: The selection criteria system for the proposed model

Comparative analysis of Fuzzy TOPSIS and Fuzzy AHP methods

The global performance of each supplier alternative to the Fuzzy TOPSIS method is given by the closeness coefficient, CC_i, calculated as in Eq.(12) and presented in Table 6. Finally, this calculation led to the outranking presented in Table 6, meaning that supplier A2 is the best alternative. And the global performance of the other alternative suppliers was computed similarly. Table 6 presents the global performance for all the alternatives and their ranking position in Fuzzy AHP. Therefore, following this procedure, similarly to the application of Fuzzy TOPSIS, supplier A2 is the best evaluated alternative.

Fuzzy TOPSIS			**Fuzzy AHP**		
Suppliers	CCi	Rank	Suppliers	Global performance	Rank
A1	0.42	3th	A1	0.81	3th
A2	0.68	1st	A2	1.00	1st
A3	0.52	2nd	A3	0.87	2nd

Table 6: Comparative analysis of Fuzzy TOPSIS and Fuzzy AHP methods

Conclusion

In the case of Fuzzy AHP method, the use of pairwise comparisons by means of comparative linguistic variables is itself a way to deal with imprecision. This feature makes this method more appropriate than the Fuzzy TOPSIS when the purpose is to replace a supplier. Other advantages of the Fuzzy AHP compared to Fuzzy TOPSIS in this example are fewer judgments and less computational complexity. This paper presented a new study comparing the Fuzzy AHP and the Fuzzy TOPSIS methods in regard to 7 main criteria and 17 sub-criteria that are particularly relevant to the problem of supplier selection. The comparative analysis of Fuzzy AHP and Fuzzy TOPSIS has shown some interesting outcomes that one should take into account so as to better align the technique to the particularities of the problem at hand. The obtained results concerning the analysis of the seven factors are valid for the context of supplier selection.

Concerning the agility in the decision process, Fuzzy TOPSIS performs better than Fuzzy AHP in most cases except when there are very few criteria and suppliers. In addition, the increase in the number of supplier alternatives imposes some limitation to Fuzzy AHP. As for the Fuzzy TOPSIS, this is not a restriction to the use of the method. In the case of the number of criteria, the intrinsic limitation imposed by the Fuzzy AHP method can be overcome by deploying the criteria into the Fuzzy AHP hierarchy structure. At the same time that the Fuzzy TOPSIS does not constrain the number of criteria, it does not allow the deployment of the criteria into sub criteria, which can be understood as a weakness of the method when applied to the problem of supplier selection. A further study could focus on the adaptation of the Fuzzy TOPSIS so as to accommodate the criteria and sub criteria into the decision matrix.

Both methods adequately support group decision making. It is worth to mention that weighted mean could be used to aggregate judgments instead of the arithmetic mean commonly used. By doing that, one could give different importance to different decision makers. Although both methods are equally adequate to deal with the lack of precision of scores of alternatives as well as the relative importance of different criteria, it is worth noting that the Fuzzy AHP is more appropriate than the Fuzzy TOPSIS when the purpose is to replace a supplier.

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THE IMPACT OF GUANXI ON BUSINESS PERFORMANCE: IN THAI SHIPPERS' PERSPECTIVE

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Introduction

One of the most significant archetype transfer of modern business management is that individual businesses no longer compete as solely independent entity, but rather as supply chains (Grean & Shaw, 2002). The higher risk of environmental, the more entrepreneurs rely on social relations to gain competitive advantages (Peng & Yadong Luo, 2000). Relationship is one of the most fundamental stage for business performance that defined as a mutually oriented interaction in between two reciprocally committed persons.

Quite recently, considerable attention has been paid to many Western literatures that investigated the relationship marketing issue between organizations and customers established in Western companies, few have examined the context of relationship in an Asian context. Doing business in China are known for its difficulty and key differences lie in between business practices of managing personal relationship, also known as "Guanxi". The term of Guanxi has been deeply rooted in Chinese confusions study for longs. Guanxi is a Chinese terms used to define the human relationship connections with a general social and cultural construct. In term of business context, Guanxi contains the use of close friends and associates, a network to help with general business activities (Yen, Barnes R., & Wang, 2010).

Encounter with market volatility and diversity in Thailand logistics, influencing of Guanxi connection play a key role in many companies to develop relatively adjustable collaboration with various channel partners to deal with unexpected market demands. As a result of the survey of PwC's 2014, global economic crime has been widely investigated that procurement fraud is a severe problem in Thailand. The outcome of Survey mentioned that at the bid process stage, frauds were often occurred through uncertified suppliers that had undeclared relationships with their employees. Therefore, the findings in Thailand suggest that organizations in Thailand would benefit greatly by suggested vendor to the company via existing employees and performing background double checks suppliers is a good idea.

In the generation of new edge technological innovation and globalization, the shorter product life cycles and swiftly alter customer preferences. As a result, business process increasing part of value adding activities is ordered from outside the physical boundaries of a firm. Therefore, many company seeks to necessitate efficiency collaboration with other company that have an impact on shippers and logistics service provider (LSPs). Both parties are strength on their core businesses and efficiency. Shipper often outsourced to specialized companies but emphasize on price range and efficiency by achieving economies of scale and scope is not the only major criterion. One way to reach such complex economies is collaboration, collaborative partner-relationships between shippers and operators have gained considerable attention in determining the effectiveness of business performance (Chao, 2011).

At present, assessing business performance has become one of the significant issue that have gained a considerable attention from researchers and practitioners. Business performance was expressed as an consideration of both effective ness and efficiency in accomplishing a given task. (Gunnasekaran & McGaughey, 2004). Equally important, Logistics performance index (LPI) that emerged by World Bank use major condition and prioritize scores in order to evaluate the logistics performances of each country. But in order to measure logistics performance closely associate with environment in Thailand, tool developed by Banomyong and Supatn (2011) that used to measure

firms' logistics performance of firm with dimension of cost, time and reliability and 9 key logistics activities are taken into account.

In Thailand, with a population estimated to include 14 percent Chinese and 30-40 of Chinese descent (Chao & Anantana, 2014). In addition, Thai culture tended to rely more on the development of social relationships and addressed to be low-trust society. Therefore, doing business in Thailand mostly rely on personal social connection and provide special benefit to those who comes from associate network. The use of Guanxi has been suggested in this study. Therefore, this study aims to evaluate the impact of Guanxi on business performance from Thai shippers' perspective.

Literature review

Guanxi

As early as the sixth century BC, Confucius compiled the individual, family, and societal ties that expressed a person's proper role and position in their environment (Luo, 1997). Both of Asian and Western academics has discussed the Chinese phrase "Guanxi" by both with the majority of them being ethnically Chinese. Guanxi embeds at the heart of China's social order, economic structure, and institutional landscape (Chao, 2011). Guanxi consisted of two Chinese characters, guan (gate) and xi (connection). One must pass the entrance to attach to connection. As such, Guanxi generally refers to interpersonal relationships or social connections depend on reciprocity interests and benefits (Lu, 2007). "The more network of Guanxi one has, the more opportunity are available for interaction privilege" (Cheng & Tang, 2012).

To better evaluate the quality of Guanxi, it is essential to comprehend the three closely related constructs: Ganqing, Renqing and Xinren (Cheng & Tang, 2012). Ganqing can be interpreted into English as "feelings" and a sense of faithfulness and unity, the reluctance to take care of each other under all circumstances. It has been found that Guanxi could be developed and maintain directly by cooperating into Renqing similar to the owing of a 'favor' in an English context (Yen, Barnes, & Wang, 2010). Renqing is a special interpersonal treatment, the providing of resources to another party as a 'gift' in the process of a market transaction. Another way to maintain Guanxi is to trust, which refer to Xinren in Chinese language. The higher tier of xinren, the stronger links between two parties, thus the better Guanxi they may have (Cheng & Tang, 2012).

With a population over billion and years of double digit economic growth since 2000, China has been attracted investment company from major multinational corporations and much attention from both academics and managers. Undoubtedly, in China, Guanxi encourage real economic advantages to the economy so, Chinese people will undertake first step to the linkages of Guanxi to found business. In consequence, employment of the Guanxi network has turn into a considerable attention basis for gaining competitive advantages beyond competitors as well as reducing conflict in the global trade environment (Chao, 2011). The business circumstances in China overlaps with prevalent personal Guanxi networks dominating the reciprocal favor through three rules: obligation, depend on people mostly offer treatments to others degree of relationships; reciprocity that should to be returned when asking; and empathy, demanding a sense of goodwill between individual.

Regardless, in the Western world the portrayal of dark sides of Guanxi can be jeopardized, which can lead to unethical behavior, corruption and bribery that stem from China's marketing economy. However, Guanxi and corruption are not necessarily to connect. As a result of legal purposes which do not violate on public interests, Guanxi can be a considerable benefit tools for network as long as follow legitimate personal or business affairs, whereas Guanxi would be corrupted in case of exchanging or transaction out of the law.

