Thorsten Blecker, Wolfgang Kersten and
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Innovative Methods in Logistics and Supply Chain Management

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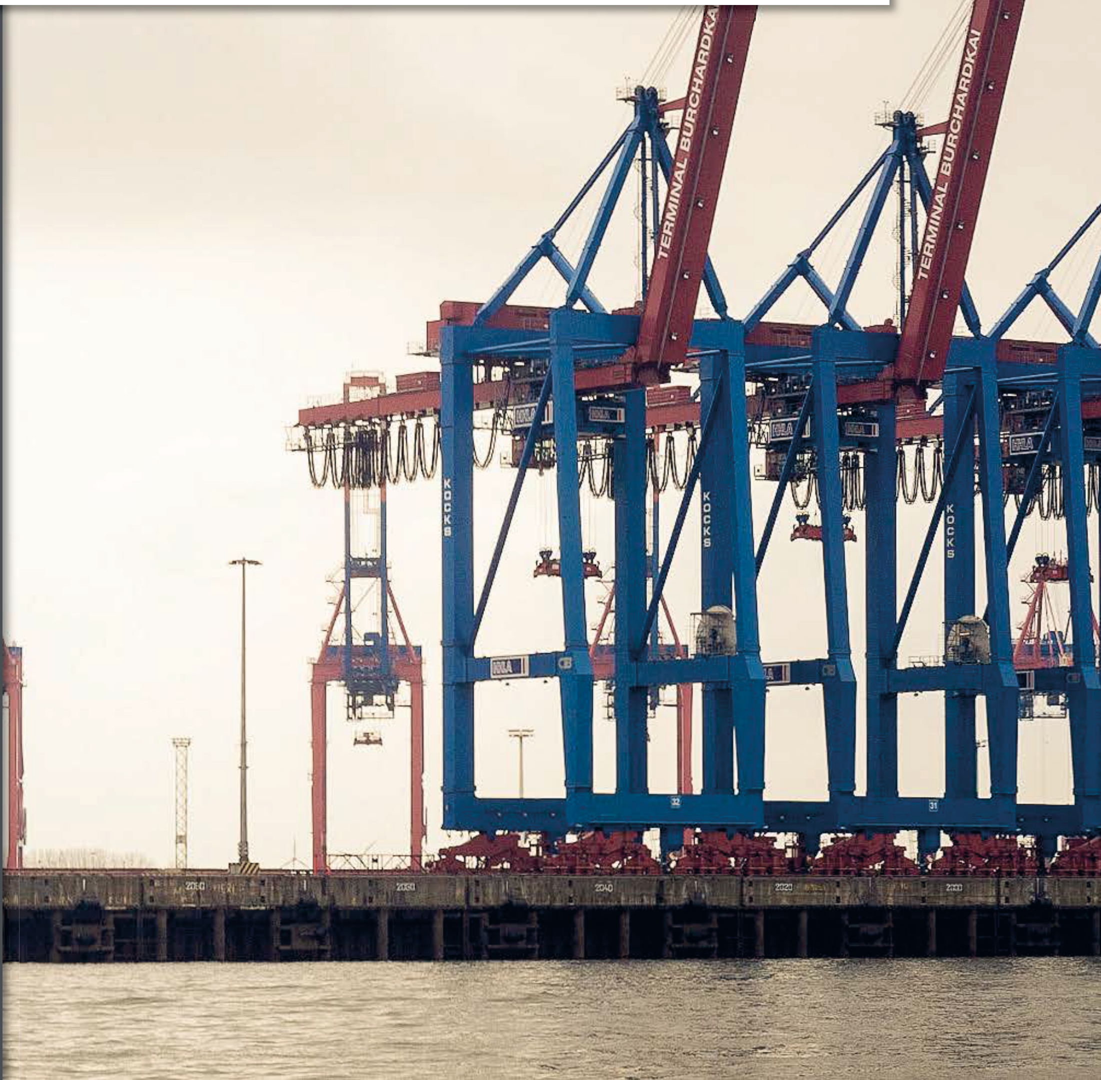

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Current Issues and Emerging Practices

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Preface

Innovation is increasingly considered as an enabler of business competitive advantage. More and more organizations focus on satisfying their consumer's demand of innovative and qualitative products and services by applying both technology-supported and non technology-supported innovative methods in their supply chain practices.

Due to its very characteristic i.e. novelty, innovation is double-edged sword; capturing value from innovative methods in supply chain practices has been one of the important topics among practitioners as well as researchers of the field.

This book contains manuscripts that make excellent contributions to the mentioned fields of research by addressing topics such as innovative and technology-based solutions, supply chain security management, as well as current cooperation and performance practices in supply chain management.

We would like to thank the international group of authors for making this volume possible. Their outstanding work significantly contributes to supply chain management research. This book would not exist without good organization and preparation; we would like to thank, Sara Kheiravar, Tabea Tressin, Matthias Ehni and Niels Hackius for their efforts to prepare, structure, and finalize this book.

Hamburg, August 2014

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Abstract

During the last decades several research projects and related initiatives have investigated innovative approaches and solutions aiming at improving transport logistics. However the level of adoption has still not reached a satisfactory level. In fact, compared with other industry sectors it is very low.

The European Union (EU)-funded project Loginn - Logistic Innovation Uptake – aims at investigating the reasons behind this and to develop methodologies for overcoming the slow innovation uptake in the field of logistics. As an example, for research and development projects in the logistics area the idea is to improve their capabilities to bridge the gap between pilot implementation and marketable solutions. For this purpose, the project will examine existing approaches of innovation achievement. Combined with the identified barriers and gaps currently hindering innovation in the logistics sector, this will serve as an input that culminates in a Logistics Innovation Action Plan for Europe integrating existing initiatives for accelerating logistics innovation market uptake into a comprehensive, straightforward form with a precise initiatives-to-do list.

In addition, the project aims at disseminating innovative logistics practices, technologies and business models to the logistics community and fostering the information exchange on innovation in logistics. For this purpose, an information hub for logistics innovation, the "LogisticsArena" (www.logisticsarena.eu), was established, which is supported by additional activities on social media like Facebook, LinkedIn and Twitter. This paper presents first results of the project.

Keywords: maritime piracy, anti-piracy measures, effectiveness, commercial shipping

1. Introduction

The transport logistics network in Europe represents the aorta of the European economy. Only through the provision of a fast and reliable logistics structure, pan-European and international cooperation between enterprises in Europe can be realised and support the European competitiveness. However due to the recent developments e.g. high fuel prices, the need for green co-modal and intermodal logistic concepts, smaller consignment sizes, etc., new challenges arose. These are often of complex nature, like the expected increase in freight transport volume and the respective impact on the environment and on the life of citizens, especially taking into consideration that Greenhouse gases (GHG) emissions, noise and dust caused by freight transport are already a problem today, contributing with one third of all transport emissions in the EU (European Commission, 2010a). Innovation is a key factor for addressing these challenges and thus it is of utmost importance that the innovation potential can be fully accessed in order to nurture intermodality and co-modality (Behrends, 2009) as well as to improve the productivity, since the efficiency within this sector improves less than average. One main factor is the lack of interest in innovation in freight transport, compared to other sectors. Research shows that other industry sectors spend from 4.8 to 17.8% of their turnover on research and innovation, compared to only 1.1 % for the transport industry (Wagner, 2008), leading to a lower adoption level than in other sectors. (Nilsson, 2006) and (Sternberg et al., 2011) see the main reasons in missing clarity about promising innovation potentials. With its Europe 2020 strategy (European Commission, 2010b) has formulated a set of ambitious goals in the areas of smart, sustainable and inclusive growth, and further decomposed them into seven flagship initiatives and in the frame of this also funded several activities, often with good results, but low visibility. Among the goals to be achieved, one should mention the 3% target of investments in Research and Development (R&D) and innovation and the 20/20/20 goal (i.e. to reduce greenhouse gas emissions by at least 20% compared to 1990 levels, to increase renewable energy consumption to 20%, and achieve a 20% increase in energy efficiency).

The main objective of the Loginn project is coordinating and supporting Research and technology development (RTD) projects in the logistics area to improve their capabilities to bridge the gap between pilot implementation and marketable solutions. To achieve this goal, Loginn set up a collaborative platform (LogisticsArena, www.logisticsarena.eu) to allow the main stakeholders of the logistics domain (industry, Small and medium sized enterprises (SMEs), public authorities, investors and research organizations) to work together on promoting innovative transport logistics solutions aiming at increasing efficiency with a particular focus on intermodal transport. The Loginn approach for supporting logistics innovation achievement involves three interlinked and mutually reinforcing dimensions: innovative business models within the supply chain, innovative logistics practices, and innovative technologies. A detailed analysis in these fields can be found in (Baalsrud Hauge, 2014).

This paper presents the analysis of the relationships existing between different barriers and drivers throughout the three dimensions of Loginn. It concludes with a list of proposed actions aiming at triggering the adoption of logistic innovation through the use of the identified solutions. These initial actions will serve as input and will be further investigated and discussed in the Loginn action plan.

2. The Loginn project and its instruments

The Loginn project is supporting the development and up-take of innovations by providing a discussion and consensus building platform, the LogisticsArena (LogisticsArena, 2013) aiming at bringing the potential stakeholders and providers together, fostering information exchange and user involvement in the development phase according to principles of co-creation and participatory design. (Schumacher, 2013; Sanders & Stappers, 2008; Bødker, 2005). These principles are not only applicable for product but also service design, and thus also relevant for transport and logistics service development.

Loginn will support innovation adoption in transport logistics by taking a holistic approach that considers several mutually reinforcing aspects of innovation: business models, logistics practices and technologies.

- Business models are the representation of the way the members of a supply chain use their skills and resources to increase customer and shareholder value.
- Logistics Practices of interest for Loginn are the ones that have enabled the transport industry to efficiently evolve in the recent years.
- The technologies considered by Loginn are the one that can support the transport industry, whether they concern infrastructure, hardware, software, or complete eco-systems.

Due to the interrelation between the three pillars, a holistic approach is essential for deriving an action plan aiming at innovation-uptake. Besides, this approach will favour the customization of RTD results towards industrial demand solutions, supporting the development of sustainable business plans for European RTD projects, exploiting synergies between European RTD projects to enable a seamless exchange between RTD projects and logistics stakeholders and finally enabling and supporting the access to Investors (Loginn 2013a-c; L4L, 2010a, 2011a,b, 2012a,b)

The basis of our research is an extensive analysis of more than 300 regional, national, and international research projects and initiatives. Based upon the outcome of these results, we looked at the maturity of the different solutions and the relevance for transport and logistics at one hand side, and its innovation potential on the other hand side. In a second step, barriers for successful introduction were identified (L4L 2011c, 2012c; Loginn 2013a-c, 2014). In a third step the identified barriers from the three areas business models, solutions and practices where compared and commonalities were identified. This methodology provides the consolidated and final list of unique barriers identified during the project, then establishes the matrix of correlation between the different barriers and the innovative solutions surveyed. This first matrix is completed by the correlation between barriers and Loginn innovation enablers of the LogisticsArena. Finally, taking into consideration both unique barriers and innovative solutions as well as the Loginn innovation enablers, this methodology produces the final correlation between all these concepts, identifying guidelines for the use of the Loginn solution according to the real and concrete needs for innovation uptake in the logistics sector.

3. Barriers for Innovation Uptake

This chapter presents the complete list of barriers that were identified in the project. As evoked in the introduction, these barriers will later be aligned into a set of unique barriers.

3.1 Business models

By examining several projects and initiatives (Loginn, 2013a) as described in the approach above, a number of barriers have been identified hindering the market uptake of innovative business models. These are briefly described in the remainder of this section.

- Financial issues

Financial issues, as expected, present one of the most frequently cited barriers. These have to do especially with cases when the initial investment cost (hard or soft infrastructure) either is too high to be covered by one company, or the actual use of the specific asset has to be shared by various organizations due to its nature (e.g. use of public infrastructure also for commercial purposes).

- Missing/limited hard facts

The majority of real-life pilots refer to the introduction of well-defined technological solutions or even practices. Business models behind them remain a "black box" area and their impact is usually treated as "other qualitative impacts" with limited hard data to assess it.

- Misaligned performance metrics

Business models, although centered on a focal organization, have boundaries much wider than those of the specific organization. Thus, by their very nature have inter-firm (and firm-customer) cooperation as a prerequisite. One of the most important barriers hindering this is the lack of alignment between the performance metrics of the involved supply chain actors leading to suboptimal or contradictory results.

- Short contract durations

Bringing an innovative business model in the marketplace requires a significant investment (in terms of preparation time and trust building) between the supply chain actors. Short contract durations and arms-length business relationships between providers and users of logistics services act as a barrier for its market uptake.

- Lack of appropriate legal/institutional framework

Innovative business models usually put pressure on existing legal/institutional frameworks extending their boundaries and challenging their content. This has become evident especially in cases of business models that involve the horizontal cooperation of supply chain actors (thus raising healthy competition concerns) or the involvement of consumers (e.g. crowd sourcing) in the delivery of logistics services (thus raising compensation & cargo insurance issues).

- Customer security issues

Besides data security, customer security issues can serve as a barrier. This is the case especially of business models that incorporate the consumer or city-dweller for the last mile. The perception of the goods recipient on whether it is safe to accept deliveries by a “stranger” or a “neighbour” can serve as a significant barrier.

- Lack of gain-sharing models

Most innovative business models are based on the perception that collaboration can lead to better results for everyone involved. For introducing them though, clear models of how these results are to be split will have to be put in place from an early stage. Such models should lead to quantifiable results and be very clear in its use and allow synergy gain calculation and redistribution.

- Lack of Trust

A fundamental requirement for realizing the full effect of innovative business innovations is to create trust between the involved organizations. This trust can only be achieved through long-term relationships between the actors and contracts that decreases the distance between the companies. Short term, arms-length relationships have to be avoided.

- Need for commonly accepted methodologies & mechanisms

Lack of commonly accepted methodologies can be a significant barrier especially in relatively unexplored areas. Methodologies for allocating the cost of urban-shared distribution systems, for estimating the environmental impact of logistics operations, for assessing the level of risk in supply chain networks, and also commonly accepted mechanisms for obtaining the required data, are cases in point.

- Need for common/compatible operational practices

Business models that involve the collaboration of various actors during the physical delivery process require common or compatible operational practices among the actors involved. This is a typical barrier found in most cases of horizontal or vertical cooperation in the supply chain.

- Need for establishing infrastructure sharing practices

Sharing infrastructure among various partners requires clearly defined practices. Such a requirement becomes evident especially in cases of horizontal cooperation between logistics services providers within a city logistics setting.

- Need for critical mass of on-line private users

Innovative business models incorporating the social media require a minimum critical mass of "enrolled" online private users. This is especially important when social media is not used only as a marketing channel but as a necessary operational tool for supply chain actors interaction. The case of crowd sourcing is the first that falls within this category.

- Need for processing huge amounts of data

Business models involving extended collaboration between different supply chain actors by their very nature place a need for processing effectively and efficiently huge amounts of data. This becomes more critical in the cases when the consumers (end users) are involved as data providers and when the logistics infrastructure is shared.

- Need for information sharing through interoperable systems

The need for processing huge amounts of data is inevitably translated to a need for systems interoperability between the actors involved. This becomes more important when the new business model requires data provision also from a variety of systems (public and private ones) and when the number of smaller-size organizations involved (e.g. such as smallholders, consumers purchasing groups, etc.) is high.

3.2 Innovative practices

Innovation is not only about audacious business models or cutting-edge technologies. Hence, one of the principle threats and most complex dimension of innovation is the one of practices. Even with an optimal business models and the access to the most efficient tools, if parties involved in the logistic chain do not apply efficient practices, their efforts will probably be vain. In this section we briefly explain the different barriers that are faced by the innovation in term of practices.

- Lack of standards

Three different types of standardization problems are identified: data quality, data reliability and Information technology (IT) interoperability.

- Data quality

Many different documents/types of data are necessary for functional supply chain and their synchronization is crucial for that functionality. The quality of data used by stakeholders will determine the quality of the decisions that are taken therefore data quality must be regarded as a crucial requirement towards functionality of the supply chain.

- Data reliability

The human dimension of any project or process has a risk factor associated to the fact that humans make mistakes and an error caused by the misuse of information might have destructive effect on the development of a project. Therefore, it is recommended to set objectives, clear forms that are easy to use by stakeholders, secure storing and confidentiality registers and clear paths of information distribution across the hierarchy of the project in order to eliminate possible reliability issues.

- IT interoperability

Interoperability is the ability of a company to collaborate with others, or among internal organisational units, using information technologies. It is understood that a sustainable supply chain needs to be interoperable both externally and internally in order to optimise the use of resources or acquire necessary relations with the entire supply chain with smooth performance based on the modern IT solutions available in the market.

- Lack of cooperation among actors

Cooperation is critical in addressing a wide range of common highlighted challenges faced by surveyed logistics companies, whose success depends very much on cooperation among relevant actors, however the actors involved could be many: government and other public bodies, private stakeholders of all sizes and, customers, society, technology developers, etc.

- Financial barriers

From initial investments to pay-back time, different economic aspects of financing a project can act as a barrier towards the implementation or the expansion. Budget restrictions limit the overall expenditure on the strategy and are often subject to change given the past profit figures or expected market reduction due to economic changes and as a result, the projects can get delayed and the costs overrun.

- Infrastructure issues

Buildings, terminals, roads, communication networks and energy supply facilities are some examples of infrastructure requiring long-term investment, with expanded life cycle, which involves significant amounts of lead-time to develop, plan and implement, not to mention maintenance investments for its continuity in time.

- Lack of information

Information could be the key to the implementation of ILP and must be properly addressed.

- Effectiveness

As important as an efficient use of information is an effective application of the content of it to the socio-economic aspects of a project. In this sense, for the future benefit of ILP projects, more effective and accurate information systems and evaluations are necessary in order to cope with socio-environmental systems and their future development.

- Complexity in administration

Administrative complexity is usually result of either unrealistic decisions or information overloads. There is still lot of paperwork e.g. for customs clearance requiring filling different forms that are often not compatible among each other and disable communication flows in detriment of the logistics activities. The efforts put in designing an ILP will not be productive if the administrative steps to be followed are not simplified, clarified and easy to access.

- Public opinion

Public opinion as collective behavior can play an important role in decisions and act as propaganda for the accepted/declined projects. An informed public opinion could result positive in reinforcing a socio-economic or socio-environmental initiative towards getting the relevant governmental attention or support. An informed society is more capable of assimilating the pros and cons of each alternative and will tend to present positive approaches to suitable options.

These barriers are identified based upon a thorough analysis of good practices (i.e. the maturity of the solutions is high and the solutions are implemented at least in pilots) (L4L 2011b, 2012b; Loginn 2013b; Amazon 2013; Google 2013; collectplus 2013; iGoeasy 2013; Locative 2013; Batco 2013)

3.3 Innovative solutions

The innovative solutions’ barriers can be divided in three categories:

1. technological barriers such as Immaturity of innovative technologies, lack of reliability and accuracy, security concerns and lack of standardization
2. barriers related to solutions' business model such as the cost, privacy concerns, limited target group, organizational issues, lack of transferability and lack of awareness
3. barriers related to business processes such as deployment considerations, labour considerations and increased fuel emissions

In detail, the following barriers were identified:

- Immaturity of innovative solutions

While technologies such as mobile communications and Social media are considered mature there are technologies that are still only subjects of research and funded projects or others that are used in commercial level but their use is not widespread and they are still facing inherent problems.

- Lack of reliability and accuracy – security concerns

Often the information channels through which information is gathered are not owned by the organization using the information. In most solutions, there are multiple stakeholders and there are different parties for collecting, transmitting, storing and managing the data. This fact raises questions about the data consistency, integrity and liability. Specific mechanisms have to be set for securing the data and evaluating their source.

- Lack of standardization

One of the main constraints for most technology solutions is the unsolved issue of the standardization of communication technology and protocols. Before solutions are adopted by the industry on a large scale, issues of technology incompatibility and lack of standardization have to be resolved.

- Costs

There are many cost aspects as far as the adoption of an innovative solution is concerned; these are in detail software costs that are usually license costs, hardware costs referring to purchasing, installing and maintaining equipment, training costs, and operational costs.

- Privacy concerns

Privacy concerns are raised in most of the solutions where data are transmitted, stored and used by many different stakeholders.

- Limited target group

Some of the solutions analyzed refer only to specific parts of the logistics industry. There are solutions dealing only with one part of the logistics operations (e.g. solutions that are used only for quotes and contracts). Others refer only to a part of the logistics sector (e.g. solutions that apply only to SME), and a third group is limited to the partners of the specific company who developed the solution.

- Organizational issues

There are solutions that involve players from many different sectors: the automotive industry, road operators and telecommunications operators, as well as road-based service and equipment providers. In some of them the participation of local or central authorities is essential. Additionally, mechanisms also have yet to be defined for the payment and billing for the services that are offered by different providers. Therefore there is a need for sufficient regulations and decisions on the governance of such systems.

- Lack of transferability

This barrier appears in solutions that they were built at first place customized for a specific organization or a specific part of the logistics sector.

- Lack of awareness

Companies that introduce innovative solutions and governments that want to set these solutions as standards have to run awareness campaigns in order to overcome the market's and people's skepticism towards these solutions or their ignorance.

- Deployment considerations

In many innovative solutions the transition from the previous legacy systems to new technologies and systems is not a smooth procedure. Highly qualified personnel is required, new business processes have to be created, other have to be abandoned and good practices have to be revised.

- Labour considerations

The adoption of innovative technologies implies changes in the workforce of an organization. New expertise is required while skills acquired before years may become obsolete. In emerging technologies there are few people with the necessary competences. Additionally, the adoption of innovative technologies may result in frustration to the employees that have to change the way they normally used to do their job.

- Increased fuel emissions

The use of vehicles by following strictly alert signals and safety warnings may result in more unstable driving speed which in turn results in more fuel consumption (cost) and more fuel emissions.

There are certain barriers that are met to almost all the innovative technologies such as lack of standardization, security concerns, involved costs and deployment considerations. As a consequence of these barriers the logistics sector is reluctant to adopt them. However, it cannot be foreseen that the adoption of innovative solutions provides strategic and operational advantages to companies that understand their needs and have a clear view of how to use new tools for fulfil them. As the technologies become mature, logistics companies should follow their evolution and find the right time to use them to their advantage (L4L 2010, 2011b,c, 2012b,c; Loginn 2013c; ActivePivots 2013), Deal 2013; Jumptrack 2013; TQL 2013; Tweetload 2013)

4. Identifying unique barriers

The identification of unique barriers could seem redundant with the previous chapter; however, beyond the natural need to remove duplicated barriers, it also serves a second need: the consideration of barriers against the complete logistic innovation space (relying on the three Loginn dimensions). Hence what is also extremely important in this process is to identify the accurate “level” of the barrier, identifying a barrier too generic or too specific will prevent the accurate identification of enablers and actions. In the following we provide a list of unique barriers which was used for our analysis:

- Complexity in administration
- Costs - Financial Issues
- Deployment considerations - system governance and ownership
- Fuel emissions
- Immature technology
- Infrastructure issues
- IT interoperability
- Labor considerations - workforce expertise
- Lack of awareness
- Lack of cooperation between stakeholders
- Lack of legal/institutional framework
- Lack of operational interoperability
- Lack of Standardization
- Lack of Trust
- Limited/Misaligned evaluation data (e.g. from pilot implementation)
- Privacy - Security issues
- Reliability – Quality - Accuracy of data
- Users' & market size considerations

5. Loginn Innovation enablers

Based upon the early identification of barriers within the three pillars, the next step is to consider how to overcome those barriers. For this purpose, Loginn Innovation enablers where identified. Some of the proposed enablers are directly related to the operation of the Logistics Arena, while others are initial proposals to be further elaborated in the Loginn Logistics Action Plan.

5.1 LogisticsArena as consultation platform for content

The first enabler is the LogisticsArena itself, which per definition should be the virtual place where interested parties could meet, discuss, share success or failure stories. Six individual factors related with the LogisticsArena were grouped under this enabler. The LogisticsArena should be a guide for logistics companies where they can see output from innovation and how to implement it themselves. Therefore the LogisticsArena should provide best cases and describe them in a way that they could be easily understood and be of help also for SMEs. To this end it would be necessary to create templates to describe best logistics practices with also a focus on SMEs. In order to stimulate the discussion, the LogisticsArena should invite relevant stakeholders to share good examples for innovative solutions for logistics problems. For a better usability of the LogisticsArena it would be appropriate to restructure and refocus arena content considering, as target group, the persons responsible of innovation in companies and providing topic groups for specific innovation issues (e.g. humanitarian logistics networks, cloud company closed services).

5.2 Arena as community

The LogisticsArena is not just another website, the most valuable result for Loginn will be the community that will grow around it. The second enabler is therefore the LogisticsArenaCommunity (LAC). The community in itself is not a real enabler, in this case the term facilitator would be more appropriate, but a live community is the real vehicle to innovation. The LAC should target/attract experienced professionals to create a fostering environment. This professional community could then become a trusted source of inspiration for professionals in logistics. The LAC will possibly introduce/request new feature in the LogisticsArena like experience database, contact list, and innovative logistics companies' catalogue to define/ accelerate the Innovative SME's Communities building. The focus on SMEs is not a limitation, but SME do need innovation and could benefit from a collaborative environment.

5.3 Education

Loginn's main objective is to make available the knowledge that is spread among different stakeholders, to this end one important aspect is education. In this context it could mean to establish educational initiatives, e.g. establishment of Master Programs at academic institutes. To support the above initiatives it will be necessary to define training and educational system dedicated to technology and innovation managers in the field of logistics and provide tools to share knowledge via practical and scientific discussion that will allow the creation of a professional network. The expected result would be a methodology to develop innovative concepts to solve real problems.

5.4 Coaching

Education would be pointless if not supported by adequate follow-ups on the field, for this reason Coaching is the fourth identified enabler as it will support logistics companies to dare to take on new alternative technologies. It should provide concrete and easy-to-use examples for logistics companies to follow in their business development, through a set of prioritized R&D action that could support the innovation uptake, examples and results from previous R&D projects. Partners of R&D Community should provide the necessary support channeling the European Commission directives and initiatives. The major result will be the possibility to link single company innovation success with the community targets for sustainability.

5.5 Innovation services intermediary

While Education coaching and technology transfer are enablers supposed to transfer the knowledge towards the logistics companies and operators, the Innovation services intermediary will operate to increase the understanding of Information and communication technologies (ICT) influence on collaborative logistics processes with the aim of supporting, developing and defining an Innovation services ecosystem for logistics.

5.6 Innovation monitoring

Promoting innovation requires also a process for monitoring its progress. The LogisticsArena will incorporate a limited but rather comprehensive set of indicators, following the logic and structure of the already established Innovation Union Scoreboard. The so called “Logistics Innovation Scoreboard” can provide the basis for harmonizing future efforts on monitoring the evolution of logistics innovation in Europe.

5.7 Consensus building platform

As this enabler involves the sharing of experiences on logistics innovation initiatives and the building of consensus on possible solutions or future focus areas, it is expected to have a positive impact on all barriers identified. In specific, the mechanism of consensus building platform where different stakeholders can bring their specific needs and perspective into discussion and also provide necessary information will make it possible to analyse the barriers from different perspectives and commonly search for common solutions. By looking at the identified barriers, it becomes clear that the complexity of these barriers requires a multi-perspective and consensus building approach. In addition, this platform will also provide access relevant information on frameworks, legal rights and obligations, new solutions etc. That will help in the consensus building process.

5.8 Innovation ecosystem

Bringing together logistics innovation experts into a community is among the main prerequisites of building an innovation fostering environment. Community members contact details and expertise will be made available to potential innovation adopters (especially SMEs due to their increased need for innovation) providing awareness on innovation services availability. Moreover, creating an innovation ecosystem, due to the improved interaction among innovation providers and users, is expected to increase trust and improve cooperation prospects. The access to the expertise will also provide a faster information of latest developments in the three areas. This will foster the ideation process and encourage people to innovate since it also reduces the risks of developing solutions already existing. The effect of best practice access presented in a trustworthy environment will also lead to a faster uptake. At the same time, as the ecosystem develops the size of the innovation market is expected to increase.

5.9 Interface for developing synergies with other initiatives

Developing synergies with other initiatives like the ALICE platform (Alice, 2014) can address in a more effective way common barriers such as the ones related to interoperability issues (operational & IT), missing legal/institutional components, technology immaturity and data quality/reliability.

6. Derivation of Actions

6.1 Overall approach

The analysis presented in the previous chapters forms an integral part of the overall approach employed by Loginn for accelerating logistics innovation market uptake, which bases on the three dimensions of logistics innovation, as identified by the Loginn project: Business Models, Logistics Practices & Enabling Technologies. For each of the innovative solutions identified within the project, the respective barriers in bringing them to the market place were identified. These dimension-specific barriers were further aligned into a set of unique innovation barriers, removing any double references. Based on this analysis, the Loginn approach for accelerating logistics innovation market uptake was applied. The first group of actions is based on the employment of the Logistics Arena. The Arena was initially envisioned as a technological platform to facilitate opinion sharing and ultimately consensus building on the major problems and solutions regarding logistics innovation market uptake. As the project was progressing, it became evident that the Arena could play a wider role. This enhanced role of the Logistics Arena is reported in the present paper and includes a number of innovation enabling functions, i.e. the Arena as an innovation ecosystem, a consensus building platform, an interface for developing synergies with other initiatives, an innovation monitoring tool, an intermediary for innovation services, and a sustainable innovation facilitator.

Finally, Loginn believes that a number of additional innovation enablers can be employed. These are of a more general nature and relate to policies, regulatory measures, financial mechanisms, innovation management actions and future research directions. These are to be addressed in the forthcoming Logistics Innovation Action Plan.

6.2 Proposed Actions

In order to advance the work on the Logistics Innovation Action Plan and to ensure the user involvement, the action plan will be developed by using an agile development approach, we here describe some of the types of actions to be envisaged to complete the channeling of logistic innovation uptake. A key for the long term logistic innovation is the exploration and organization of future research directions. It will be critical for the logistics domain to fully accompany its future research directions with clear objectives, ensuring that research outcomes are indeed taken into account and fully exploited. The uptake of logistics innovation is prevented or limited by the lack of research or proper management. In the end, finance plays a core role within logistics. Hence, the very nature of goods transport is not only about an unavailable good, but rather about obtaining it at the lowest price, even if it is already available at the desired location. As an example some countries are exporting high quality fruits while importing lower quality ones at the same time, requiring very competitive shipping costs. In this perspective, the proposition and emergence of more adapted financial mechanisms would become both a driver for innovation accomplishment and a key element fostering new innovation. Even if innovation has to be fostered and protected, it cannot be done at all costs. As illustrated in the previous sections, some of the barriers faced by the further uptake of logistics innovation are linked to the lack of proper regulatory measures that would channel their application. In this perspective, logistics innovation and policies have to be considered together with proposals of regulatory measures on a transnational level.