Relationship Marketing

The evolution of business has transfer from a production direction to a selling direction, later marketing direction, and eventually to a Relationship Marketing Orientation (Dhanushanthini, 2011). Relationship marketing categorized by reciprocal, interconnection, committed and long-term relationship among sellers and customers (Sin, et al., 2005). Another terms is focuses on attracting new customers as a first step in marketing activities while maintaining or retaining customers bonding (Shaalan A. S., 2013). As stated in principle of relationship marketing and social exchange, most of an important construct in relationship marketing strategy belongs to trust, also trust has been found to be complicated factor that compass the integrity, honestly and confidence from one party to another (Coulter & Coulter, 2003). Some studied claimed that relationship marketing has been expressed as all marketing action directed towards establishing, developing, and supporting successful mutual exchange, which could gain a competitive edge for company, and to have a positive effect on organizational and supply chain performance (Alrubaiee, 2010).

The Difference between Guanxi and Relationship Marketing

Criteria	**Guanxi**	**Relationship Marketing**
Network type	Social network	Business network
Network nature	Particularistic	Universalistic
Network foundation	China and emerging Asian markets	Western markets
Network level of working	Individual	Organizational
Relationship nature	Personal	Impersonal
Relationship established	By individuals	By organizations' people
Consequence of relationship and transaction	Personal relationship leads to transaction	Satisfactory transaction leads to relationship
Orientation	Tactical	Strategic
Exchange type	Favors and affection	Commercial and economic
Exchange partner's role expectations	Implicit	Explicit
Commitment type	Affective	Calculative
Relational behaviors	Care and favors	Cooperation
Motives for reciprocal behaviors	Face-saving	Mutuality
Promises type	Implicit	Explicit
Deadline for fulfilling promises	No deadlines	Well-defined deadlines
Customer position	Company and customer become one cooperative unit	Customer viewed as more of a subset than a merged partner
Measure of customer expectations and satisfaction	Complex to measure for most promises	Mostly measurable
Importance of trust development	Relatively more important in guanxi than relationship marketing	Relatively less important in relationship marketing than guanxi

Table1: Guanxi and Relationship Marketing Differentiation

Source: (Reast, Johnson, Tourky, & Shaalan, 2007)

In term of business performance, many research has emphasized on relationship marketing from the both of academics and practitioners since 1900s. Coupled with a several studied interest in Guanxi, which has been identified as the Chinese version of relationship marketing or business connection (Wang C. L., 2007). Guanxi including with relationship marketing have both principle differences and certain commonalities (Flambard-Ruaud, 2005; Wang, 2007). Several scholars examine the similarities and differences between Guanxi and relationship marketing from various perspectives (Shaalan, Reast, Johnson, & Marwa, 2013).

The difference of social interaction between the West and Guanxi in China is that, in China a person may introduce a business favor and return them a personal favor instead such as a logistics service provider might suggest better knowledge or introduce competence supplier and might provide faster service to a friend's firm because shipper help them with personal issue. On the other hand, in Western cultures people are strongly divide interpersonal or social and business relationships (Cao, Baker, & Schniederjans, 2013). in context of Western cultures, exchanging the equivalent favor and advantages to both parties widely appear in Western culture whereas in Guanxi, a less powerful business may ask for a personal favor without unequal social position (Cai & Yang, 2013). Notably, Western society enforce legality and rules in context of relational exchange, but in China are controlled by morality and social norms in principles of relational behaviors (Wang C. L., 2007).

Logistics Performance Index

Recently, World Bank has developed the first measurement index to evaluate the countries' logistics performance index in accordance with certain standard and arrange them based on their scores. Logistics performance index (LPI) is an international index that developed to evaluate the countries' logistics performances according to certain criteria and ranks them based on their scores. In order to measure logistics performance closely associated with Thai business context, Banomyong and Supatn established KPI assessment framework based on 9 logistics activity (Customer service and support, Demand forecasting and planning, Purchasing and procurement, Inventory management, Order processing and logistics communications, Material handling and packaging, Transportation, Facilities site selection, warehousing and storage and Return goods handling and reverse logistics) and 3 dimension (Cost, Time and Reliability) to evaluate logistics performance.

H1	Guanxi has positive impact on logistics performance index in cost dimension (Chung et., 2011)
H2	Guanxi has positive effect of logistic performance index in time dimension (Shaalan et., al, 2006)
H3	Guanxi has positive effect of logistic performance index in reliability dimension (Chung, 2011)
H4	Logistics performance index in cost dimension correlates positively to business performance (Franco et., al, 2007)
H5	Logistics performance index in time dimension has positive impact on business performance (Adeyingka, 2012)
H6	Logistics performance index in reliable dimension has positive impact on business performance (Konya et., al, 20114)
H7	Guanxi has positive impact on business performance (Chao, 2011)

Business Performance

According to the manifold and potent marketplace, many organizations investigate several ways to monitor and control the administration of strategic goals to meet customer requirement. Periodic evaluation of company performance is conducted for several motive: it assists investors to develop their expectations concerning the future earning potential of firms; it support a probable feedback on how well the company has achieved its goals (Venanzi, 2012). Business Performance was expressed as an consideration of both effectiveness and efficiency in accomplishing a given task. Regarding to business performance academic literature, there are two widely used performance measurements which are financial and non-financial measurement. For non-financial measurement aspects, sales growth and market share seem to be the most common used of measurement. Conversely, financial performance considers the effectiveness and efficiency in complete a given business task that

regularly operated to measure the productivity of a certain ratio of real output and real input.

According to intensive literature review and theoretical justification gather from previous studies, this section subsequently considers the relationships between each key elements and established research model bellows.

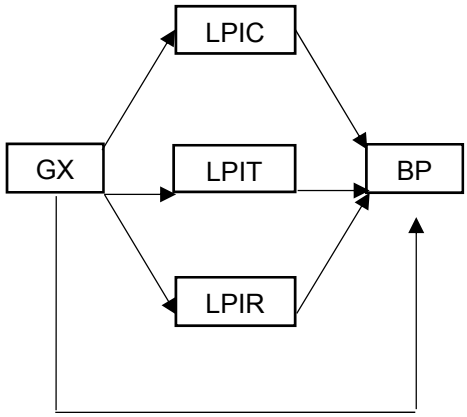

Fig.1 Research Model

Methodology

In order to gather the empirical data, this study uses a questionnaire survey. There are four sections. The first three sections are Five-Likert-scaled subjective questions to test the satisfaction level of each factor used in this study such as Guanxi, LPI (cost), LPI (time), LPI (reliability) and business performance. The latter is general background information that is not used in the structural equation model. The questionnaire compost of 61 self-administered questions: (of which, Guanxi- 22, LPI – 27 and business performance – 12) and 10 background questions. The definition terms such as Guanxi and LPI were provided on separate sheet of paper from academic wording. The questionnaires were examined the possibility of actual data conditions by distributed to academic professors with logistics degree to find and error in wording, sequencing, layout and clarity. The database of respondent in this study was from Thai National Shipper Council (TNSC) lists. We distributed questionnaire by email to the 2787 Thai shipper lists in TNSC.

Validity Test

Validity		**Criteria**
Overall model fit or Unidimensionality	**Absolute Fit Index**	X^2/df < 3.0
		GFI > 0.8
		RMSEA < 0.08
	Incremental Fit Index	CFI > 0.9
		TLI > 0.9

Table3. Measurement Model Validity
Source: Chao (2014)

It is necessary to measure the overall model fit and validity test in structural equation model. Model fit was evaluated using the norm chi-square according to standard criteria, values of chi-square should be less than 5 are considered a good fit. A major incremental fit indices include, Comparative fit index (CFI; Bentler, 1990), Tucker-Lewis index (TLI; Tucker & Lewis, 1973). The most widely used residual-based index is standard root mean square residual (SRMR) that should be less than 0.10 [15]. Root

mean square error of approximation (RMSEA), model fit is considered good at values less than equal to 0.05. A summary of the measurement model validity indices is shown in Table 3. The CFA results suggest a good overall fit with verify unidimensionality (Table 4). Discriminant validity was assessed by determining the confidence interval around the correlation for each pair of factors. We compared the seven possible pairs of construct to measure the value for the constrained and unconstrained.

Construct	Item	χ^2/df	GFI	TLI	CFI	RMSEA
GX	15	1.581	0.928	0.925	0.938	0.050
LPI(C)	4	2.822	0.958	0.949	0.968	0.089
LPI(T)	7	2.200	0.965	0.976	0.985	0.073
LPI(R)	4	1.094	0.995	0.998	0.999	0.020
BP	7	2.366	0.960	0.950	0.967	0.077

Table4. Model Fitness of Overall Model

Note: X^2 - Chi-square; df – degree of freedom; GFI Goodness-of-fit; RMSEA – Root Mean Square Error of Approximately; CFI – Comparative Fit Index, TLI – Tucker-Lewis Index.