7. Conclusion and next steps toward an holistic action plan

Innovation is a key factor for the competitiveness of the European industry and has historically played a vital role in increasing efficiency. The transport logistics industry has seen relatively small improvement in terms of innovation with o only 1.1% of the turnover for the transport industry.

In this paper we describe the Loginn approach and presented the first analysis results of innovative business models, good practices as well as technological solutions. There are several solutions available at a prototype level, i.e. technological solutions are available, but either not robust enough yet, or the potential market is not ready for the innovation. In addition, it can be stated that several of these prototypical solutions do not deliver a business model suitable for potential customers, and that there is a lack in large scale deployment of many of the solutions.

This paper provides a critical element for the uptake of logistics innovation by identifying the links existing between the current barriers faced by the domain and the drivers that could help overcome them. In addition we identified how the enablers offered by Loginn’s LogisticsArena supports, channels and fosters innovation, further allowing the overcoming of existing barriers. This paper provides valuable information about the most useful and promising solutions and enablers. A clear identification of unique barriers is provided requiring attention due to the necessity of specific solutions. Finally, we propose actions leading to an improved innovation uptake in logistics by considering logistics innovation and policies together with proposals of regulatory measures on a transnational level.

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A General Framework for Open Service Innovation in Logistics

Katharina Kalogerakis and Nikolaus Wagenstetter

Abstract

Compared to other industries the innovative output of logistics service providers (LSPs) is rather low. By enforcing their attempts to innovate these companies could improve their competitive position. Empirical studies indicate that proactive innovations result in significant improvements of customer loyalty for LSPs.

Most LSPs are B2B service providers and therefore depend heavily on good relationships with their customers. Additionally, they have to act in a very competitive environment characterized by low profit margins. Looking at this special position, the question arises if methods of open innovation are a suitable approach for LSPs to fix their innovation deficit.

Methods of open innovation originate from development processes of tangible products. Although, by now, open service innovation is also evolving, the logistics sector is still lacking behind. The aim of this paper is to evaluate a general framework for open service innovation in logistics. To specify requirements of LSPs in regard to open innovation procedures, interviews with responsible managers of LSPs were conducted.

Keywords: open innovation, logistics service providers, innovation methods, interviews

1. Introduction

Due to an increasing trend towards outsourcing and globalized supply chains the logistics industry is rapidly growing (Anderson et al., 2011; Ellinger et al., 2008). Many logistics service providers (LSPs) try to take their share in this expanding market segment. Fierce competition often results in thin profit margins for LSPs. In this context, innovations provide LSPs an opportunity to strengthen their competitive position. The launch of new services offers additional revenue streams and can establish a unique selling point to the customer. Improved processes are valuable contributions to cost savings as well as increased quality. However, the innovative output of the logistics service industry is rather low. Wagner (2008) shows exemplarily for German firms that the share of innovators in the transportation sector is only 30% compared to an average of 60% innovators in manufacturing companies or 52% innovators in knowledge-intensive services. These figures indicate that LSPs face significant deficits concerning their innovation management.

The development of new logistics services differs from the development of tangible products as performed by manufacturing firms. Services have special characteristics calling for new approaches of innovation management (de Brentani, 1989; Gallouj and Weinstein, 1997). As services are intangible, they cannot be stored and their actual performance occurs during the process of consumption. Furthermore, their production usually requires the participation of the client (Gallouj, 2002; Cowell, 1988). Accordingly, service innovation relies even more on customer orientation and integration than product innovation.

Today logistics service innovations are predominantly developed as a reaction to specific customer requests (Wallenburg, 2009; Burnson, 2013). Such reactive innovations are more difficult to manage than proactive innovations, because they are restricted by extreme time pressure (Oke, 2008). Furthermore, following such a reactive approach to new service development hampers the development of standardized solutions. Usually, a large additional development effort is required to offer these individualized innovations to other customers (Wagner and Franklin, 2008). Besides, often only minor improvements strongly based on industry trends are generated, because these ad hoc unplanned innovation efforts are seldom supported by methods of innovation management (Busse and Wallenburg, 2011; Wagner and Franklin, 2008).

Furthermore, empirical results indicate that proactive improvements can strongly foster customer loyalty (Wallenburg, 2009; Cahill, 2007). A large customer segment does not perceive logistics services as a commodity (Anderson et al., 2011) For these customers, the offered logistics services are essential to their business performance. Therefore, they choose LSPs that provide good quality services and show their ability to proactively develop new service solutions (Cahill, 2007; Anderson et al., 2011). Finally, service innovation capability can directly lead to higher levels of market performance for LSPs (Grawe et al., 2009) and innovative LSPs profit from lower logistics costs as well as higher EBIT margins (Little, 2007).

Traditionally, LSPs are very operative oriented and only a few LSPs have special personnel or a budget for innovation management. Hence, it seems unlikely that these companies will be able to enhance their innovative output based on solely internal resources and capabilities. Therefore, we suppose that the concept of open innovation (Chesbrough, 2003) will help to identify practices and methods to increase the innovation performance of LSPs and thereby improve their competitive position. Accordingly, the aim of this paper is to analyze the concept of open innovation for the logistics sector. It needs to be evaluated if certain practices and methods of open innovation are suitable to overcome innovation deficits of LSPs. In order to answer this question, special demands of LSPs concerning their innovation context are raised in interviews with leading persons from LSPs.

In the following section the concept and methods of open innovation are introduced. Then, in section three, our research approach is described. Afterwards, in section four, results of our qualitative investigation are presented. The paper concludes with a discussion of results and an outline for future research.

2. Concept of open innovation

Open innovation is a concept of innovation management characterized by open systems of research and development. Innovative ideas and solutions can stem from inside as well as from outside of the company.

“Open Innovation is the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively.”(Chesbrough, 2006)

Two main processes of open innovation can be distinguished. Inbound open innovation encompasses the use of external knowledge and discoveries. In this sense, internal R&D should be supplemented by external sources. Outbound open innovation describes openness towards the market. Companies should be aware that there might be external organizations better capable to commercialize a new developed technology (Chesbrough and Crowther, 2006; Chesbrough, 2003). Gaining external knowledge and bringing ideas to new markets can, of course, also be combined. These coupled processes encompass “co-creation with (mainly) complementary partners through alliances, cooperation, and joint ventures during which give and take are crucial for success.” (Enkel et al., 2009)

Although practices of open innovation have been used over many decades, recent developments made it necessary to further open up innovation processes. Due to trends like outsourcing, agility, and flexibility, companies were forced to reconsider their strategies and processes leading to new approaches of innovation management (Huizingh, 2011).

As the concept of open innovation is rather broad, there exists no consistent classification of open innovation activities or methods. Based on a literature review about open innovation and own research about inventive cross-industry analogies an overview and classification of open innovation activities is given in Table 1 (Enkel et al., 2009; Parida et al., 2012; van de Vrande et al., 2009; Mina et al., 2014; Chesbrough, 2006; West and Gallagher, 2006; Kalogerakis et al., 2010; Wagenstetter et al., 2013).

Inbound Open Innovation (Outside-In)

- Technology scouting
  - Systematically assessing technology trends
  - Search for cross-industry analogies
- Technology sourcing
  - Buying external technology
  - Investments in start-ups and other businesses
  - Inward licensing of IP
- Customer involvement
  - Engaging with lead users and early adopters
  - Submission websites and idea competitions
  - Virtual communities
- Use of innovation intermediaries
- Outsourcing R&D

Technology exploration

Outbound Open Innovation (Inside-Out)

- Venturing
  - Spin-off
  - Spin-out processes
- Outward licensing of IP
- Selling IP
- Selling technology to other industries

Technology exploitation

Coupled Processes / Co-Creation

- Vertical collaboration (with present or potential customers and suppliers)
- Horizontal collaboration (with partners from the same or other industries that are not part of the value chain)
- Participation in open source developments
- Innovation networks

Tab. 1: Overview of open innovation activities

Prominent examples of open innovation stem from large manufacturing firms belonging to the high-tech sector (Chesbrough, 2003). However, growth strategies concerning revenues as well as new products led to the adoption of open innovation concepts across diverse industries (Chesbrough and Crowther, 2006). Furthermore, small and medium sized companies also practice open innovation. They can profit a lot from opening up their innovation processes, because they often lack resources to develop and commercialize new products on their own. Empirical results of van de Vrande et al. (2009) "indicate that open innovation in SMEs is mainly motivated by market-related targets: SMEs make use of several open innovation practices at the same time to serve customers effectively or to open up new markets, with higher-order objectives to secure revenues and to maintain growth." This was confirmed by Parida et al. (2012) who investigated effects of four inbound open innovation activities on innovation performance of high-tech SMEs. On the one hand, SMEs compared to larger firms are restricted concerning the practice of open innovation due to a lack of own resources and unstructured innovation processes. On the other hand, SMEs can profit a lot from open innovation activities, because these provide a way to compensate for the scarcity of internal resources and competences (Parida et al., 2012). Based on these results, it can be supposed that small and medium sized LSPs who lack internal resources and competences to innovate will also profit from the open innovation approach.

Although research about open innovation started in the tangible goods sector and most empirical results stem from manufacturing and high-tech companies, Chesbrough (2011) himself expands the discussion of open innovation to service innovation. He provides several examples how service companies can profit from open innovation. One important strategy for service companies is to open up towards their customers. For B2B-service providers it can be valuable to embed their company in the customer's organization. United Parcel Service (UPS), for example, offers its customers to take over the function of their shipping department regardless of which company is responsible for transportation. Thereby, their services can reach higher quality and they get valuable insights into processes of their customers stimulating further innovations. In this case, open innovation also means an increased sharing of previously internal resources and processes like information technology with customers. Besides, open innovation in the service context often encompasses economy of scale effects – such as Amazon created by opening up their shop-portal to external sellers. Furthermore, openness helps service companies to stay ahead and create a series of temporary advantages. Although these advantages will be copied by other companies if they are valuable, they help to establish a leadership position attracting more customers. Finally, a major advantage – also for small companies – is the opportunity to enrich and strengthen the relationship to their customers (Chesbrough, 2011; Chesbrough and Euchner, 2011).

The importance of customer involvement in open service innovation is also confirmed by Mina et al. (2014). Based on a large empirical survey of UK firms, they provide evidence of open innovation practices in business services firms. Results show that 70% of the respondent service firms engage directly with lead users and early adopters. All other analyzed open innovation activities were much less frequently used (Mina et al., 2014).

In the context of B2B service innovation in the transportation industry, Wagner (2013) conducted a first quantitative analysis. Based on secondary empirical data raised 2005 in a German innovation survey, he tested the influence of different external partners as sources of innovation in relation to innovation performance (measured as service improvements and new services). Results show that altogether the innovative output of the participating LSPs is low: Only 6% of their annual sales are based on improved services. Hence, it is not surprising that external sources of innovation are only seldom used by these companies. Yet, the proposed hypotheses could be supported: (1) "The utilization of external partners as sources of innovation is positively related to innovation performance" and (2) the "benefit of utilizing external partners as sources of innovation … depends on the type of partner". Improved services were positively related to customers, suppliers, and competitors as sources of innovation, but not to consultants and universities. The development of services new to the firm was only positively related to the involvement of customers (Wagner, 2013).

Altogether, the results presented in this section indicate that open innovation practices constitute a promising approach for LSPs to foster their innovative output. In order to further investigate the suitability of certain open innovation activities for LSPs and to derive more specific recommendations for improvement, we interviewed leading persons working for LSPs of different sizes.

3. Research Approach

Because of limited research results available regarding open innovation practices of LSPs, a qualitative research approach was chosen to identify their demands and requirements (Myers, 2013). Eight interviews were conducted in six different companies starting in April and ending in June 2014. The interviews were addressed to higher management of small and medium-sized LSPs as well as to leading managers of large LSPs based in Germany. Table 2 provides an overview of some basic facts concerning the surveyed LSPs.

The semi-structured interviews were held either personally or via telephone and lasted each between 30 and 60 minutes. In an introductory part, facts about the company and the interviewed person were complemented. Additionally, it was asked if they actively practice innovation management and what innovation means to them and their company. The rest of the interview was structured in three main parts:

- Involvement of customers in the innovation process
- Involvement of other external parties in the innovation process
- Innovation contests

Each topic was looked upon from different perspectives. First, current practices were collected including pros and cons. Second, the interviewees were asked to anticipate future developments in order to evaluate which further activities might be feasible and which activities they strictly reject including an explanation of their choices.

Company	Size (no. employees)	Interviewee position	Competence area of interviewee
A	Medium (< 100)	Innovation assistant	B2B-logistics (last mile)
B	Large international (> 90.000)	Site manager	Manufacturing logistics (automotive)
		Project manager	Manufacturing logistics (automotive)
		Branch office manager	Manufacturing and distribution logistics (diverse industries)
C	Large international (> 2.000)	Head of projects	Manufacturing and distribution logistics (diverse industries)
D	Small (< 50)	Managing director	Freight forwarding
E	Large international (> 50.000)	National Manager	Sea freight systems (development and support)
F	Large national (< 500)	Managing director	Freight forwarding and warehouse logistics

Tab. 2: Overview of interviews

4. Results

4.1 Innovativeness

In order to better understand and assess the answers regarding open innovation practices, we will first take a look at the general answers concerning innovation and the innovation management at the surveyed companies.

The innovativeness of the interviewed companies varies greatly as an effect of company size and culture. At the low end of the spectrum, company D is situated, a small freight forwarder struggling with its day-to-day business. In this company, resources for innovative projects are very limited and customers usually demand standard freight solutions.

Company F classifies as a large national company offering standard and branch specific freight forwarding and warehouse logistics. It has no special department or personnel for innovation management. The only driver of innovation is improvement in processes.

Medium sized company A is very innovation driven. Due to a strong innovation focus of its managing directors, weekly internal meetings to spur innovation are held. The interviewee is a special innovation assistant responsible for pushing and promoting innovative projects.

All three large international LSPs (B, C, E) provide a central innovation department. However, most innovative projects are conducted decentralized at the local sites of the companies. Compared to the size of the companies, they still have deficits concerning structured processes and competences to proactively develop innovations.

4.2 Involvement of customers in the innovation process

4.2.1 Dialogue with the customer

The qualitative study of Flint et al. (2005) indicates that LSPs regularly interact with their customers to identify unmet needs and difficulties offering opportunities to improve their services. An important foundation for this dialogue with the customer is the establishment of a customer-oriented and innovative culture. A frequently used approach to gather clues for innovation is the establishment of customer groups: “Key members of strategically important customer organizations were invited to come together at one time in one place to discuss issues with the logistics service provider.” Furthermore, Flint et al. (2005)

describe special approaches of LSPs to intensify this process, as for example formal depth interview processes or extended, single customer retreats.
In the same vein, all interviewed companies from our study regularly seek conversations with their customers. These meetings usually address issues related to improvements of existing business relations. Both customers as well as LSPs initiate such meetings. From the customer side, contact is searched if expectations or agreements are not fulfilled. In company C, for example, continuous improvement processes are part of the contracts with some major customers. If the LSP is lacking behind concerning productivity and cost reductions, these issues will be addressed by the customer.
The LSPs also actively invite their customers to special meetings – usually each customer separately. Strategic meetings are held regularly with large and important customers. Traditionally, these interactions with the customer are used to improve existing customer relationships and for acquisition of new business. However, some interviewees report that they explicitly address topics like improvement processes and future innovations (A, B) with their customers. Interactions based on virtual communities and social networks in the web are not considered a suitable instrument for customer interaction by the interviewees.
An approach to intensify the dialogue with their customers already practiced by companies A, B, C, E and F is to send own employees to the customer company in order to study their processes. However, the LSP first needs specific reasons to enter the customer company. These could be for example:

- Remedy of urgent problems the customer is facing: Employees of the LSP pass through the defective processes and test the involved interfaces in order to detect the causes and to develop new solutions.
- Improvement of existing processes: Joint workshops are held at the customer site to advance and optimize processes involving the operational level.

Employees suitable for this task usually stem from customer management or sales force and possess logistics planning competences. Aim of these visits should be an intensive process analysis and optimization on the operational level as an enabler for new innovative projects. Interviewee from company E, for example, reported that in his competence area they have a special process-team consisting of four business analysts specialized for analyzing customer processes.

Altogether the interviews show that LSPs are involved in an intense dialogue with their customers. Diverse opportunities exist to discuss innovative topics. This should be more actively used by the LSPs to develop new innovative services. Existing information channels used for daily business need to be further evolved to enhance innovations.

4.2.2 Innovation cooperation with the customer

Wagner and Sutter (2012) provide evidence based on four case studies that innovation projects between third-party logistics providers and customers can be very beneficial for both parties involved. All four of their analyzed projects were initiated by customers. However, customers as well as LSPs invested resources in the projects. These resources were mostly complementary to each other and could not have been compensated if the other party was not involved. Direct interactions between the employees of the involved firms as well as testing opportunities provided by both sides paved the way to successful innovation. As a result of the projects, the LSPs could strengthen their innovation capabilities and intensify the relationship to their customers.

Three of the companies that we interviewed already have experience concerning innovation cooperation with their customers (A, B and C). In order to initiate such cooperation a primary willingness of the customer to work jointly and fair with the LSP needs to exist. This encompasses openness towards the development of really new solutions instead of incremental improvements of already existing solutions as well as a willingness to transparently and openly share essential information. Knowledge of the customer’s value chain is a prerequisite to most joint development projects.

The customer needs to draw a benefit from the innovation cooperation to achieve a win-win situation. This is likely if the LSP has higher logistics competences than the customer. Customers with strong own logistics competences are more likely to develop innovations on their own. Sometimes these customers give special defined work packages to external LSPs. In this case, however, the LSP is rather regarded as implementing entity and not as equal cooperation partner. Furthermore, the willingness and ability of a customer to participate in an innovation project depends on its own innovation culture. If innovations are rated high in the customer company then the willingness to also advance logistics innovations increases. Some customers also seek innovation cooperation if properties of their goods are not conforming to standard logistics solutions. For example, if a company wants to ship a good that is too heavy or too valuable for normal transport solutions, it is likely that this company is willing to innovate together with his LSP.

So far, the interviewees did not actively seek lead users among their customers. However, some of the interviewees could report about innovation projects with leading customers of one branch that could be transferred to other customers of the same branch afterwards. Furthermore, some industries are more advanced concerning their logistics solutions than others, as for example the automotive and high-tech industry. Solutions developed here, often can be introduced to other industries later on.

Interviewees from companies D, E and F could not report own experience with customer innovation cooperation projects. However, only the interviewee from the small LSP (D) states that his company is lacking resources and competences to approach customers for innovation projects. Interviewee from company E states that in his competence area of the large international LSP they are aspiring joint innovation projects with their customers, but they are still at the beginning of such approaches. As they are a large international leading LSP, customers attractive for such cooperation projects would need to have a similar size and position in their respective industry. Likewise, interviewee from company F thinks there is a realistic possibility to start innovation projects with industry customers that possess an own innovation department.

4.3 Involvement of other external parties in the innovation process

Apart from their customers, other external parties can be integrated in the innovation processes of LSPs: research organizations, technology providers, consultants and other LSPs.

Joint developments of technology providers and LSPs seem to be common practice. All interviewed companies except for D and F could describe such experiences. Trigger for this kind of cooperation often is a specific customer demand that cannot be fulfilled by currently available systems. Therefore, these joint developments with technology providers usually are initiated after a corresponding contract with the customer was confirmed and the result will contribute to the promised service. The tie of a joint development project with a technology provider to a specific customer mandate is especially important, if the LSP has no own innovation budget.

None of the interviewees reported about a systematic assessment of potential cooperation partners. An important prerequisite for the choice of a partner company is trust in its competence and honesty. This seems to be especially true for software developments, as the effort for such a project can only be estimated with difficulties by the LSPs. A success factor, mentioned by one interviewee is a sufficient support capacity from the side of the LSP for the project. Due to high operational pressure, this often constitutes a bottleneck for LSPs. Furthermore, as participants of these cooperation projects often belong to different knowledge fields and hence are used to different vocabulary, the development of a coherent picture at the beginning can be a great challenge.

Based on the results of the interviews, two versions of development cooperation between LSPs and technology providers exist. The most common way seems to be the development of an individualized product (or a specific customization of a standard product) that the LSP orders from a technology provider. Thereby, the employees of the LSP translate demands of their customers into technical requirements and push the project. Depending on their contract agreements, the resulting technical product either can be solely used by the LSP or is free for

further marketing of the technology provider. In an alternative type of cooperation the technology provider is not paid by the LSP and no formal contract exists. The LSP just contributes his experience into the development of a new product and can thereby influence the final outcome of the project.
A crucial point brought up by one interviewee concerns intellectual property rights (IP). As IP often remains with the technology provider due to cost issues, other competing LSPs might also profit from the new development in the future. Another problem might arise due to a high dependence on the technology provider after the project, as barriers to switching the technology provider can arise. A possibility to reduce this risk is intensive project supervision on part of the LSP. Thereby, missing expert knowledge can be built up and the development output can be transparently documented in order to allow other partners to join the project later on.
All interviewees state their willingness to contribute to research projects, if they are approached. However, they do not actively seek research cooperation, because results will be free to their competitors as well. Most interviewed LSPs could report experience concerning cooperation with external consultants, but these projects were not specifically focused on innovation. Cooperation projects with other LSPs were not described. It seems as if until now, rivalry outweighs expected benefits that might result from such cooperation.

4.4 Innovation contests

Open contests to obtain innovations can be traced back several hundred years (Adamczyk et al., 2012; Boudreau et al., 2011). However, due to developments of Web 2.0 and an increased openness in the innovation process, innovation contests raised in popularity recently. Prominent examples by companies such as BMW, IBM, Dell or Siemens show that innovation contests can constitute a valuable approach to idea generation and concept development (Adamczyk et al., 2012; Füller et al., 2006; Bayus, 2013). Furthermore, idea contests can also deliver solutions for difficult scientific problems (Lakhani et al., 2007) or new software algorithms (Boudreau et al., 2011). Even in the logistics sector some successful examples exist, such as the contests by Deutsch Post DHL and the German CEP service provider Hermes[1].

All interviewed experts had already heard about innovation contests. However, none of the interviewees could look back on own experiences concerning external innovation contest. Just one interviewee from company B described internal idea contests among the employees of his company. A common difficulty seen by the interviewees is the problem of information disclosure in public contests. If they seek solutions to specific customer requests, they are restricted by confidentiality agreements. However, some of the interviewees can imagine using public idea contests for general problems that are not connected to a specific customer request. Here, positive effects are expected concerning the communication of innovativeness to the public.

As an alternative, some interviewees approve of the idea to address innovation contests to logistics technology providers. Within the framework of a functional call for tender, these companies could compete against each other about the best concept. As a reward the winner would get the job to further develop and implement the submitted solution.

Based on these insights, public innovation contests seem to be an instrument that can be rather used if innovations are to be developed independent of specific customer requests. As, however, a proactive innovation development seems not to be in the realm of possibilities for most LSPs, currently the active use of external public innovation contests does not constitute a favored strategic approach for them.

[1] Deutsche Post DHL: “City Logistics Open Innovation Contest” (2011)
http://www.citylogistics-ideacontest.com
Hermes: “Getting, delivering … what else?” (2013)
https://www.innovationskraftwerk.de/Wettbewerb/Hermes/HolenBringenWasNoch

5. Conclusion

The open innovation paradigm defines itself mainly by contrast to closed innovation, which was the traditional approach for most manufacturing firms with high internal R&D competences until the end of the last century. These companies were equipped with high R&D budgets and special innovation infrastructure within. Such a closed innovation approach has never been a realistic scenario for LSPs. Until now, only a few LSPs – mainly large global players – have established an innovation department and provide a small budget for innovation projects. Besides, as service companies, LSPs are highly dependent on customer involvement in innovation development. Most innovations developed by LSPs start with specific requests from their customers. Furthermore, even internal and technology oriented process innovations, that are not visible to the customer, often cannot be developed independently due to missing competences.

The question arises how LSPs could best start or improve open innovation activities to overcome their innovation deficits. The results of our interviews confirm the importance of customers and technology providers in innovation projects of LSPs. Although these parties are already involved in innovation processes, there seems to be significant potential for improvement. Furthermore, it has become obvious that some of the open innovation methods need evaluation and advancement in the context of LSPs. The lead user approach, for example, seems to be a realistic method for LSPs. However, it is still unclear how LSPs best identify such advanced users and which context factors are relevant to transfer this innovation approach to LSPs. Specific methods and guidelines for LSPs to better integrate external parties in their innovation efforts seem to be needed.

Altogether, open innovation in logistics can be either specifically bond to certain customers or it can be proactive and aimed at a variety of customers. In order to proactively develop innovations that are not directly financed by specific customer orders, LSPs need to provide special resources or a special budget for innovation. For example, employees could be provided with extra time for innovation projects to be conducted parallel to their regular tasks. Especially large LSPs will profit from an innovation department that can support the decentralized innovation activities within the company. However, without a strategic commitment from the top management to innovation, a proactive innovation approach seems to be unrealistic for LSPs.

Our research confirmed that innovation management at LSPs is still beginning to evolve. The open innovation concept seems to constitute a valuable approach to foster innovation at LSPs. Hence, we will further address this issue in our current research project aiming at the development of guidelines for LSPs to make more effective as well as efficient use of open innovation methods. Especially small and medium sized LSPs need to be provided with support to increase their innovative output and thereby improve their competitive position.

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Managing Demand and Supply Networks of the Chinese Fashion Apparel Industry under the Complexity of the New Economy Transition

Nicole Ying Ye and Kwok Hung Lau

Abstract

Purpose: The purpose of this study is to explore the impacts of the latest Chinese economy transition, which commenced in 2010, on the local Fashion Apparel (FA) industry. It investigates the current supply chain practices of the FA firms in responding and adapting to the economic changes. A dynamic supply chain alignment approach (Gattorna 2012), which stresses the inclusive concept of marketing, supply chain management and business administration, has been adopted in the investigation.
Research Problem: Based on (Chorn 1991) alignment theory and (Gattorna 1998) dynamic network alignment practice, this study investigated how the new economy transition in China had impacted on its FA industry in market management, organizational adjustment and supply chain operation.
Research Methodology: Qualitative multiple case study with semi-structured interview was chosen to adopt due to the nature of the study.
Working-in-process Findings: Results of the case studies suggest that optimal trade-off between supply chain efficiency and effectiveness could be achieved through proper alignment of marketing demand management, supply network building, and organizational culture reconfiguration. Chinese FA industry is confronting the need for specialized supply chain innovations and business ideology review based on the new economy environment in China.
Originality/Value: Demand and supply management of the Chinese fashion industry in the post-Mao era under local dualist economy is a field, which has not

been investigated in research academia. By summarizing the Chinese economy transformation chronologically and investigating the impact of the current forth economy transition on the local FA market, this study sheds new lights on both the local and the global FA industry.

Keywords: demand and supply chain management, dynamic network, alignment practice, internal supply chain capabilities, external marketing demand innovatives

1. Introduction

Fashion apparel (FA) industry is an important area of research in the study of supply chain management (SCM). Many studies have been conducted focusing on the dynamic characteristics of FA demand with various recommended supply chain solutions (Bruce, Daly & Towers 2004; Castelli & Brun 2010; Christopher, Lowson & Peck 2004). They range from the early traditional one-size-fits-all models based on just-in-time (JIT), lean, agile or leagile strategies to the latest approach of aligning market management with supply chain capabilities (DSCM). In a global context, it is proposed that success of a company in the FA industry can be determined by how the organization designs its supply network to achieve optimal balance between supply chain responsiveness and efficiency (Christopher, Lowson & Peck 2004). Retailers that can successfully manage the complex network to achieve supply chain speed and flexibility to meet diverse market needs will maximize profit and at the same time minimize penalties associated with failures in meeting demands (Masson et al. 2007).

China as one of the most influential markets in the global fashion apparel and textile trade is facing severe challenges in recent years (Candace, Ngai & Moon 2011). As the economy transition from labor-intensive to value-adding mode on the Smiling Curve (Da-zhong 2006) commenced in early 2010, local textile and apparel companies undergo disruptive transformation in terms of supply chain resource reallocation and multi-intuitional culture innovation. Chinese textile and apparel industry under the background of dual economy (Dulius Herman Boeke, 1999), are confronted with challenges of losing world labor competitiveness and pressure for innovative development in entrepreneurship and value adding areas (Flaven 2013c; Melouney 2013);(CN 2011, 2012). From inner-scope perspective, invasion of large international fast fashion retailers and click-and-mortar network booming after 2010 results to fierce competition for the local market (Li & Fung 2011). Meanwhile, consumers exposing to global fashion trends and shopping network diversification tend to shop with higher fashion consciousness and savvier buying behaviors (Dickson et al. 2004; Flaven 2013b; Parker, Hermans & Schaefer 2004; Zhang et al. 2002). As research in this regard is limited, a study focusing on the perception of FA firms about the market trend, their responses to the impacts and the rationale behind the changes they made to adapt to the market transformation is considered timely and critical in filling the gap in the literature.

This paper attempts to exploit the impacts of the economic reshuffles in China on the local FA market from three perspectives based on (Chorn 1991)'s Alignment Theory and (Gattorna 2009)'s Dynamic Supply Chain Alignment. The three perspectives are external market management, internal supply chain capabilities, and organization administration respectively. In order to capture the extent of impacts of each perspective, drivers of changes identified are used as guidelines for investigation. The use of demand and supply chain drivers to develop capabilities has been widely investigated in the academia and the industry. For example, (Chopra & Meindl 2007) identified six logistical and cross-functional drivers: *facilities, inventory, transpiration, information, sourcing and pricing* as key determinants of supply chain structure. (Hilletofth, Ericsson & Christopher 2009) proposed the approach of demand supply chain management (DSCM) integrating demand management with supply solutions under an aligned organizational configuration and identified the critical success factors in each perspective. (Lorentz & Lounela 2011; Richey Jr et al. 2009) investigated the key supply chain criteria and categorized them into three macro levels covering management, logistics and marketing embracing factors such as information technology (IT), transportation, sourcing and pricing. Based on a comprehensive literature review (Chopra & Meindl 2007; Esper et al. 2010; Gattorna 2009; Hilletofth 2011; Hilletofth, Ericsson & Christopher 2009; Ismail & Monsef 2012; Jüttner, Christopher & Baker 2007; Lorentz & Lounela 2011; Rainbird 2004), this study plan to choose four to five essential drivers in each of the three perspectives – market management, organizational changes, and supply chain operation – as probes to investigate the perceived impacts and responses of the FA industry to the economic changes in China. Critical drivers other than those as shown in Table 1, if any, will be identified during the study to give a deeper understanding of the current operation of the industry.