Pair of Construct	CMIN(df)		CMIN(df) Difference
	Constrained Model	Unconstrained Model	
GX vs LPI(Cost)	995.060(299)	963.228(298)	31.832(1)
GX vs LPI(Time)	1033.576(299)	1028.238(298)	5.338(1)
GX vs LPI(Reliability)	927.710(275)	890.279(274)	37.431(1)
LPI(Cost) vs BP	377.261(90)	351.224(89)	26.037(1)
LPI(Time) vs BP	408.706(90)	398.442(89)	10.264(1)
LPI(Reliability) vs BP	300.844(77)	238.341(76)	62.503(1)
GX vs BP	837.725(324)	795.364(323)	42.361(1)

Table5. Discriminant Validity Test

Note: df – degree of freedom. **p < 0.05

Paths	Estimates	S.E	*t*-value	*p*-value	Results
H1: GX → LPIC	0.806	0.241	7.214	***	Supported
H2: GX → LPIT	0.937	0.141	8.119	***	Supported
H3: GX → LPIR	0.799	0.120	7.993	***	Supported
H4: LPIC → BP	0.394	0.222	1.958	0.050**	Supported
H5: LPIT → BP	0.892	0.171	7.333	***	Supported
H6: LPIR → BP	0.532	0.223	2.741	0.006**	Supported
H7: GX → BP	-0.543	0.468	-3.300	***	Not Supported

Table6. Hypotheses Testing

Result

The result of hypothesis testing shows that six of seven hypotheses were significant. Guanxi was found to have a positively significant effect on Logistics Performance Index in Cost, Time and Reliability Dimension (estimate = 0.806, *t*-value = 7.214; estimate = 0.937, *t*-value = 8.119; estimate = 0.799; *t*-value = 7.993, respectively) but not with Business Performance (estimate = -0.543, *t*-value = -3.300). In addition, Logistics Performance Index in Cost, Time and Reliability Dimension were found to have positively significant impact on Business Performance (estimate = 0.394, *t*-value = 1.958; estimate = 0.892; *t*-value = 7.333; estimate = 0.532, *t*-value = 2.741, respectively).

Conclusion

In this manuscript, the measurement model in this research appears to adequately fit with the data gathered and the construct validity of the measurement items are developed with the procedures used in this research. According to the result of hypotheses testing, H1 has shown a positive impact on Logistic Performance Index in Cost Dimension. As stated in survey of Hong Kong Chinese by regarding the significant role of Guanxi connection can be decreasing transaction costs related with uncertainties in competitive environment. These benefits included the smooth running of routine business operations, considerable penetrate wider information about government policies, reduce cost of operating each activity, and quicker receipt of administrative approvals (Cheng & Tang, 2012). H2, which assumed that Guanxi has positive effect of Logistics Performance Index in Time Dimension was supported. Guanxi also can use more flexible and decrease time to conduct business transactions with lower risks. So in logistics process or business tasks need less time to operate. (Lu, J., & Omta, 2006). In addition, the result of H3, business Guanxi can also have a positive effect of Logistics Performance Index in Reliability Dimension. In this regard, good Guanxi with associated partners is inevitably essential for companies to make these resources obtained with higher efficiency.

H4 was valid, therefore, Logistics Performance Index in Cost Dimension correlates positively to Business Performance. Collaboration along the supply chain, reducing costs, shorter lead time, cross docking, direct delivery, increase reliability with logistics service providers is one of the key element to improve the business performance (Hou & Liu, 2011). H5, Logistics Performance Index in Time Dimension has positive impact of Business Performance was supported. Powerful time management is an access to reach the highest business performance levels. (Adeyinka, 2012). As the same way, H6 was supported, therefore, correspondingly to withstand in a competitive business environment, it is important for companies to specially emphasize on consumer (Konya, Missouri, & Ball, 2014). So as to increasing customer satisfaction and tie in a personal relationship with customer to exceed business performance, provide customer a trust and reliability of products or services.

The effect of Guanxi was not supported to be positively associated with Business Performance. This was unexpected result because there is a prior research stated that engaging with Guanxi relationship could bring many benefits to business performance. The result shows that indirect effect of Guanxi with Business Performance proposed a stronger than the direct effect. The indirect effects of GX → BP were: GX → LPIC→BP, GX → LPIT → BP and GX → LPIR → BP. This suggests that even with a positive Guanxi between shippers and logistics service providers, a more stable business-to-business relationship should take into account. This particular phenomenon might be caused by a fear of the negative impacts of Guanxi that might jeopardize the business if relied on too much (Chao & Anantana, 2014). Moreover, the insignificant relationship between Guanxi and business performance may be motived by demographic characteristics of responding company. Guanxi plays a greater role in small and medium-sized companies, due to their limited economic influence than in larger companies. Small and medium firms may need specific strategic behavior (relationships) to enhance their business performance. Manager of small of medium firms shows dependent relationships via interaction between different channel members in order to help them accommodate external changes (Chao, 2011).

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TOWARDS SUSTAINABLE PORT DEVELOPMENT MODEL: A COMPARATIVE ANALYSIS BETWEEN SINGAPOREAN AND KOREAN PORTS

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Introduction

Increasing environmental pressure and awareness such as the impact of climate change posit new challenges to port development which, in turn, call for measures that aim at minimizing their impact and pursuing sustainable operations. In this respect, several legislations relating to the construction and extension of ports have been timely introduced at both international and national levels in an attempt to minimize the environmental impacts and pursue sustainable operations in the long run. Based on stricter standards, these legislations aim to incorporate environmental issues into core strategies of port development. Therefore, sustainability is increasingly seen as one of the key drivers of port development in the next decades.

Pots must plan and manage their future developments (growth and expansion) and operations in a sustainable manner in order to cope with the limited or decreased environmental space and intensified interactions with their hinterlands. The required harmony of ports with their surrounding cities clearly renders green growth an important economic driver (Black, 1996). In this respect, several studies have been conducted to measure ports' sustainable performance (i.e. Lirn et al. 2012; Wiegmans and Louw, 2011; Chin and Low, 2010: Tsinker, 2004). Nevertheless, there is little knowledge which describes clearly and comprehensively what sustainable port development actually entails or, in other words, what are included in terms of sustainable port development indicators. This study therefore aims to investigate the main factors that shape sustainable port development and their priorities from the perspectives of Singaporean and Korean Ports. It also aims to examine how these ports practise sustainable development so as to suggest academic, managerial and policy implications.

Literature Review

Environmental management is increasingly practiced as an essential business plan component of any operation that claims to be sustainable, efficient and compliant with legislations. This is particularly evident in port activities (Puig et al. 2015). Implementing environmental programs and green marketing strategies would lead to better environmental performance (Gimenez et al. 2012; Rao, 2002; Zhu and Sarkis, 2004) and firm competiveness (Yang et al. 2013). Promoting and practicing ISO 14001 series would enhance firms' environmental performance (Saengsupavanich et al. 2009; Yang et al. 2013).

Activities to reduce environmental damages are consistently needed as well (Wagner and Schaltegger, 2004; Yang et al. 2013; Zhu et al. 2007). Monitoring programs are implemented to reduce the cases of having business partners acting unethically or even illegally in terms of environmental and/or social issues (Carter and Rogers, 2008; Simpson and Power, 2005). In this regard, it is found that audits, evaluation, assessment practices of business partners have positive impact on environmental performance (Saengsupavanich et al. 2009; Yang et al. 2013).

It is important for port authorities to continuously collaborate with shipping companies in reducing environmental impacts such as reducing CO_2 emissions (Buhaug et al. 2009; Qi and Song, 2012), practicing low sulphur content emissions or vessel speed limit (Lai et al. 2011; Puig et al. 2014; Yang et al. 2013), and adopting environmental-friendly materials, equipment and design (Yang et al. 2013). It is also suggested that regular exercises of Port State Control for ship inspection are needed for sustainable development ports (Saenguspanvanich et al. 2009).
Meanwhile, internal social programs such as employee welfare, education and training play an important part in environmental management (Wu and Goh, 2010) as they have been positively related to the reduction of potentially damaging environmental practices and can lead to improvements of environmental performance (Florida, 1996; Gimenez et al. 2012; Marshall et al. 2005).

Success in addressing environmental management could improve a firm's image (Hick, 2000; Shrivastava, 1995) and provide new opportunities for firms to enhance their capabilities (Hansmann and Claudia, 2001). Gimenez et al. (2012) argued that the use of more environmentally friendly materials and processes can lead to resource reduction and efficiency resulting in reducing costs. Profitable firms can afford to make sustainable investment in green activities to raise their environmental performance (Stefan and Paul, 2008).