Tab. 1: Various drivers of changes from three scopes

Market Management Drivers	Organizational Change Drivers	Supply Chain Operation Drivers
Strategic Planning	Organization Structure	Supply Chain Strategy
Product Development	Organization Culture	Supply Chain Configuration
Branding and Sales	Strategies and Policies	Supply Chain Infrastructure
Market Segmentation	Management Practices	Inventory and Transport
Market Research	Leadership	Information and IT
Forecasting	Capital Investment	Logistics Practices
Customer Relationship Management	Technological Support	Supply Chain Collaboration

Purpose

This study aims at answering the following primary research question:

How has the new economy transition in China impacted on local fashion apparel industry in market management, supply chain operation and organizational changes?

To fully investigate the primary research problem, the following subsidiary research questions are raised:

a) What are the responses, in terms of market management, of the Chinese FA companies to the impacts of the new economy transition on the customer demand for fashion?
b) What specific supply chain capabilities have the Chinese FA companies possessed in order to meet the diverse customer demand under the new economy transition?
c) How does the new economy transition in China affect the competitive strategy, organizational structure, culture and leadership of the Chinese FA companies?

2. Literature Review

2.1 Current development of supply chain strategies in the global FA industry

Fashion markets are synonymous with rapid change. The industry is characterized by a number of factors, namely short lifecycle, high volatility, low predictability and high impulse purchase (Christopher, Lowson & Peck 2004; Fernie 2004). As a result, commercial success or failure of a company in the fashion industry is largely determined by the organization's flexibility and responsiveness to changes. In the last two decades, many models and supply chain strategies were proposed for this particular industry with an aim to enabling more flexible and synchronized supply chain management. The evolution began with internal supply chain optimization focusing on 'one-size-fits-all' solutions. In this regard, many classic examples could be referred to (see Table 2). They include (Fisher 1997) product classification, paradigm of push-pull strategy (Levy, Weitz & Beitelspacher 1992), logistics practice of quick response (Bruce & Daly 2006; Lowson 2002), just-in-time (JIT) principle (Choi 2011), and lean, agile or leagile strategies (Ben Naylor, Naim & Berry 1999; Christopher & Towill 2001). With the rapid development of fast fashion industry in recent years, these conventional models, which focus more on 'insular' or 'self-contained' supply solutions, are not enough to cope with the increasingly dynamic market demand

(Ericsson 2011; Esper et al. 2010; Hilletofth & Hilmola 2010; Rainbird 2004). More integrative solutions relying on network collaboration have been presented (Castelli & Brun 2010; Gattorna 2012; Hilletofth 2012). These approaches stand on a broader basis of alignment by linking supply chain operation with market/demand management to provide more flexible supply solutions. They include the concept of collaborative planning, forecasting and replenishment (CPFR) under the demand chain management (DCM) background (Jacobs 2006), demand and supply chain management (DSCM) (Hilletofth 2011; Jüttner, Christopher & Godsell 2010), and portfolio model design for different value streams under an aligned business setting (Brun & Castelli 2008). These approaches are largely developed on the basis of contingency and alignment theories to account for what have been practiced in the business world (Chorn 1991; Gattorna 2009).

From the perspective of business management research, the change in nomenclature from SCM, DCM to DSCM reflects the progressive evolution from a single-focus strategy to a multi-discipline approach integrating the entire demand and supply network. The supply chain solutions created for the FA industry could be traced historically starting from a few decades ago emphasizing internal supply capability improvement to the modern time focusing on total optimization. Table 2 summarizes the representative supply chain research in the literature relating to the FA industry.

Research niche	Strategic solutions	Literature reviews	Main perspective/analysis
Internal supply chain management/ supply capability optimization	JIT, Lean, agile and leagile or other combination of these strategies	(Bruce, Daly & Towers 2004; Cao et al. 2008; Christopher 2000; Christopher, Lowson & Peck 2004; Fisher 1997)	Focusing on 'one-size-fit-all' solutions from internal supply chain performance. Although some level of collaboration between suppliers and retailers has been taken into consideration, it still focuses on insular SC optimization in functional basis.
Process-driven collaboration/dysfunctional integration with supply chain	Supply Chain integration and collaboration	(Banomyong 2012; Candace, Ngai & Moon 2011; Choi 2011; Guercini 2011; Jacobs 2006; Masson et al. 2007)	Holistic collaboration among each stakeholder has been concerned. It advocates process driven integration for optimal tradeoff between responsiveness and efficiency.
Demand and supply management/ alignment network	Integrating marketing and supply chain strategy/ supply and demand fusion models	(Brun & Castelli 2008; Castelli & Brun 2010; Childerhouse, Aitken & Towill 2002; Gattorna 2012; Hilletofth 2012; Jacobs 2006)	Looking the issues from downstream demand and customer behavior perspective. Identifying separated value stream, and configuring these independently. Outside-in model catering for flexible strategic portfolio.

Tab. 2: Supply chain management research on the global FA industry

2.2 Industrial background of the Chinese FA industry

The development of the fashion retailing industry in China dated back to 1980s during which wholesale market domination prevailed (Chan 2011; Chuang 2008). From 1978 to the present, the Chinese textile and garment industry has undergone four significant reshuffles (Chuang 2008; Commission 2008) (refer to Table 3 and Figure 1 on p. 10). The first reshuffle was from 1978 to 1990 with the initial introduction of foreign brand as a result of the Open Door Policy. During this period, fashion retail sales in China increased from RMB 179 billion to RMB 725 billion representing a growth rate of 300% (CMIC 2000). A few brands emerged and shared the market with clear niches occupied by high-end western brands, such as Pierre Cardin, and Goldllion, and low-end local brands, such as Red Beans and Heng Yuan Xiang (Chuang 2008), respectively. The second reshuffle occurred from the year 1990 to 2000 during which a substantial number of local apparel brands emerged focusing on two main retail models (Chan 2011). Companies such as Younger Ltd. and Luo Meng emphasizing vertical integration (all-in-one) dominated the market. Other brands of sport fashion, such as

Meteresbonwe and LinNin targeting mainly the medium-low market, adopted a virtual subcontract model to permit quick start-up.

The Chinese FA industry was ushered to the third reshuffle upon China's accession to the World Trade Organization (WTO) in 2001 (Kwan, Yeung & Au 2003). Global sourcing for lower labor cost turned China into a world-manufacturing factory with huge competitive advantage. Soon, Original Equipment Manufacturing (OEM) and mass production became the dominant operation models for the Chinese FA industry. Although many coastal areas and port cities, such as the Yangtze River Delta Region, the Pearl River Delta Region, and the Bohai Gulf Rim in China, had benefited from technology transfer and production method standardization due to global outsourcing, China's high-end clothing was still firmly in the control of some foreign luxury brands, such as LVMH Group, the Italian Gucci Group and the Prada Group (CN 2011; Zhen 2007).

From 2010 onward, proliferation of fast fashion models, such as Gap, Zara, and H&M, became the new wipeout innovation in the FA industry (Li & Fung 2011). Since the last fashion supply chain reshuffle, competition in the local FA market had become extremely fierce. Seeing the success of the Gap and Zara, many medium-low FA firms tended to believe that quick profit could be made easily by imitating the foreign FA supply models (Lu 2011).

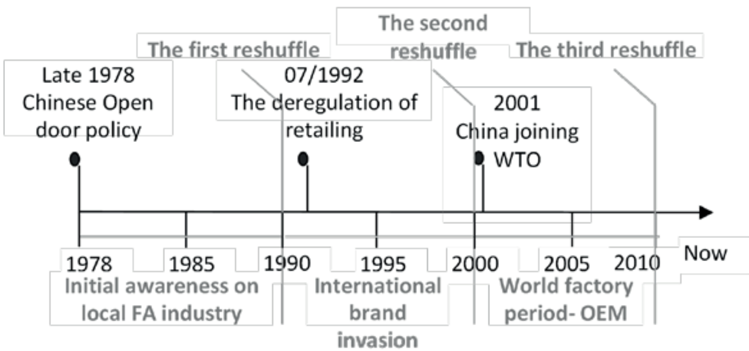

Fig. 1: Evolution of the Chinese FA industry

issues. For example, inferior market management and misalignment of supply chain network had resulted in large amount of redundant inventory (Yi 2012). Also, mere copying of fashion styles from big brands without in-depth analysis of the local market requirements resulted in disastrous demand forecasting (Flaven 2013b). Furthermore, factors such as diverse fashion awareness of end consumers, rigid business structure and the double-edged *guanxi* network also

Consequently, many local apparel	Time Frame	Attributes	Source
I.	1978 to 1990	Few brands share the market with limited expansion after Open Door Policy	(Chan 2011; Chuang 2008; Commission 2008; Kwan, Yeung & Au 2003; Zhang et al. 2002)
II.	1990 to 2000	Brand invasion from international and local trial	(Chuang 2008; CMIC 2000; CN 2011; Frohlich & Westbrook 2002; Kwan, Yeung & Au 2003; Wang 2009; Zhen 2007)
III.	2000 to 2010	World manufacturing factory after China joining WTO	(Chan 2011; Chuang 2008; CN 2012; Flaven 2013b, 2013c; Kwan, Yeung & Au 2003; Li & Fung 2011; Parker, Hermans & Schäfer
IV.	After 2010	Fast fashion booming and brand identity	(Flaven 2013a, 2013b, 2013c, 2013d; Harilela 2013; Lee, Lina 2013; Lee, Lina & Wang 2013)

Tab. 3: Economic reshuffles in the Chinese FA industry

added complexity and formidable challenges to the practical operation of local fast FA business. Most local apparel companies failed to look at the macro picture from a more dynamic perspective (Yi 2012). All these factors account for the many failures of the local FA firms which tried to adopt western FA supply models directly without adaptation. The current economy transition in China presents a new era of changes and opportunities for the FA market. To survive and thrive in such dynamic business environment, FA companies are forced to react and restructure their business plans to the need of the new market demand (Cameron & Quinn 2011). Companies not recognizing this requirement are inevitably heading for demise due to intense competition in the industry.

2.3 Current study of SCM in the Chinese FA industry

Upon a thorough literature search and review involving archives of 13 (4 Chinese and 9 international) logistics and supply chain management journals and 10 global influential fashion and textile news magazines and industry reports, it is found that only a few studies had looked at the Chinese FA supply chain or investigated the Chinese FA business environment. Furthermore, most of the studies were undertaken from a news reporting perspective with broad conclusions without following a systematic research approach to in-depth analysis (see Table 4). Many investigators tended to focus mainly on the influence of the unique Chinese culture and institutional environment on the FA market. In contrast, the intricate integration between market management and SCM had hardly been explored with only five studies barely touching on the area (see Table 5).

Literature	Title	Research focus	Research methods	Type
Kwan, Yeung and Au (2003)	A statistical investigation of the changing apparel retailing environment in China	Holistic industrial report— Examination of China's demographic and economic indicators over the past 20 years, and the changing pattern of other macro-factors and micro-factors	Desktop Research	Business report
Taylor (2004)	China textile trade	Industrial trading report— Introducing the special issue on the textile trade in China. Outlining its growth, which has reinforced its role as a preferred supplier to major markets, and its alignment with other members of the WTO.	×	Editorial
Chan (2011)	Fashion retailing in China: an examination of its development and issues	Holistic industrial report— Examining the macro development issues of fashion retailing in china	Desktop research and exploratory research techniques	Business report
International Trade Centre (2011)	The Chinese Market for clothing	Holistic industrial report—Focusing on giving a comprehensive business overview on local Chinese FA market. The topic delivers through many perspectives, such as macro economy, trading, marketing and logistics perspectives.	Business case study and desktop study	Business report

Literature	Title	Research focus	Research methods	Type
Yi (2012)	Fast fashion model questioning to be 'Fast' in China	Industrial news report—Analyzing the issues in the local FA companies for recent years.	×	Editorial
Zhang et al. (2002)	Casual wear product attributes--A Chinese consumers' perspective	Marketing/consumer behavior perspective—the importance of product attributes of casual wear for Chinese consumers was investigated. A total of 15 attributes were identified. It is found geographic and demographic factors had great impact on these attributes.	Quantitative survey study	**Research paper**
Dickson et al. (2004)	Chinese consumer market segments for foreign apparel products	Marketing/consumer behavior perspective--Identifying the product attributes salient to consumers' apparel purchase intentions	Quantitative cluster, multiple regression and other statistical analysis.	**Research paper**
Chuang (2008)	A strategic study for quickening brand building of Chinese textiles and garment industry	Marketing/consumer behavior/branding—analyzing the favorable and unfavorable factors for brand development for local apparel industry and putting forward some main measures and strategies for brand development	Desktop study	Business report

Literature	Title	Research focus	Research methods	Type
Wang (2009)	The empirical study on the ladder like development trend of Textile industry	Marketing/consumer behavior perspective—Analyzing the regional development characteristics of China's textile industry. namely regional ladder-like development mode. Pointing out the big distinction between strong and weak region.	Quantitative clustering analysis methods	**Research paper**
Li and Fung (2011)	China's apparel market	Marketing/branding perspective—statistic industrial report for these five years. Introducing the latest development on local FA industry and bringing the future trend about this industry.	Business case study and desktop study	Business report
Eng-Meng (2013)	Clothing brand Metersbonwe takes cue from Zara's fast fashion	Branding—news report on famous local brand Metersbonwe business model reconfiguration	×	Editorial
Flaven (2013b)	In China, Hangzhou Brands Face Identity Crisis	Branding—In today's large and highly competitive China market, developing a real brand identity is crucial to success.	×	Editorial

Literature	Title	Research focus	Research methods	Type
Lam and Postle (2006)	Textile and apparel supply chain management in Hong Kong	Internal supply chain perspective—the paper focuses on reviewing the concept of supply chain management and Fisher SC strategy. Analyzing how to use Fisher' s SC strategy to balance tradeoff between efficiency and effectiveness for Hong Kong textile supply chain	Case study	**Research Paper**
Candace, Ngai and Moon (2011)	Supply chain flexibility in an uncertain environment: exploratory findings from 5 case studies	Internal supply chain perspective-- To illustrate and examine the different flexibility strategies adopted by supply chain participants as a result of different environmental uncertainties	An exploratory multi-case study involving 5 Chinese FA companies	**Research paper**

Tab. 4: Demand supply chain studies on the Chinese FA industry

2.4 Impacts of the new economy transition under local economy structure

Compared with global fashion brands such as Gap, Zara, H&M and Uniqlo, domestic apparel brands have less marketing experience since the open-up development only happened in recent decade. OEM was a dominating mode for last decades while retailing and branding begins to develop in late 2000s (Chan 2011). The development of FA is under the process of dualistic economy (Dulius Herman Boeke). In this regard, Chinese government plays a great role in social resource allocation rather than 'free market' referred in western capitalist economy theory during 1980s to 1990s (Feng, Shen & Zhao 2014). However, the swift economy transition after 2010 accelerates the modern industrialization in urban areas from the traditional economy, which relies on rural labor supply (Sir

Arthur Lewis, 1954). In this case, transition triggers new round of government's Quantitative Easing (QE), which give a significant booming for market practitioners after long monopoly in FT/FA industry. The extreme open-up causes significant industrial restructuring.

At this edge of the reform, without the systematic marketing and supply pipelines management, how the new value could be better delivery for the customers, suppliers and shareholders will be a vital issue. As China is losing its labor competitiveness, new solution emphasized on innovative economy in entrepreneurship and value adding areas seems to be an alternative direction for future local economy (Flaven 2013c; Melouney 2013). Table 5 summarizes the various issues faced by the Chinese fast fashion industry, which can be categorized into three main streams.

Perspective	Issues and Challenges	References
Marketing management	Booming awareness of Brand identity from market lead to increasingly dynamic market segments Diverse fashion culture renaissance Diversification of retail channels	Li & Fung 2011 Doeringer and Crean 2006
Business management	Intuitional hierarchy regime in most enterprises Unclear product market identity for most companies Dislocation of supply network design with demand Development bubble from top management level due to e-commerce booming Capital accumulation as main purpose Immature market regulationfor FT sector	Flaven 2013a Yi 2012
Internal supply chain	Excessive inventory due to information mistranslation from downstream market and huge volume push-up from upstream Bullwhip effect caused by miscommunication among SC nodes Factory dying due to the financial chain break and labor cost increasing (suppliers)	Chan 2011 Yi 2012

Tab. 5: Issues and challenges faced by the Chinese fast fashion industry in recent years

Market Management

Even though Gross Domestic Profit of China has increased more than twenty times during the period between 1980s-2000s, domestic firms in mainland China were remarkably disadvantaged in areas such as patent application, high-tech export and R&D intensiveness in contrast to its counterparts in the advanced countries (Tylecote, 2010). The economy transition in 2010 crashed the traditional economy mode and brought a new era of value creation. One of the impacts is the emergence of diverse retail channels, such as online retail, private label and multi-brand with multi-layered business model (Harilela 2013). For example, some e-commerce merchants at the forefront of the fashion trend try to initiate small-scale supply chain operation with ethnic-centric entrepreneurship that combines design with manufacturing and direct sales online. Other companies marketing with private labels transfer manufacturing to in-house operation so as to strengthen the collaboration between the teams responsible for product design and production (Flaven 2013a, 2013c; Tokatli 2008). These market elites take full advantage of their potentials for supply chain flexibility and quality production by cutting the intermediates and picking up the production role directly (Doeringer & Crean 2006). It accelerates the industrial development compared with traditional brick-and-mortar retailing but also demands highly innovative configuration.

In terms of consumer behavior perspective, marketing diversification causes the booming awareness of brand identity and product innovation in this new transition, which in turn educate the consumers with savvy fashion insight and strong personal style. Consumers are now cultivated to project the design message, in charge of own image instead of dazzled by the market (Tokatli 2008). In this paper, *Strategic Marketing Planning; Market Segmentation; Product development; Branding and Sales* (Hilletofth, Ericsson & Lumsden 2010; Jüttner, Christopher & Godsell 2010; Kotler 2009) are selected as four main drivers as probes to investigate the specific changes for local FA companies from the marketing management perspective

Supply Network Design

Most of companies lack the awareness of synergetic utilization of supply chain capabilities and operate in an 'insular' functional management style (CN 2012). Confronting with swift open-up, many private company owners put more focus on quick fortune accumulation rather than product line optimization on the supply chain. It could also be the reason of 'insular' operation. Meanwhile, the push system and lack of marketing experience lead to excessive inventory, which ends up with financial chain dislocation and factories (suppliers) bankrupt (International Trade Centre 2011; Lu 2011).

"Industrial agglomeration" (Wang 2009) is taking into shape in the garment industry with the booming of e-commerce entrepreneurs (Flaven 2013a). Issues such as changing retail landscape, new force of multi-brand with industrial diversification (Harilela 2013), diverse customer segmentations, and unique local institutional structure, have increased the complexity in the supply chain operation of the Chinese FA companies (Flaven 2013a, 2013c; Lee, Lina 2013). In terms of supply network capability, *SC configuration; SC Process Operation; Logistics Practices and IS/IT Implementation* are selected as four supply chain drivers to investigate the response of FA companies to the economy transition.

Business Management

At firm level, as a fundamental part of the competence building of top managers, the cognitive development of top managers is a crucial base for the strategic human resource management (Lado and Wilson, 1994; Nyberg, et al, 2014).

3. Conceptual Framework

Based on the alignment theory, a tentative theoretical framework for investigation into the impacts of the new economy transition on the Chinese FA industry and the responses of the firms is proposed (Figure 2). The framework suggests an end-to-end demand and supply network collaboration involving the alignment of three components – market management, organizational changes and supply chain operation. Four drivers in each component are used to depict the impacts of the external environment and the responses of the firms. It is believed that companies in the Chinese FA industry would react according to what the alignment theory is promoting and the proposed framework can serve as a basis for investigation in this study. The framework also sheds light on the 'outside-in dynamic theory' from the business administration aspect as advocated by (Gattorna 2012). Findings from this study will help validate the framework hence the use of the alignment concept as the underpinning theory for the research. Additional drivers may also be revealed in the investigation process to further expand or refine the framework for future studies.

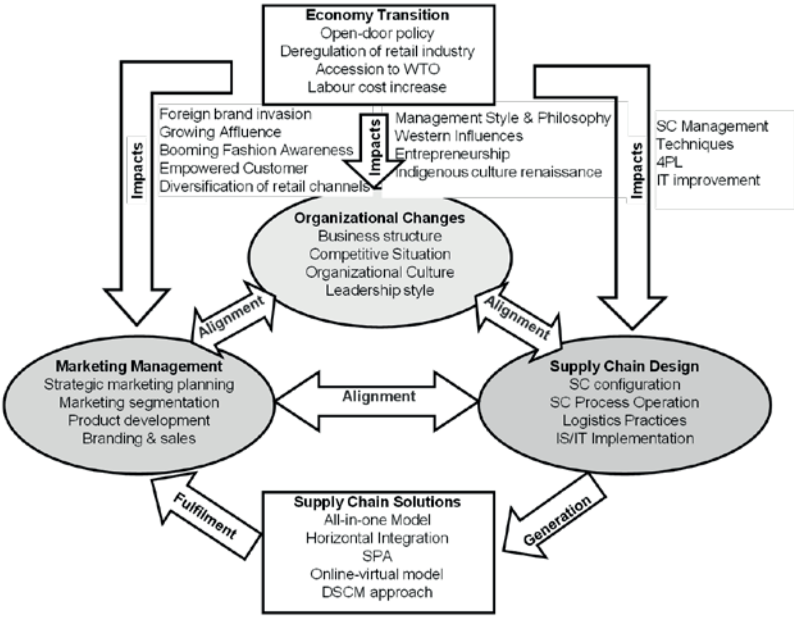

Fig. 2: Demand and supply chain framework based on Chinese FA industry

4. Research Methodology

The objective of this study is to investigate the impacts of the new economy transition in China on the local FA industry and how the firms respond in terms of market management, organizational changes and supply chain operation. As the study is exploratory in nature, interpretivism is considered an appropriate approach to collecting information to answer the research questions. As such, multiple case study methodology will be adopted to cover a range of firms in the industry in the investigation for comparison.

To increase the breadth and depth of the study, six local FA firms with different supply network models covering the national and private-owned business patterns in the local economy are selected to give a comprehensive and holistic picture of the current situation in the industry. At the moment, two companies and six key personals in different managerial level of intermediaries, manufactures and logistics providers located in China have been investigated so far. Data are collected through business document review, onsite observation and semi-structured interviews. In the data analysis stage, Nvivo software is applied to facilitate process of thematic coding, within-case analysis and cross case comparison.

5. Discussions and Case study findings (Working-in-process)

Three representative companies have been investigated with diverse supply chain model of traditional virtual SC, SPA model and online B2C. The cases show the represented negative and positive-influenced example of local FA companies under the economy transition. Table 6 and Figure 3 show the general information about 3 representative cases.

	Marketing Attributes				Supply Chain Attributes			
	Fashion Sensitive	Price range (RMB)	Age segmentation (Year)	Brand culture	Product Quality	Lead-time	Network Model	Economy transition influence rate
A: Vancl	Medium	RMB 50-500	Young generation (not clear)	B2C fast fashion (obscure brand identity)	Low level	50 days	E-commerce	Highly Influenced (Negative)
B: VM	Medium	RMB 100-3000	25-35 female business casual	Casual to feminine (lady style)-multi-development	Medium level	90 days	Franchising	Medium
C: JNBY	High	RMB 500-50000	20-35 female	Joyful Natural Beauteous Yourself: natural futuristic style with edgy personality	High level	80 Days limited production	Vertical (SPA)	Less Influenced (Positive)

Tab. 6: General information about 3 cases

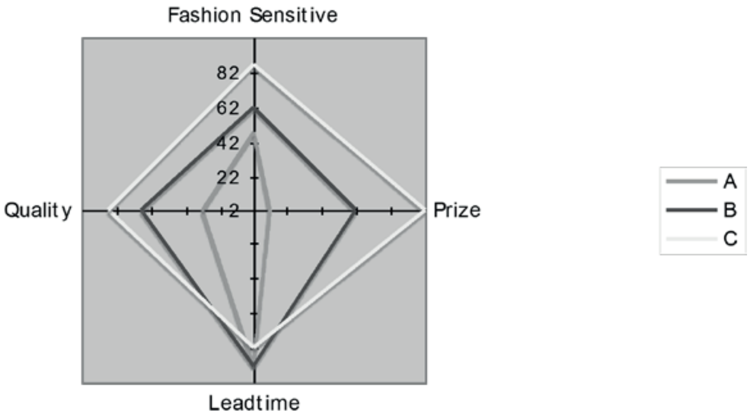

Fig. 3: Marketing Position of 3 Cases

Company A

This company is based on the National B2C online retail shopping sales report, company A ranking 7 founded in 2007

The company begins the product line with male T-shirt and polo shirt with triumph of 5 billion dollar revenues with B2C market share of 5.1% in 2008. After the significant market campaign and CPS online advertisement in 2010, company starts to diversification development with huge category expansion.

Major problems:

- Misleading product-branding position: The marketing position for company A is online fast fashion company. However, the real supply chain operation cannot respond to the demand immediately and align the network with the “fast” principle. Meanwhile, whole team especially top CEO level focus more on marketing campaign and online advertising rather than the original product design.
- Supply chain breakdown.: Due to the mistranslation of the market demand, it leads to huge amount of inventory and debts on factories and OEM.

- Eager to booming: Compared with traditional apparel company like brick and mortar, online ecommerce accelerate the booming pace while also bring the risk of HR bubble and financial bubble. The company has no time to restructure the business model under swift transition.
- Dislocation of Managerial level and supply network operation: The cognitive of top CEO is unsure how to execute the company for clear direction upon the transition
- Lack of systematic management on HR.

Company A: Vancl

Perspective	Sub-Ares	Data-analysis
Market Management Drivers	Strategic Network Planning	Click-and-mortar (SPA)
	Product Development/Material desgin	Have own designers, however, the company put more emphasis on product marketing campaign instead of material desgina or product design and quality control
	Branding and Sales	Investing huge amount of money on marketing campagin and advertising without enough product position focus.
	Market Segmentation	Starting with marketing speicific for man's shirt and polo shirt in 2018, gradually expending to cloth for women, kids, shoes, furniture, accecories and cosmetic lines. At the end of 2010, the diversification development gradually undermines the company

Company A: Vancl		
	Customer Relationship Management	Applying self-developed ERP modular, obtaining half synchronized information transition. Focusing on consumer experience, working with subsidiary 3pl company for enhance delivery speed and product return guarantee within 5 days.
Supply Chain Design	SC configuration	Virtual supply network. Product design-OEM manufacturing-product distribution
	SC Process Operation	Outsourcing function of logistics and manufacturing. Only have online platform and designing team
	Logistics Practices	80% of service is outsourced under affiliation 3PL company; while 20% is outsourced to other delivery company
	IS/IT Implementation	Self-developed model. It is hard to achieve macro IS network integration
Organizational Management Drivers	Company’s competitive edge	Marketing and sales campaign
	Business Structure	Hierarchy structure (centralized-business structure)
	Culture and leadership style	Highly controlled by CEO

Tab. 7: Themetic coding of Company A

Company B

As one of the most famous brands in China, Company B belongs to BESTSELLER organization group which includes four brands targeting huge marketing share of young teenager group, mature female, male group and kids group in China. The brand position targets mainstream of fashion market for daily wearing with diverse style and color choices. The price is reasonable, trying to achieve economy of scale rather than small market niche with high margin of per customer transaction.

Company B		
Perspective	Sub-Ares	Data-analysis
Market Management Drivers	Strategic Network Planning	Franchising Model. Only have the branding, and marketing function. Outsourcing other logstics functions. After 2012, the stakeholders try to get back the franchisers to the direct SPA sales model for preventing the risk from market uncertainty.
	Product Development/ Material desgin	Fashion style: Business casual style with feminine look. Having more emphasis on apparel design, style matching with colors and themes than material development. Position itself on mainstream market rather than small niche.
	Branding and Sales	Having many sales campaigns to support the brand. However, beginning from 2012, the sales turnover and product order quantity in each city is slightly decreasing due to the market transition. After 2012, the brand is gradually extending the style from casual look to mature independent feminine look with more stylish diversification targeting middle write-collar class.

Company B		
	Market Segmentation	With the diversification of market, the company decidesmake more diverse segmentation based on cloth styles which integrates causul style with mature ladylook for market extension. However, it delivers without systematic consumer behavior research and poll survey.
	Customer Relationship Management	Only use POS machine to record customer data. Have no systematic
Supply Chain Design	SC configuration	Integrating Virtual Franchiser model with direct sales model. Have more direct stores takeover. Launch the O2O (online to offline) model and online sales network. Cooperated with big shopping mall to select store location. Flag stores are opened close to regional center.
	SC Process Operation	Outsourcing function of logistics and manufacturing. Only have designing team
	Logistics Practices	Outsourcing logistics function to 3PL companies. Lack of efficiency considered overall store arrangement among cities.
	IS/IT Implementation	Setting up self-developed ERP system. Have not achieved scale of information integration
Organizational Management Drivers	Company's competitive edge	Diversified designing for mainstream market and reasonable price
	Business Structure	Decentralized
	Culture and leadership style	The brand is under part of Group organization with multi-brand competitive culture. Collaborative and competitive culture.

Tab. 8: Themetic coding of Company B

Company C

Company C contributes to new material design and looking for more environmental-friendly solution with nature material; Focusing on brand internationalization.