Greater collaboration among members of the supply chain is a key component not only to foster the development of improved environmental practices and reduced pollution (Gotschol et al. 2014; Vachon and Kassen, 2006) but also benefit supply chain members from the economic and environmental point of view (De Giovanni and Zaccour 2014). Yang et al. (2013) indicated that external green collaboration has positive impact on green performance and firm competiveness. Firms that integrate environmental responsibility in their economic strategies can achieve cost savings from resource reduction and efficiency while increasing revenue generated from improved stakeholder relations and brand image (Hart, 1995; Hoffman and Ventresca, 1999). Rao and Holt (2005) and Zhu and Sarkis (2004) also found that environmental programs that include both collaboration and assessment of business partners have a positive impact on economic performance.

It is nowadays believed that socially responsible firms, which contribute both economically and ethically to the society and local communities they serve, are better positioned to grow in terms of reputation and revenues (Drobetz et al. 2014). Environmental programs have positive effects on internal and external communities (Gimenez et al. 2012; Pullan et al. 2009). The adoption of a process that generates less pollution improves the working conditions as well as supporting community projects which may result in improvements to a firm's social performance and reputation. In the context of ports, relationship with the local community to promote positive image and building trust through various efforts from port authorities has been implemented (Saengsupavanich et al. 2009; Puig et al. 2015). Meanwhile, increased CSR reporting enhances firm's transparency and lowers information costs on the part of investors, potentially leading to positive financial effects (Drobetz et al. 2014).

Methodology

This study adopted multi-phased mixed methods, combining semi-structured validation interviews and Analytical Hierarchy Process (AHP). First, the main indicators for sustainable port development were identified through a comprehensive literature review. Secondly, for validation purpose, a semi-structured interview questionnaire was constructed based on the literature including internal and external management aspects of sustainable development following the previous studies of Gimenez et al. (2012), Gotschol et al. (2014) and Yang et al. (2013). The interview questionnaire was distributed via email to 17 ports in Korea and two ports in Singapore. A total of 67 responses from Korean port managers in three major ports in Korea (Busan, Incheon, Gwangyang) and two from Singaporean port managers were received. Lastly, after validating the sustainable port development indicators, AHP analysis was conducted to prioritise the identified sustainable port development factors.

Phase 1: Validation of Sustainable Port Development Factors

Since there is scarce literature on important factors of a sustainable port development model, semi-structured interviews were conducted to validate the sustainable port development factors and indicators which were derived from sustainable development studies in the supply chain and shipping literature. The objective of these validation interviews was to verify sustainable port development factors from port managers' point of view.

The interview questionnaire was distributed via email from August to November 2015 to 17 ports in Korea. In total, 67 responses from Korean port managers in three major ports in Korea (Busan North Port – 24 responses, Busan New Port – 8 responses, Incheon – 15 repsonses, Gwangyang – 20 responses). In Singapore, the same interview questionnaire was administered during September 2015 and two responses from port managers were received.

Phase 2: Analytical Hierarchy Process (AHP) Analysis

The AHP analysis allows the determination of relative importance of individual criteria and pairwise comparison matrix to be formed in order to determine the priority of major criteria. In this study, a total of 18 Korean port managers from Busan, Gwangyang, Incheon, and Ulsan participated in the AHP evaluation. For Singapore, two port experts from the Maritime and Port Authority of Singapore (MPA) and Jurong Port participated in the current study. They made individual evaluation using a scale of nine levels to determine the values of criteria in the pairwise comparison matrix. Table 1 shows an example of how the relevant importance is determined between two criteria and how it is converted into a numerical rating. The participants' consensus on the criteria's preferences is calculated using the geometric mean. Entries for the remaining cells of the matrix are completed by taking the reciprocal value of the numerical value of importance, when the comparison of two particular criteria is undertaken.

Definition	Numerical Value
Equal importance	1
Moderate importance	3
Strong importance	5
Very strong importance	7
Extreme importance	9
Intermediate values between adjacent scale values	2, 4, 6, 8

Table 1 Internal Management Criteria Results (unit: %)

The next step is to calculate the priority of each criterion in terms of their contribution so as to identify the most important criteria to port managers. This process is known as the synthetisation and can be determined using an exact mathematical method or by applying a procedure that provides a good approximation of the synthetisation result. The following synthetisation procedure was used: 1) calculate normalized pairwise comparison matrix through adding all values in each column and then dividing by each column's total; 2) compute priorities for each criterion by calculating the average of the values in each row of the normalized matrix (Anderson et al. 2013).

Since the comparison was carried out through personal or subjective judgments, some degrees of inconsistency may occur. Therefore, to ensure that the respondents' judgments are consistent, the consistency verification is undertaken in that the judgments are considered to be consistent and the pairwise comparisons are acceptable only if the corresponding consistency ratios are less than 0.1 (Saaty, 1980). If a consistency ratio is greater than 0.1, the pairwise comparisons have to be reviewed by the decision-makers before being analysed. To calculate the consistency ratio (CR), λmax which is an average of the values and calculated as follows: each value in a specific column of the pairwise comparison matrix is multiplied with the corresponding priority of that criterion; the values across the rows are then added to obtain the weighted sum; then the values in the weighted sum are divided by the corresponding priority of each criterion. Subsequently, the consistency index (CI) is computed (CI = (λmax – *n*)/(*n* – 1)), and then used to calculate CR (CR = CI/RI, with RI being the random consistency index of a randomly generated pairwise comparison matrix depending on the number of items being computed. In the current study, there are eight factors (*n* = 8), therefore RI = 1.41 according to the random consistency indices table (Saaty and Kearns, 1985; Anderson et al. 2013). The working mechanism of AHP process was described in more details by Torfi et al. (2010).

Findings

The port managers confirmed the following factors which should be included in the sustainable port development model (Table 2).

Internal Management
A. Internal Environmental Management
A1 Clear environmental statement
A2 Establishment or upgrade of the "Green Policies" annually
A3 Regular updates of environmental conservation information in the port's website
A4 Environmental Management System
A5 Management support environmental supply chain
A6 Environmental risk management practices
A7 Activities to reduce environmental damages
A8 Environmental education and training support
A9 Clear environmental performance indicators
A10 Budget on green performance, including promotion campaign
A11 Punishment mechanism to penalize operators that disobey environmental rules
A12 Regular exercise of Port State Control for ship inspection
A13 Green initiatives and eco-services to attract customers
B. Optimized Operation Planning
B1 Continuously implementing berth planning improvement strategy
B2 Continuously implementing quay crane scheduling improvement strategy
B3 Continuously implementing loading/unloading sequence improvement strategy
B4 Continuously implementing space planning improvement strategy
B5 Continuously reducing truck queuing time at the port's gates
B6 integrated various port operations activities

B7 Collaboration with business partners in information sharing, improving data accuracy, and integrated scheduling
B8 Continuously improving customer satisfaction monitoring programs
C. Cost Savings
C1 Use of cleaner technology port equipment, such as hybrid/alternative/ quay cranes, RTGs, etc.
C2 Use of automated port equipment
C3 Collaboration with business partners in sharing the cost of environmental-friendly equipment
D. Internal Social Programs
D1 Constantly giving support for corporate social activities
D2 Constantly improving employees' working conditions and safety
D3 Constantly improving employee welfare
D4 Constantly giving support for employees' training and education
D5 Constantly improving transparent employee evaluation system
D6 Constantly improving transparent recruiting sytem
External Management
E. External Environmental Management
E1 Having common environmental goals collectively with business partners
E2 Developing a mutual understanding of environmental risk and responsibilities with business partners
E3 Working together with business partners to address environmental risks and establish a green supply chain
E4 Requiring and guiding business partners to comply with ISO 14001 environmental management standards
E5 Including environmental criteria in selecting business partners
E6 Conducting environmental audits for partners
F. Environmental Collaboration with Shipping Companies
F1 Providing incentives to shipping companies which use cleaning-burning low sulphur fuels for their ships' main and auxiliary engines while at port
F2 Providing incentives to shipping companies which use environmental-friendly materials and equipment
F3 Providing incentives to shipping companies which adopt environmental-friendly design of shipbuilding
F4 Providing incentives to shipping companies whose ships reduce speed while at port
G. External Social Program
G1 Providing expansion plan project information to the public
G2 Giving support to community social activities
G3 Providing scholarships to students
G4 Providing internships to students for work experience
G5 Giving support to community economical activities
G6 Giving support to community projects in general
H. External Evaluation Collaboration
H1 Working with external partners such as academic/research institutions to evaluate port projects
H2 Collaboration with academics/research institutes for project evaluation
H3 Providing transparent trade information to establish fair transaction culture

Table 2 Sustainable Port Development Factors and Indicators

The computational results of AHP analysis are presented in Table 3 (Korean experts). The consistency ratio of the pairwise comparison matrix was 0.018 < 0.1, meaning the pairwise comparison was acceptable and consistent. As can be seen from Table 3, Optimized Operation Planning (B) was considered the most important factor with a weight of 0.204. The next two most important factors are Environmental Collaboration with Shipping Companies (F) and External Evaluation Collaboration (H) with the weights of 0.151 and 0.148 respectively. Meanwhile, Internal

Social Program (D) was considered the least important among factors of sustainable port development with a weight of 0.069, followed by Internal Environment Management (A) with a weight of 0.073.