Company C		
Perspective	Sub-Ares	Data-analysis
Market Management Drivers	Strategic Network Planning	SPA
	Product Development/Material desgin	More focusing on material development for better qulity and SC sustainability. Exploring the comtemporary collection but at the same time maintain JNBY-style consistancy for high-end customers; compared with international mega-brands, company’s high end collection has better price advantage and stable fan-segments of ethics fashion stream.
	Branding and Sales	Emphaising on brand development and internaitonal market exploration for China Chic; more soficitation marketing research on consumer behavior. Which also lead to systematic channel selection. Imbeding lifestyle and personal value ideology on product branding campaign

Company C		
	Market Segmentation	Targeting age 25-35 female customers, More specific customer segmentation with 30% classic look of high end design, 45% popular fashion style and 25% generic products. Product lines are more segmented based on diverse circumstance; such as evening dress/avant-garde/causual; seaonal themes and story-series.
	Customer Relationship Management	Transition from half platform synchronization to fully synchronized ERP platform/ after 2012, the company stress on the IS exploration on each business modular integration. Implementing VIP specialized service for after-sales.
Supply Chain Design	SC configuration	Decentralized operational model (SPA), Design (own)-produce (own factory)-retail sale; Have 2 sales network (online and flag shop)
	SC Process Operation	Focusing on material exploration, raw material and apparel suppliers' exploration and supply chain control; apparel product and accessory design. Leagile

Company C		
	Logistics Practices	Working with 3party-logistcis companies for optimal solution. Main function focus is inventory management and IT integration with both online and offline. Working closely with 3PL for inventory control and information management
	IS/IT Implementation	EPR system Implementation for industrial chain integration to prevent modular separation/ enrolls OA implanting EIP, KM, HRM, CRM, WM and PM for business modular integration with supply chain IS.
Organizational Management Drivers	Company's competitive edge	First-class product design and raw material exploitation based on green, natural and sustainable theory
	Business Structure	Decentralized
	Culture and leadership style	Business Modular interchange of opening environment

Tab. 9: Thematic coding process of Company C

On confronting of economy transition, company C strengthens its competitive edge by looking for more sustainable textile material and specific designing collection based on more segmented consumer groups based on their diverse

lifestyle and dressing-up theme. At the same time, due to the high end slow fashion purpose, the lead-time is controlled in acceptable pace with 80days, however, the supply chain main focus lies in inventory control and EPR system integration with their 3PL optimization companies.
In terms of organizational management, the cognitive of top CEO level tends to be innovative under the new economy transition. It could be seen; the supply chain strategy is closely integrated with the marketing goal while the overall business mission is aligned with product marketing strategy.

6. Conclusion

Within-Case Analysis:
Company A relocates most resources on branding and sales part disregard the need to understand better their customers and sense their new needs. Besides, the business mission and management style fail to match appropriately with its brand position. The ambiguous brand niche may not properly suit the sustainable development of apparel products as well. Though the company had great achievement and market reputation as top 10 brands in local FA industry before 2009, the company has not responded well under the new swift transition which has resulted in great issues for the company.
Company B extends the product variety by enlarging the causal style to more mature sexy designing-focused style to explore the consumer base under the new trend. The slow move is gradually penetrating into its business mission strategy. The company is confronted with the challenges from logistics perspective. However, the reactive moves help the firm survive the significant transition risk.
Company C acts a good example of being positively influenced under the economy transition. The company has great reputation improvement under the new era after 2012. By internationalizing the brand, the company has successfully drawn global attention in the FA industry.

	Market factors				Supply chain factors				Business administration factors		
	Network planning	Market segmentation	Product development	Branding	SC configuration	Process Operation	Logistics Practices	IS/IT Infrastructure	Competitive edge	Business structure	Leadership & Culture
A			×	×			×				
B	×	×		×	×			×	×		×
C	×	×	×	×		×	×	×	×	×	×

Tab. 10: Cross-comparison among the three case companies

Cross-Case Comparison:

Table 10 reveals that optimal trade-off between supply chain efficiency and effectiveness could be achieved through proper alignment of marketing demand management, supply network building, and organizational culture reconfiguration. Under the forth economy transition, the recent economy QE make an extreme open-up for many private entrepreneurs compared with the last two decades. On the one hand, it gives a significant industrial booming on local FA market. On the other hand, due to the swift development, the market does not have enough time for gradual maturity as compared to developed European market. It brings challenges and opportunities. As shown in Table 10, Company C with corresponding strategic restructuring from the three perspectives gets positive influence with the trend while Company A with an unbalanced focusing on single part undermines the overall supply chain and suffers from finance chain dislocation. It can be seen that the Chinese FA industry is confronting the need for specialized supply chain innovations and business ideology review based on own competitive edge and business mission.

The area highlighted in red frame in Table 10 shows that companies usually start off the restructuring process through marketing management via sales campaign and branding establishment since it is the most lucrative and obvious part of retailing function. However, the analysis suggests that synchronization of supply chain capability and business administration readjustment is also vital for the overall business improvement in the long run.

Summary:

In conclusion, the case study findings show that the proposed framework for investigating the impacts of the new economy transition in China on the FT industry seems to be valid. Among the three companies investigated, only the one focusing on a proper alignment between the three perspectives – market management, organization changes, and supply chain design – succeeded in benefiting from the changes in customer preferences and demands under the rapid reshuffles of the new economy transition. In the volatile and dynamic business environment of the FA industry, using one-size-fits-all or simple leagile supply models will no longer be able to meet the diverse and rapidly changing market demand while reducing supply chain cost in terms of inventory and distribution. Drastic changes in operations at both end of the supply chain as well and in management philosophy and structure have to be made to mitigate risks and exploit market niches during the era of opportunities for the FA industry in China. This study has succeeded in reporting the evolution of the FA industry in China from a historical as well as economic point of view and highlighted the direction for development for the entire industry. It contributed to knowledge by providing a comprehensive summary of the background of the area of investigation and pinpointed direction for further research, one of which will be to investigate the detailed relationships among the three perspectives during the alignment process.

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A Functional Mathematical Optimization Algorithm for the Integration of the Tactical Berth, Crane and Vehicle Scheduling

Teemu Linkosaari

Abstract

In this paper, the main problem considered is a tactical discrete berth allocation, including both the quay mobile crane scheduling and vehicle dispatching as sub-problems. Berths, cranes and yard vehicles are the most important resources used in container terminals. The objective is to reduce the vessel turnaround times with fewer resources. We assume that the vessel's stowage plan and yard templates or their estimates are given.

We integrate using functional decomposition, where sub-problems are solved sequentially and in parallel, resulting in more modifiable and detailed parameters to the main problem. We have chosen the sub-problems and their solution algorithms primarily so that they are mathematically proven to be optimal or have proven properties. Different techniques are utilized: mixed integer linear programming, max plus algebra, greedy algorithms, dynamic programming written in functional language and general algebraic modeling system.

In addition, we extend the features of the sub-problems. While allocating the cranes, we use the concept of the quay crane profile. We reformulate the crane scheduling problem so that the mobile cranes can be heterogeneous, and there can be both quay and mobile cranes. Some features are optional: for example, double cycling and yard remarshaling. Alternatively, we can reduce the number of vehicles by deciding how we unload or load stacks. The study is motivated by the practical needs of Finnish port operators.

Keywords: container terminals, scheduling, optimization, functional programming

1. Introduction

In maritime transportation, container terminals are a source of many interesting large-scale optimization problems. There needs to be deeper insight into these complex systems and they require a larger set of solution techniques. The main function of the container terminal is to transfer containers from one mode of transportation to another. A container is a rectangular metal box, usually 20 or 40 feet long. The second function of the terminal is to provide a temporary storage facility of a few day’s duration.

Container activities can be divided into the following categories: export, import and transshipment. We will focus here on import-export terminals in Finland, which are smaller than transshipment terminals and hence easier to optimize. Container vessels can also be categorized as feeders and mother vessels. Here we will focus on feeders.

Almost all relevant problems in concerting container terminals are NP-hard or NP-complete in nature. Fortunately, restricted special cases have polynomial or pseudo-polynomial time complexity and as such, can be exploited.

The time it takes to handle a container vessel depends on many factors due to interdependencies between different processes. Berth planning is highly interrelated with vessel, yard, equipment and workforce planning. A good berth plan saves time, money and resources. The duration of berthing of a vessel depends on the number of quay or mobile cranes allocated to the vessel. Vessels are partitioned into bays which contain deck and hold. The processing time of the vessel depends on the strategy for how bays are handled and on the amount of yard resources the strategy uses and how far or close the containers are positioned relative to the vessel. When there is a limited number of berths and limited number of quay and mobile cranes, these resources must be allocated wisely.

The main objective of our research problem is to find a way to use existing literature directly, by modification, or by integration in order to solve real-world problems in Finnish ports. Our research is aimed toward creating an interactive optimization and planning tool for container terminals. We review only those research papers that have been implemented or are relevant for this work. We try to reduce each vessel's turnaround times in addition to the resources described above.

Clearly, there are multiple objectives, which are treated lexicographically: first, minimize the vessel turnaround time; second, minimize the number of handling resources within a time window. The contract model between the terminal and the shipping company may affect the objectives. If, for example, the time window of one vessel is relaxed, then we can it will be possible to give more of its resources to other vessels. We do not consider how containers are loaded onto trucks or trains, since that is not critical to the turnaround time. There could be other objectives such as: minimizing travel distances, fuel maintenance, and remarshaling costs.

In the literature, the trend is to integrate the resources-related sub-problems. In deep integration, sub-problems are merged into a monolithic problem and can be hard to solve or modify. We use functional modular integration, in which sub-problems are solved sequentially and in parallel, resulting in creation of more modifiable and detailed parameters to the main problem. The port planner should also have the opportunity to lend his insight and experience to the optimization process (see Bruggeling et al. (2011) for more). Therefore we use modularization, in which the operator can give a rough estimate of some parameters and more detailed data to for others.

In the forthcoming sections we present relevant literature, models, and solution methods. One can think of the berth and resource allocation problem as a three-level optimization problem. First, we introduce the vehicle dispatching algorithms used, followed by an examination of quay crane scheduling problems. Third, we address the tactical berth allocation problem. The final section concludes the paper.

2. The structure of the modular algorithm

In this section we outline the input, the main algorithm and the chosen programming paradigm. We assume that the vessel's stowage plan and yard templates or their estimates are given. Container vessels can be modeled as a 3-dimensional matrix, in which containers are stacked on top of one another and arranged in rows. In the yard storage space, containers are freely positioned in the yard in any orientation. Usually, they can be stacked to form blocks. To calculate distances between different container locations, one may construct travel paths and then determine the shortest paths, in which the triangle inequality holds between distances.

The structure of the program is as follows: first, we compute the set of strategies that can be used to process one ship bay. This computation can be done in parallel. Next, we calculate the optimum vessel schedules for different quay crane profiles. On the third level, we attach the crane schedules to berth allocation and to the week schedule.

Here, sub-problems are treated as functions in a more mathematical sense, which is the advantage of functional programming that is a declarative way to write a program with functions. Programs are coded in F#. In this study, functions have deterministic behavior and no side-effects. Therefore, it is also easier to reason about the program and even to provide a formal verification of the system. Parallel and asynchronous programming are also easier.

The non-functional part of the program uses the general algebraic modeling system (GAMS), which is also a declarative way to model optimization problems. It supports a variety of commercial solvers such as CPLEX, which is utilized in mixed integer linear programming. Vector graphics is used as a communication tool and to read and write data (e.g., time windows, container locations). Spreadsheets or databases can also be used.

3. Yard side scheduling

Vehicle dispatching problems can be considered as the first level of the algorithm. They are usually quickly solved due to polynomial time algorithms and hence suitable for a sub-problem. They were introduced early in container literature: see Bish et al. (2005), Li et al. (2004) and Zhang et al (2005). They are designed for automated guided vehicles in order to schedule a given number of homogenous vehicles and a crane sequence, but they can be used more generally. Here we refer to their results and how they are used.

Here we use these methods to ask: Given the yard template and the stowage plan what is the minimum number of vehicles necessary to unload or load one bay? We may also ask: what is the minimum number of vehicles necessary if the vessel's total handling time or makespan is fixed.

In manned terminals, the yard transportation vehicles used are yard trucks, straddle carriers and reach stackers. We assume that there is no buffer time below the crane. The work is usually organized as a team, usually called a gang, which services one crane and consists of a chosen combination of the aforementioned vehicles and other employees in the yard.

3.1 Vehicle dispatching problems

In solving vehicle dispatching problems we first need to determine the crane processing time for a container job: how long it takes to move a container from the ship to the yard or vice-versa. An exact method would be to use control theory to model the crane movement and minimize its travel path. Alternatively, one can use an average time of the container.

Secondly, we need to calculate the vehicle processing time: how long it takes to pick up a container, move it to the yard location and then drop it there and come back or the same operation, but in another direction. Several factors affect the drop-time: how high the stack is and whether one uses intermediate buffers or a yard servicing vehicle. We assume that there is no congestion in the yard vehicle traffic.

Thirdly, Zhang et al. (2005) formulated unloading phase as a mixed integer program, but the problem structure enables us to solve it by using a greedy algorithm, that is, by the first available truck rule as appears in Li et al. (2004). While Bish's algorithm does not assume job starting times, Zhang's algorithm does. The other difference is that in Bish's algorithm the crane begins to unload a container after the next vehicle arrives, not earlier. In Zhang's algorithm, the crane is allowed to start the next job immediately and then wait for the vehicle. It is therefore more efficient.

Next, Bish et al. (2005) also provided a loading lemma, which gives the reversed greedy algorithm. It is the same as the latest busy truck rule by Li and Vairaktarakis (2004).

Lastly, the unloading and loading phases can also be combined. For small problems, total enumeration works. Li and Vairaktarakis (2004) also studied heuristics. However, combining phases is sometimes unnecessary since port planners may want first to unload all the bays and then load them, because the purpose of the land trucks is to transport their cargo immediately to its final destination (see Figure 2, section 4.2). These strategies are sufficient when the distance between crane and container is short. The processing of one bay is not really a deterministic process; thus, stochastic methods could also be used to solve this problem.

3.2 Servicing a block

Gilliambardo et al. (2010) utilized a piecewise linear function for calculating the cost of transporting a container depending on the distance. For short distances, a greedy structure is sufficient, but when the block and the crane are situated far from each other, then a more complicated crane-mover-vehicle assignment is necessary. The next tour optimization method by Vis and Roodbergen (2009) can be used in combination with greedy algorithms to reduce bay processing time when containers are situated far from the vessel. Thus we have one more strategy to handle a ship bay.

Next we describe the problem and its solution methods. Let us imagine a straddle carrier in one yard block for storage and retrieval of containers. The block consists of a number of yard-bays or rows. The stack has only one layer. The outcome is defined as an optimal tour for storage and retrieval requests. One heuristic is to use the first-come-first-served rule for every requested container, but a block-scheduling approach is more effective. In it, we optimize the tour of the next few containers ahead in the straddle carrier's task.
The modeling technique for tour optimization is interesting and complex. A row can be understood as a special case of the Directed Rural Postman problem, and then converted into an asymmetric Steiner Traveling Salesman Problem, use optimal assignment with Monge matrices and convert back. We can combine the rows from different directions with dynamic programming with utilizing Bellman's optimization principle.
We note that terminal productivity will not benefit much from faster vehicle operations without effective storage yard strategies. When there is time, it usually possible to reorder the yard or some of it before the next ship arrives and therefore reduce turnaround time. This could serve as one additional strategy.

4. Berth side scheduling

Now we have methods for calculating one ship-bay using different techniques and different vehicle configurations. Next we consider how to use them in the next level.

4.1 Crane sequences

The usual bottleneck of the terminal is a quay or mobile crane which loads and unloads containers to and from a vessel. The quay cranes are rail mounted and cannot cross each other producing non-crossing constraints to the mixed integer model. Mobile cranes, on the other hand, are usually slower but are not rail-mounted and therefore are easier to move across the terminal. Also, mobile cranes can cross other cranes. The crane sequence (the order in which containers are handled), also affects the number of yard vehicles. We assume that a crane can handle only one container a time, although this could be changed in the future.