	A	B	C	D	E	F	G	H	Weight
A	1.00	0.31	0.76	1.36	0.50	0.45	0.80	0.38	0.073
B	3.25	1.00	1.11	2.62	2.27	0.80	2.54	1.61	0.204
C	1.32	0.90	1.00	1.27	1.11	0.88	1.17	0.81	0.123
D	0.73	0.38	0.79	1.00	0.58	0.43	0.62	0.41	0.069
E	1.99	0.43	0.85	1.72	1.00	0.93	1.12	1.04	0.122
F	2.24	1.24	1.14	2.30	1.08	1.00	1.03	0.86	0.151
G	1.25	0.39	0.86	1.62	1.01	0.97	1.00	0.86	0.110
H	2.66	0.62	1.23	2.43	0.96	1.16	1.16	1.00	0.148
λmax = 8.174 CI = 0.025 RI = 1.41 CR = 0.018									

Table 3 Results from AHP Analysis (Korean experts)

Meanwhile, the computational results of AHP analysis in the case of Singapore are presented in Table 4. From the Singaporean port experts' perspective, Optimized Operation Planning (B) was also considered the most important factor with a weight of 0.210, similar to the view of Korean port managers. The next two most important factors are Internal Environmental Management (A) and Cost Savings (C) with the weights of 0.197 and 0.136 respectively. On the other side, External Evaluation Collaboration (H) was considered the least important among factors of sustainable port development with a weight of 0.066, followed by External Social Program (G) with a weight of 0.082.

	A	B	C	D	E	F	G	H	Weight
A	1.00	2.24	3.00	1.73	1.41	1.41	1.41	1.41	0.197
B	0.45	1.00	3.00	2.00	2.45	1.73	3.00	3.46	0.210
C	0.33	0.33	1.00	1.41	1.58	1.58	2.24	3.16	0.136
D	0.58	0.50	0.71	1.00	1.00	0.82	1.00	1.41	0.092
E	0.71	0.41	0.63	1.00	1.00	1.41	1.73	1.73	0.110
F	0.71	0.58	0.63	1.22	0.71	1.00	1.73	1.73	0.107
G	0.71	0.33	0.45	1.00	0.58	0.58	1.00	1.73	0.082
H	0.71	0.29	0.32	0.71	0.58	0.58	0.58	1.00	0.066
λmax = 8.473 CI = 0.068 RI = 1.41 CR = 0.048									

Table 4 Results from AHP Analysis (Singaporean experts)

Discussion

From the AHP analyses, Optimized Operation Planning (B) was identified the most important factor which should be included in the sustainable port development model for both countries (Table 5). Korean ports collaborate actively with business partners for facility improvements, system development through regular meetings as this collaboration was perceived the most important factor for sustainable port development. They share feedbacks from each other on how to improve their operations planning. Incentives are negotiated by securing a certain level of throughputs. Meanwhile, Singapore ports regularly reach out to business partners to explore how they can provide better value added services in all aspects including operations planning. Optimized operations planning is practiced at dedicated terminals. As Singapore plan for the next generation port, port operators are engaged in various port development projects and assured that their voices are clearly heard. They sit in various planning committees as the biggest stakeholder in the development of the next generation port. Meanwhile, for both countries, IT is applied throughout by computer-aided operations and management at the terminal level to achieve rapid and accurate information sharing and processing which may result in reduced harbour fees, minimized human errors, and reduced loading and unloading time. Optimization of planning to reduce truck waiting time is also planned as well.

Rank	Korean Experts	Singaporean Experts
1	Optimized Operation Planning	Optimized Operation Planning
2	Environmental Collaboration with Shipping Companies	Internal Environmental Management
3	External Evaluation Collaboration	Cost Savings
4	Cost Savings	External Environmental Management
5	External Environmental Management	Environmental Collaboration with Shipping Companies
6	External Social Program	Internal Social Program
7	Internal Environmental Management	External Social Program
8	Internal Social Program	External Evaluation Collaboration

Table 5 Comparison of Priority Factorsbetween Korean and Singaporean Experts

Environmental Collaboration with Shipping Companies (F) was ranked second by Korean port managers while Internal Environmental Management (A) was perceived the second priority by Singaporean port experts. Among Korean ports, only Busan Port Authority (BPA) provides incentives to shipping companies. Since 2014, BPA has implemented the Environmental Ship Index (ESI) scheme by assigning scores for four substances emitted by vessels namely NO_x, SO_x, CO_2, and OPS (Onshore Power Supply) on the scale of 1 – 100. Busan Port is the first in Asia to adopt this system by providing ESI incentives, reducing entry and departure charges by 15% for vessels with over 31 ESI points. In 2014, the number of eco-friendly vessel callings was 423, and a total of KRW 603 million was reduced for entry and departure fees (BPA, 2015). Meanwhile, the Maritime and Port Authority of Singapore (MPA) initiated the Maritime Singapore Green Initiative which seeks to reduce the environmental impact of shipping and related activities and to promote clean and green shipping in Singapore (MPA, 2013). In 2011, the MPA pledged to invest up to S$100 million over 5 years in the Maritime Singapore Green Initiative. It is a comprehensive initiative comprising three programmes – the Green Ship Programme, Green Port Programme and Green Technology Programme. These are voluntary programmes designed to recognise and provide incentives to companies that adopt clean and green shipping practices over and above the minimum required by International Maritime Organization (IMO) Conventions.

It is interesting to note from Table 5 that internal and external social programs were considered less important by experts in both countries although their ports implement and practice various social

programs in the name of corporate social responsibility (CSR). Korean ports also consistently improve their human resources through transparent recruiting and appraisal systems although this was considered the least important criterion of sustainable port development. They focus on developing training and education programs to strengthen their employees' work skills, capabilities and personal responsibility.

Port experts in two countries showed significantly different view regarding Internal Environmental Management (A) and External Evaluation Collaboration (H). Specifically, the former was perceived second least important by Korean port managers (while it was ranked second most important by Singaporean port experts). Meanwhile, the latter was ranked the third important factor by Korean port managers (while it was perceived least important by Siungaporean counterparts). Hence, these factors deserve further investigation.

Conclusion

This research empirically validated the factors and indicators contributing to sustainable port development and their priority ranking in Korea and Singapore. Unlike previous studies in which only one or two sustainable dimensions were considered, the current research applies a holistic approach in which sustainable port development involves all three dimensions of sustainable development (economic, social and environmental). Port experts in both countries confirmed that a sustainable development port should have most of the criteria in the proposed conceptual model. Through the AHP analysis, it was agreed by both Singaporean and Korean port managers that Optimized Operation Planning is the most important factor for a port to be developed sustainably. Meanwhile, Internal Social Program and External Evaluation Colaboration were perceived to be the least important factors by Korean and Singaporean port managers respectively. Sustainable port development factors and indicators provide a development model to port authorities and operators on how their port should be developed for sustainability. Given the factors' prioritised importance, port managers are informed of areas which should be focused on for improvement in order for their ports to be developed sustainably.

This research contributes to both existing literature and management practice, as it is the first in Korea and Singapore to consider sustainable port development taking an all-rounded approach. Nevertheless, there exist various limitations in the current research. Specifically, responses were low due to limited time frame. However, the current research could be a stepping stone for further research in validating a conceptual framework to inform port sustainable development policies in the future.

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USE BIG DATA TO PREDICT SERVICE TIME FOR DELIVERY PLANNING IN CITY LOGISTICS

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Introduction

With the flourishing of e-commerce, distribution management also becomes more and more challenging to the logistics and distribution companies. There are more and more jobs with a single parcel at each delivery point. Moreover, customers may require that the delivery to be done within the predetermined delivery time window. The Vehicle Routing Problem with Time Windows(VRPTW), which is at the core of transportation logistics, is commonly seen in real life applications, for example, replenishment of vending machines, delivery of consumer packaged goods to retail/convenience stores and customers, mail collection from post-boxes and mail delivery to households, etc. Extensive studies have been done in the area of VRPTW over the last three decades, with the focus on developing exact and heuristic algorithms for solving VRPTM optimally or near optimally (Laporte 1992).

With an increasing speed of urbanization, urban freight transport system or City Logistics, becomes more and more popular and important to the urban economy. Unlike intercity delivery planning where traveling time plays a significant role, service time (loading/unloading) in city logistics constitutes a high percentage of the overall delivery time. In order to develop an efficient vehicle routing and dispatching plan in city logistics, it is important to have accurate service times. Vleugel and Janic (2004) showed in Amsterdam that approximately 11% of the time is spent driving to the service area, 32% of the time for loading/unloading, and 51% of the time for waiting or driving between customers, and 6% of the time for the driver's lunch time or personal needs. It is clear that these values are city dependent but it also shows that service time plays a critical role in city logistics.

Most of the research work on VRPTW assumes that the service time is known although this may not be true. Accurate service time is essential to forming executable delivery routes, but to most transportation companies, the service time resides in the drivers' brain and is known to the drivers only. Moreover, it is not easy to obtain the service time for new delivery locations which have not been visited before by any drivers.

This paper provides a framework to collect historical data and use the historical big data to retrieve service time. Based on the historical service time, it is able to effectively predict the service time for future delivery jobs. It is noted that we use "delivery" job in this paper but both delivery job and collection job service time can be predicted using the same method.

The main research focus of this paper is to develop a theoretical framework to predict service time based on Global Positioning System (GPS) track data and Electronic Proof of Delivery (EPOD) data. The paper is organized as follows. In Section II, we describe the proposed framework on how to collect GPS and EPOD data as well as how to process the GPS data. Then we present an approach to use GPS track data and EPOD to retrieve service time in Section III. Experimental data analysis is also presented in Section III. Lastly, conclusions and future research directions are summarized in Section IV.

Data Collection and Data Processing

The primary idea here is to analyse historical GPS data and EPOD data to retrieve and predict service time. Based on the GPS data of a delivery man and EPOD data, it is possible to analyse the delivery man's speed (vehicle speed and walking speed) and location for each delivery job and hence retrieve its start and end time. An algorithm was developed to retrieve the total service time starting from the time that a delivery man stops his vehicle to carry out his delivery to the point that he starts his vehicle engine again for the next delivery job. When the transportation companies build up enough delivery historical data, they can predict the service time accurately.

Data Collection

In this study, an Android application was developed to run on Android phone as illustrated in Figures 1a and 1b. The Android application is installed on an Android phone which is carried by the driver or delivery man for the whole delivery trip. The mobile application is used as GPS track logger and is also an EPOD to update job status Note that the GPS track data will be collected in background automatically once the user logins into the mobile application at the beginning of his delivery trip. The GPS data include: latitude, longitude, timestamp (which is the time and date), speed and accuracy, as shown in Table 1. When a job is finalized, the user will click "Done" in the application to update job status and EPOD data will be captured at the same time. The EPOD data fields include Customer ID, Postal Code, Address and Delivery Time as illustrated in Table 2.

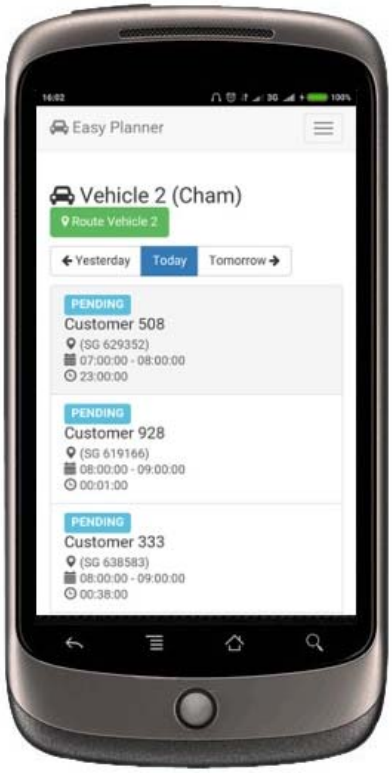

Figure 1a: List of jobs

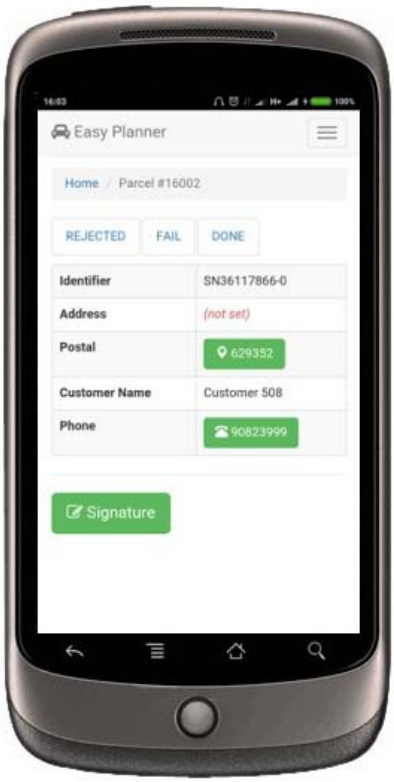

Figure 1b: Complete a job

LOCAL DATE	LOCAL TIME	LATITUDE	LONGITUDE	SPEED(km/h)	ACCURACY(meter)
14/6/2016	17:52:33	1.3900	103.9103	57	8.4
14/6/2016	17:53:16	1.3855	103.9146	55	9.3
14/6/2016	17:53:40	1.3830	103.9168	45	9.5
14/6/2016	17:54:00	1.3830	103.9168		***287.2***
14/6/2016	17:54:21	1.3791	103.9232	***128***	9.5
14/6/2016	17:54:46	1.3784	103.9251	51	9.8
14/6/2016	17:55:10	1.3777	103.9278	51	9.8

Table 1: Sample GPS Track Data

ID	LATITUDE	LONGITUDE	TIMESTAMP	POSTAL CODE	ADDRESS
1323	1.4459	103.7951	14/6/2016 10:17	730758	REMOVED FOR PRIVACY
1324	1.4463	103.7953	14/6/2016 10:23	730758	REMOVED FOR PRIVACY
1325	1.4464	103.7942	14/6/2016 10:29	730759	REMOVED FOR PRIVACY
1326	1.4465	103.7944	14/6/2016 10:32	730757	REMOVED FOR PRIVACY

Table 2: Sample EPOD Data

Data Processing

GPS data acquisition devices have been proven to be useful tools to collect vehicle track data. However, errors may appear in the collected raw GPS data. Common sources of error in GPS data (Adam and Matthew 2012) include sudden signal loss, extraneous or outlying data points, speed drifting and signal white noise. Especially when smart phone is used to collect GPS data, the GPS data accuracy may be affected by indoor environments and the distribution of the nearby cellular towers. As the delivery man will carry the smart phone when he is doing the delivery, the walking speed will also be captured in the GPS track. In this study, we adopted the similar GPS data filtration process proposed by Adam and Matthew (2012). The GPS data filtration process is shown in the following sequence:

1. Remove duplicated records and data with negative differential time
2. Replace outlying data point
3. Fill in speed and timestamp gaps in GPS track data
4. Remove zero-speed signal drift and reset walking speed to zero.

Remove duplicated records and data with negative differential time

This step removes any data points with duplicated timestamp values and data points that have negative or zero differential time. The filter calculates the differential time values for each of the data points and then remove any data points with differential time values less than or equal to zero. We do this step first as it is not possible to estimate missing speed or data points based on differential/integral time information if a duplicated record or negative differential time exists in the GPS track data.

Replace outlying data point

In this step, any erroneous data points, such as single-sample high speed data spikes or missing speed data, are replaced with interpolated data. If the speed in the GPS raw track data falls outside of the range of the pre-set low and high speed limits, the speed will be replaced by the interpolated speed. We derive the interpolated speed by calculating the great-circle distance between two points (Chris 2016), which is the shortest distance over the earth's surface from the neighbouring data point with good accuracy in GPS track data, i.e., accuracy is within 50 meters.

For example, the distance between points (1.3830, 103.9168) and (1.3791, 103.9232) in Table 1 is 833 meters and the differential time is 46 seconds, the derived speed is 65km/hour. Therefore, the missing speed and the high speed spike (128km/hour) in Table 1 are replaced with the derived speed, which is 65km/hour.

Fill in speed and time gaps in GPS track data

The filtration algorithm tries to correct for gaps in the speed-time GPS track caused by any reason, for example, satellite signal is blocked by high rise building, traveling in tunnel or parking vehicle in basement loading bay where satellite signal is lost. The filter examines the timestamp information pulled from the GPS track data and attempts to interpolate any signal gaps which is longer than the time interval based on the sampling rate of the underlying GPS track data. The same interpolation method in replacing outlying data point is used to interpolate speed and time based on the GPS data sampling rate with monotonically increasing time signals.

Remove zero-speed signal drift and reset walking speed to zero

The speed given by GPS device may not be zero when the device is in a stationary state, an effect called "zero speed drift". The GPS device will record a very low speed value, which depends on the sensitivity of the GPS device and satellite signal. To remove the zero-speed signal drift, the filter examines the speed for all data points and the speed is replaced with zero speed value if the raw speed is lower than the pre-set lower speed limit.

As delivery man carries the smart phone when he is walking, the walking speed will be also set to zero in order to detect the smart device's stationary status, which is used to retrieve service time. As the human average walking speed is about 5km/hour, we choose the upper walking speed limit to be 10km/hour in order to consider the variation of walking speed. Therefore any data points with speed less than 10km/hour will be set to zero.

Figure 2 is the raw speed data with zero-speed drift and walking speed. The filtered speed data is shown in Figure 3. As shown in Figures 2 and 3, applying the 10km/hour speed limit makes the track data smoother which is more reflective of the actual delivery operation.

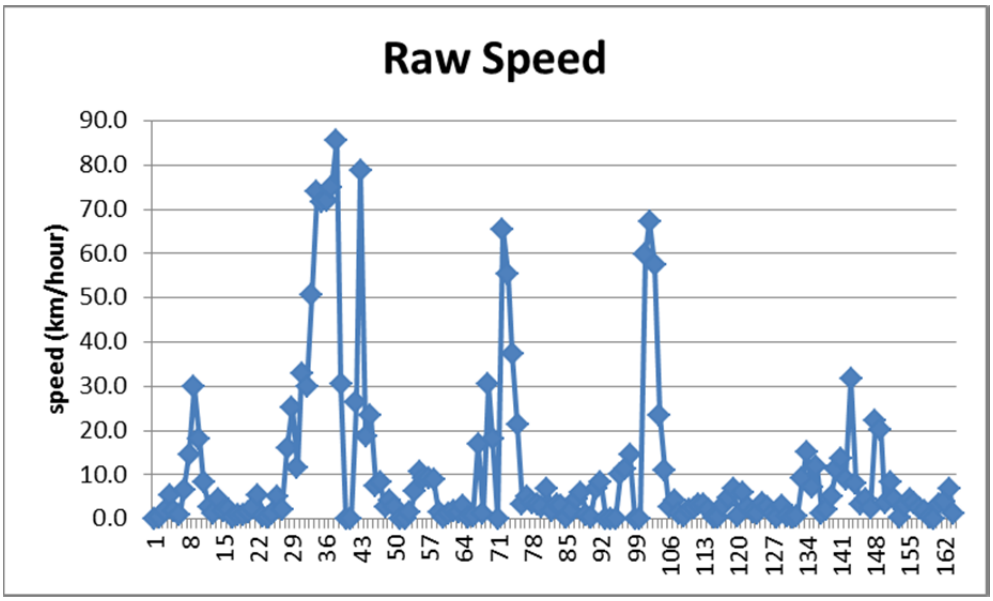

Figure 2: Raw speed in GPS track data

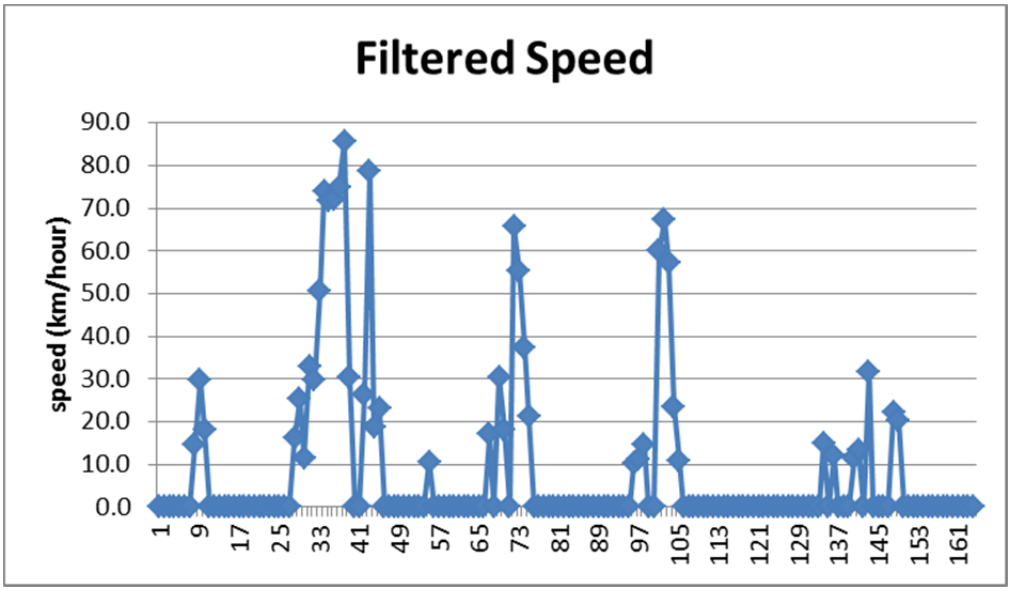

Figure 3: Filtered speed

Approach to Retrieve Service Time

Description of the Proposed Approach

We use both filtered GPS data and EPOD data to retrieve service time of delivery jobs. In the proposed approach, we match the timestamp of EPOD to the GPS track timestamp. Then we trace the vehicle's stationary state and then get the start time and end time of the stationary state based on the zero speed data points in the filtered GPS track data.

The steps to retrieve service time from the filtered GPS data are summarised as follows:

1. Sort the EPOD by non-decreasing order of timestamp
2. Match the EPOD timestamp to GPS track data, if the speed in the GPS track is zero, then find the first and last data points of the vehicle stationary state, the interval of the two timestamps will be the service time. Otherwise, ignore this EPOD as the EPOD data may be invalid.

3. If other EPODs also fall in the time interval obtained in Step 2, then these delivery jobs are a cluster of delivery jobs and share the same service time. Otherwise, go to Step 4.
4. Find the next EPOD which has yet been checked against the GPS track, go to Step 2. If all EPODs have been checked, stop the searching.

Experimental Data

We use the sample EPOD data in Table 2 and the filtered GPS track data shown in Figure 4 as an example to illustrate how the service time is retrieved.

Step 1: Sort the timestamp of EPOD data.

Step 2: The first EPOD data is for job ID 1323 with EPOD time 10:17. From Figure 4, we can get the first zero speed data point timestamp before 10:17, which is 10:15:39, and the timestamp of last zero speed data point in the vehicle stationary state after 10:17 is 10:34:21. Therefore, the service time is from 10:15:39 to 10:34:21, which is 18 minutes 42 seconds.

Step 3: Jobs with ID 1324, 1325 and 1326 are also in the interval of 10:15:39 to 10:34:21. Therefore, the total service time of the four jobs are 18 minutes 42 seconds and the four jobs form a delivery cluster, which means the four jobs are completed by parking the vehicle one time only.

Step 4: Stop as all EPOD data points have been checked against the filtered GPS track. The service time we obtained is shown in Table 3.

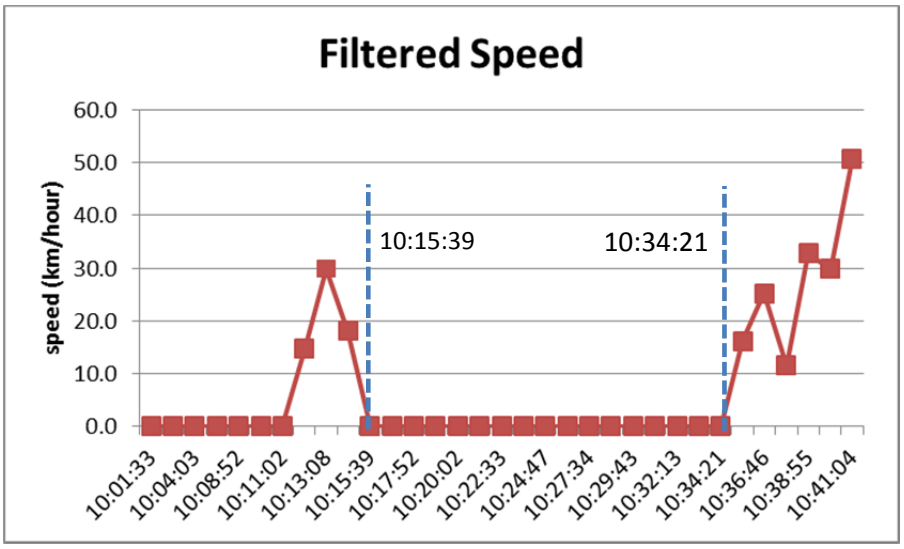

Figure 4: Illustration of service time derived from GPS track data

ID	LATITUDE	LONGITUDE	TIMESTAMP	POSTAL CODE	TOTAL SERVICE TIME
1323	1.4459	103.7951	14/6/2016 10:17	730758	18 minutes 42 seconds
1324	1.4463	103.7953	14/6/2016 10:23	730758	
1325	1.4464	103.7942	14/6/2016 10:29	730759	
1326	1.4465	103.7944	14/6/2016 10:32	730757	

Table 3: Cluster service time obtained from GPS track data

In Singapore, each postal code represents one unique delivery location and hence jobs ID 1323 and ID 1324 are at the same location and share the same “overhead” time, which is the time taken to park the vehicle and walk to/from the building. Based on the postal code data in Table 3, we also find

that jobs with ID 1323&1324, job with ID 1325 and job with ID1326 are at different locations. In this study, we split the cluster service to each individual location. From the delivery cluster, we split the service time of two different locations using the midpoint of the two EPOD timestamps. As illustrated in Figure 5 below, 4 addresses with 3 different locations are visited. As block 758 has 2 delivery jobs, we consider the earliest delivery (job ID 1323) as the first delivery (FD) and the latest delivery (job ID 1324) as the last delivery (LD) for the same delivery location. The same method is used to define any number of delivery jobs in a single block. If the block has only one delivery, it will be both the first and last delivery.

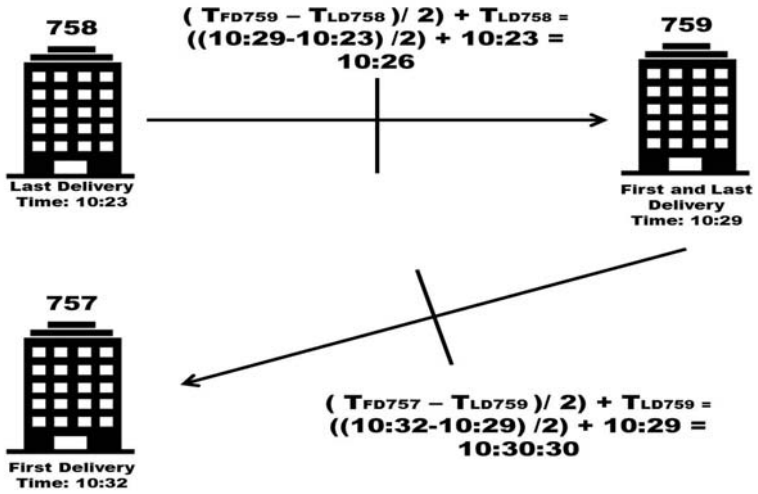

Figure 5: Illustration on how to split the service time

Based on the method described above, the service time is split into three service times based on different delivery locations as shown in Table 4.

ID	LATITUDE	LONGITUDE	TIMESTAMP	POSTAL CODE	SERVICE START and END TIME
1323	1.4459	103.7951	14/6/2016 10:17	730758	10:15:39 to 10:26
1324	1.4463	103.7953	14/6/2016 10:23	730758	
1325	1.4464	103.7942	14/6/2016 10:29	730759	10:26 to 10:30:30
1326	1.4465	103.7944	14/6/2016 10:32	730757	10:30:30 to 10:34:21

Table 4: Split the cluster service time

Conclusions

In this paper, we proposed a framework to retrieve the delivery service time for vehicle routing. Delivery service time can be retrieved from GPS track data and EPOD data. More service time data can be collected when more and more historical data are collected and processed. As the weight and volume of the product delivered by different transportation companies may be very different, the historical service time can only be used by the company itself. Based on the proposed framework, transportation companies is able to predict the service times of delivery jobs based on the historical service time retrieved from their historical GPS track and EPOD data. Therefore, it is possible to develop more efficient and executable delivery routes which are very important for on time delivery service.

In this study, we did not study the relationship between cargo weight, cargo volume, address type, product type, vehicle type and service time. Further work can be done to study the relationship between these factors and service time in order to predict more robust service time. Moreover, the service time may be able to be used cross different companies.

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3) Three letters of recommendation.
4) A statement of intent to pursue a Ph.D. degree.
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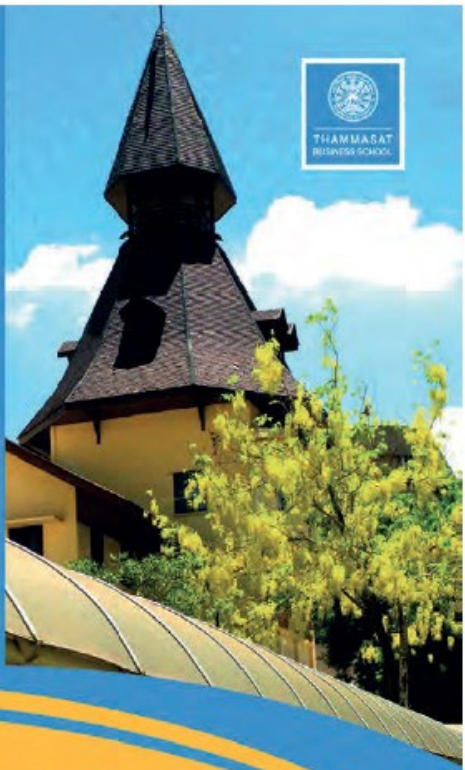

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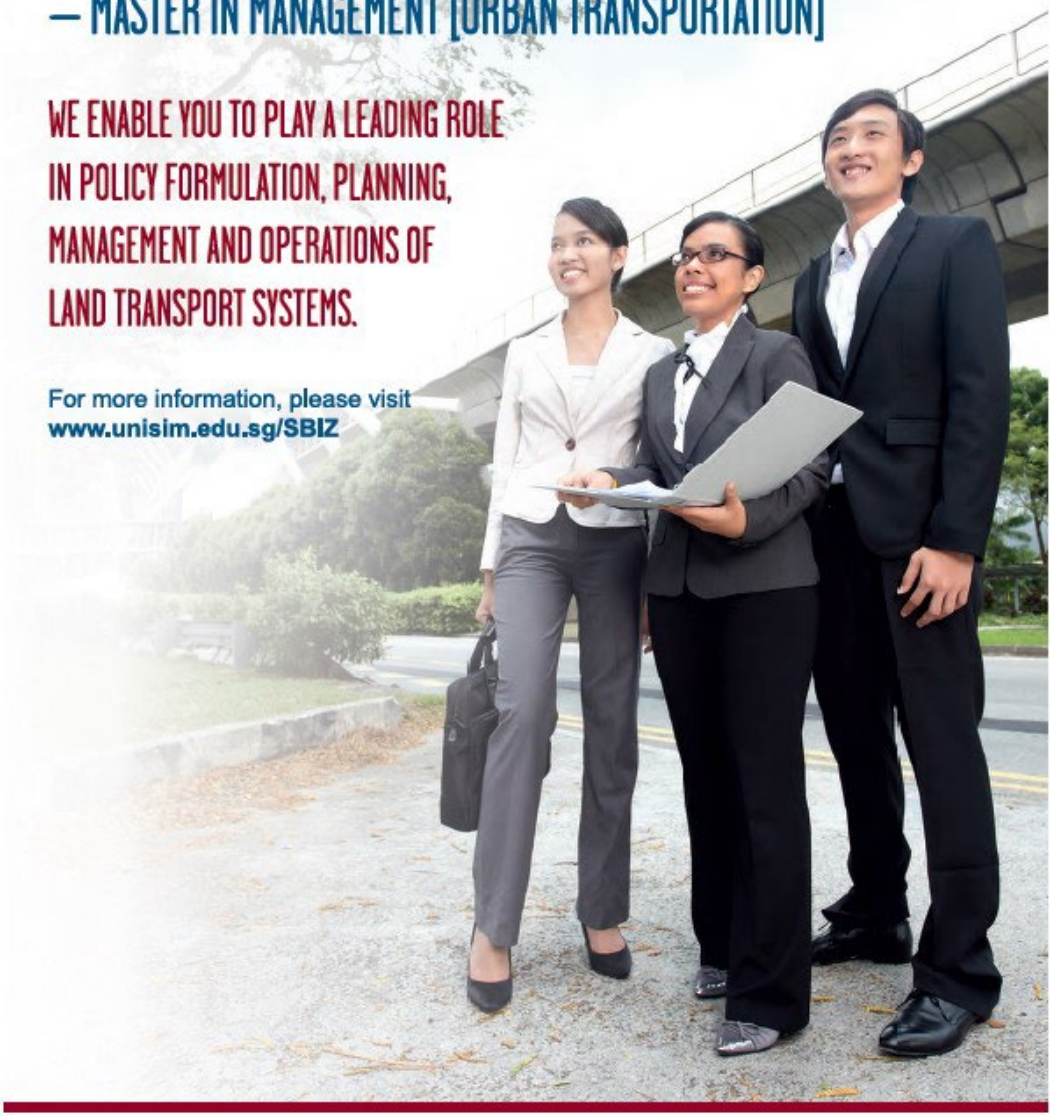

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