Pap et al (2011) noticed that one can minimize the number of yard vehicles by unloading or loading stack from the ship in a different order while the bay makespan remains the same. They used max-plus algebra, which is an attractive method for modeling non-linear problems linearly. Unfortunately, Pap's study did not attempt to find the optimum stack handling order. We have used max-plus algebra in a very similar fashion as we used the greedy algorithms mentioned above. By combining a basic genetic algorithm with a max-algebraic formulation we have found a near-optimal stack handling order which minimizes the number of yard vehicles.

Another type of crane sequence is a double cycling sequence in which we unload and load containers at the same time. Goodchild and Daganzo (2006) reformulated this han¬dling method as a two-machine flow shop scheduling problem which is solved to optimality using Johnson's rule. When to use and not use double cycling would be a decision variable in this instance. The crane’s cycle time is longer but the reduction of turnaround time can be even up to one fifth depending on the structure of the vessel. This technique is not always applicable due to limits of buffer size in some terminals.

4.2 Crane scheduling

We turn now to the second level of our algorithm: how to use these different bay strategies and their times to calculate the processing time or makespan of one vessel.

With regard to the problem of quay crane scheduling, our goal is to determine a handling sequence of holds for quay cranes assigned to a container vessel considering interference between quay cranes, at the same time minimizing the makespan. There are additional restrictions we must take into consideration. For example, two cranes cannot be too close to each other. That is, there must be a minimum separation constraint, usually at least one bay. The input data for the quay crane scheduling consists of the vessel stowage plan, the loading plan, and a yard map showing the stowage locations of containers to be loaded on the vessel. This problem has been shown to be NP-complete. Recent research has aimed at adding features of practical relevance and developing efficient solution ideas (see Bierwirth and Meisel (2010) for more details).

Next we model and extend the problem proposed by Lee et al. (2008), who modeled the quay crane scheduling problem using a homogenous set of quay cranes. However, if processing time depends on the crane used, the worker or workers, the number of vehicles, or any particular strategy involved, then clearly we have a heterogeneous set of cranes. The processing time depends also on how long it takes to move containers with using a chosen strategy. Since the yard locations are known, then we can calculate the processing time of every bay in the unload and load phases.

Thinking in this way, we can minimize the number of yard vehicles used in the gang working in a bay. Here we assume that there is one gang per one crane, but it would be interesting to consider how vehicle pooling, in which vehicles work together with many cranes, would integrate to this setting. Figure 1 illustrates a solution to an instance of this problem with involving vehicles. In future research a more advanced quay crane scheduling model can be used as a basis.

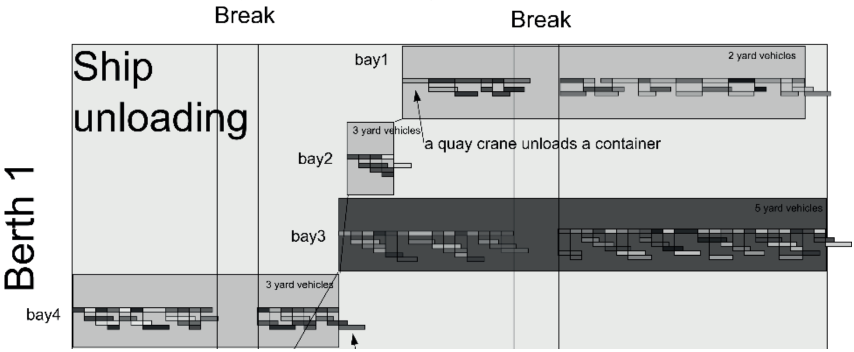

Fig. 1: A schematic example of the unloading phase with indicating breaks and amount of yard vehicles used. Crane one processes bays 5 and 3. Crane two processes bays 4, 2, and 1.

In the literature, crane models assume that the work is done non-stop. In manned terminals, work shifts and breaks also affect the model. We have primarily considered minimizing a vessel's turnaround time and the number of vehicles involved in unloading and loading, but there are other factors to consider as well. We can assume that night shifts are more expensive than day shifts. One decision variable could be whether we skip the night shift or not. Also if the contracted time window is exceeded, then a penalty has to be modeled.

Modular design enables us to solve special cases such as the single crane version (that is, a Traveling Salesman Problem with Precedence Constraints), separately. Otherwise, depending on the accuracy available, the crane scheduling problem can be very time-consuming to solve. In the case of small-sized instances our formulation can be solved by using CPLEX. For larger problems such as branch-and-price, branch-and-cut and still larger problems, metaheuristics would have to be utilized for their solution.

4.3 Berth allocation

We will conclude our study by considering the third level of the algorithm, berth allocation problems. These problems are highly interrelated with quay crane scheduling. A berth allocation problem involves assigning arrival ships to good berthing positions. It belongs to the class of NP-hard problems. Problems can be classified as either discrete or continuous. If we can assign only one ship at a time, the problem is discrete; if there is more than one ship, it is continuous.

In a quay crane assignment problem, we assign a number of quay cranes to vessels. The number of quay cranes assigned to a vessel often depends on contracts between the terminal and shipping companies. We say that the berth allocation problem is tactical if it involves quay crane assignment, in which we allocate cranes to vessels over time.

There have been many attempts to integrate crane allocation with berth scheduling. We refer here to the model articulated in Gilliambardo et al. (2010). That particular model was designed for a transshipment terminal, but it can be modified for an import-export terminal. Gilliambardo’s study used the idea of quay

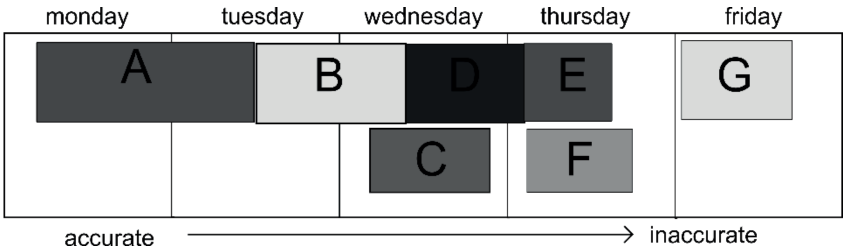

Fig. 2: Real-life time windows for vessels A to G and accuracy of information

crane profiles (how to assign cranes over time), for a discrete berth allocation model. Profiles can start either at the beginning of the shift or in the middle of the shift.

Figure 2, illustrates typical time windows of vessels. In our example, there are a few overlapping vehicles. The objective is to schedule and forecast the week's schedule that is the planning horizon is at most one week.

In practice, the terminal does not have all the information about the following week. The actual arrival times are uncertain and stochastic in real life. For example, winter affects the estimated schedules. Due to incomplete data, it is essential to be able to give both an exact and a rough estimate of the parameters. When crane scheduling is considered from a berth allocation point of view, the model comes more complex. In real life, for one ship the number of crane varies over time, with different amount of quay cranes used in different workshifts. Therefore, a new quay crane model is needed. Difficulties also arise if multiple vessels are berthed at the same time. The main concern here is: for any two ships and their windows, what the minimum number of resources is such that the two ships are processed within their time windows. If the vessel is moored within the contracted time window, then the terminal is responsible for processing a certain amount of moves per hour, otherwise operators are free to choose a berthing time outside the time window.

We extend the idea of quay profiles to contain different set of cranes: quay crane and mobile cranes. In a smaller terminal, it could be possible to treat cranes individually. We may also assign a different set of vehicles and their strategies.

Small problems can be solved with commercial mixed integer programming solvers, but a different method might be needed for larger instances.

5. Conclusion

In this paper, we considered how to integrate tactical the berth allocation problem, the quay crane scheduling problem and a set of related sub-problems into one functional algorithm. Our study was conducted from the point of view of Finnish ports. We focused primarily on how to calculate different bay times with different strategies and how to use these values in quay crane scheduling.

We can summarize the main conclusion of this paper as follows. We proposed a method to integrate the vehicle dispatching problem with its variations to the quay crane scheduling problem. This was done by calculating the bay processing times with different strategies, which provides a variety of parameters. Like Gilliambardo et al. (2010) who applied quay crane profiles to the berth allocation problem, the same idea can be used to provide vehicle profiles for ship bays. Therefore we used a heterogeneous set of cranes in our model. We also considered stack reordering and double cycling as tactics for minimizing the number of yard vehicles. We also used a quay and mobile cranes and considered breaks and skipping night shifts. Other tactics could be reordering the yard and providing a yard server. We also considered berth allocation with a different quay crane profile that contains both the quay and mobile cranes.

With modular design it is now easier to add new features and remove unnecessary elements. It is possible to use both exact information and rough estimates together. We also noticed that functional programming is a succinct and efficient way to combine different algorithms. In the future we will perform extensive computational experiments and present a detailed mathematical description of the model and the algorithm.

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The Role of Company Standards in Supply Chains – The Case of the German Automotive Industry

Anne-Marie Großmann and Paul von Gruben

Abstract

Company standards cover aspects such as quality assurance, testing procedures and terms of delivery. They are used not only internally but also imposed on suppliers. In this function, company standards have a potential to facilitate knowledge diffusion along the supply chain as well as assuring supplier's quality and have an impact on the bargaining power equilibrium between the buyer and its supplier. Especially in the automotive industry these aspects play an important role. This article uses a mixed methods approach to explore the employment of company standards in the supply chain of the German automotive industry with a special focus on the company's position within this supply chain. We analyze quantitative data from the German standardization panel to map the usage of company standards on different stages of the supply chain. An extensive qualitative analysis reveals how company standards play a role in the automotive supply chain. By examining the network that company standards span between manufacturers, suppliers and raw material producers we are able to highlight the various ways of diffusion of codified knowledge along the supply chain. This analysis reveals that especially large and powerful downstream players are able to burden their company standards on their suppliers but also upstream producers can provide their standards to their customers. Suppliers use different tactics to deal with heterogeneous external company standards they receive from their buyers. The results show that company standards can be a tool to manage the delivered quality of suppliers in

the automotive industry but the different company standards of multiple buyers can lead to increased efforts on part of the supplier.

Keywords: company standards, standardization management, supplier management, supply chain management

1. Introduction

The automotive industry is characterized by high consolidation, outsourcing of important parts of product development by manufacturers and dense competition. In this context, original equipment manufacturers (OEMs) can force their suppliers to comply with their company-specific standards (Sturgeon et al., 2008). The link between companies along the supply chain does not stop here, however, as suppliers and even upstream raw material producers (RMPs) also set their individual company standards and provide these to other firms. This paper analyzes the role of company standards in a representative part of the automotive supply chains, from the providers of raw materials to the OEMs.

We aim to understand how companies within the German automotive industry deal with their internal company standards and those of other firms. The supply chain "is traditionally characterized by a forward flow of materials but a backward flow of information" (Beamon, 1998, p.281). Our analysis will reveal that the information flow through company standards does not follow this traditional path. Answers reveal that the strong players in the industry at either end of the supply chain, the OEMs and RMPs, are able to impose their internal company standards on the smaller suppliers.

We arrive at this understanding by a quantitative analysis of data on automotive companies from the German standardization panel followed by an in-depth qualitative analysis of 21 deliberately chosen players within the industry. We follow the established procedures in developing a methodologically sound qualitative analysis (Maxwell, 2005; Yin, 2014) of these company standards.

We find that considering company standards can be important for supply chain management. Company standards are an indispensable tool to manage the required quality of a company´s supplier and were found to play a significant role in the bargaining process between companies. Also different strategies to deal with the heterogeneity of requirements from different companies in form of external company standards become eminent.

2. Conceptual Framework

2.1 Importance of Company Standards

A company standard is the outcome of the process of standardization carried out by an organization with regard to its own requirements (Düsterbeck et al., 1995). Confining this definition to the internal company perspective is not sufficient, as company standards can be used within one company but also be shared with direct business partners or suppliers to exchange basic information (Vries, 1999). Hence company standards can also be provided to other companies, e.g. suppliers, to request the fulfillment of their requirements. Blind and Großmann (2014) have therefore introduced a distinction between internal and external company standards. They defined internal company standards (ICS) as “documented standards developed within the company that are either used in the company or with cooperating companies, such as suppliers” and external company standards (ECS) as “documented standards developed by other companies (e.g. customers/buyers), excluding standards produces by formal standardization bodies or consortia, that are used within the own firm” (Blind and Großmann, 2014, p. 36).

2.2 The automotive Supply Chain

The three fundamental stages of the supply chain are the upstream acquisition of raw materials, the conversion of raw materials into specified final products and the delivery of final products to retailers (Beamon, 1998; p. 281). A rise in product complexity and a paucity of sufficient industry standards in the automotive industry has tightened the relationship between buyers and suppliers over the last decade (Sturgeon et al., 2008). On a global level, the supply base has consolidated and outsourcing by OEMs has grown, which led to an increase in value added by suppliers compared to the OEM (Sturgeon et al., 2008). Sturgeon et al. (2008) further stated that “the industry has historically relied on inter-personal interaction and proprietary standards […] to manage the flow of tacit information” (Sturgeon et al., 2008, p. 308) so the specific role of company standards in this industry is recognized.

At the downstream end of the automotive supply chain, the original equipment manufacturers (OEMs) produce final parts and assemble the end product. Recent developments in the industry led to only a small number of OEMs remaining (Sturgeon et al., 2008). Although OEMs have a larger number of direct suppliers, upstream in the supply chain only a small number of raw material producers (RMPs) exist (Agrawal et al., 2014). Due to the low number of OEMs and RMPs, we assume oligopolistic structures on both ends of the supply chain. Due to the resulting increase in purchasing power on the side of the OEM, Sturgeon et al. (2008) found that OEMs can force their suppliers to accommodate their idiosyncratic standards. Unfortunately, Sturgeon et al. do not consider the particular dynamics of company standards within the supply chain in depth. Also, they neglect the importance of the dynamics with regard to the upstream handling of these standards.

As Agrawal et al. (2014) however proposed, the upstream supply chain is worth looking at and a better management of the knowledge residing within the raw material supply chain can help firms to create value. Our objective is therefore to understand the use and implications of company standards along the entire supply chain.

2.3 Company Standards within the supply chain

The requirement to fulfil company standards can be a barrier for some suppliers to enter into trade relations with a particular buyer (von Schlippenbach and Teichmann, 2012). Once a standard is established and a commitment to a particular interface is made, switching costs arise (Farrell and Saloner, 1985). Hence, if a supplier has chosen to fulfil the company standards of their buyer (e.g. the OEM), they might be “locked-in” this trade relationship, which means that the costs of serving a different buyer and thereby switching to an alternative standard are too high (Farrell and Saloner, 1986). For example, if a suppliers lays out its production to fulfil a very low quality, this can lock them into trade relations with that customer who requires such low quality.

Recently, some studies in the field of food policy have covered the importance of private standards[2], following a shift from public to private governance in global agri-food systems. Such private standards are issued by retailers to their food growers mainly to assure a particular level of quality. We assume that some findings of that literature are of relevance for our study, where growers bear a resemblance to RMPs and retailers to OEMs[3]. A recent study by Thompson and Lockie (2013) of the Australian vegetable supply food system shows that the vegetable growers are not just obediently following private standards of their retailers, but that they also employ their own knowledge and power. Here, growers expressed concerns about the costs involved in fulfilling multiple standards from various retailers (Thompson and Lockie, 2013). A further study argues that retailers can exert their power due to their size and position at the top of the supply chain to impose a private quality assurance standards as “de facto condition of market access” (Hatanaka et al., 2005).

These results seem applicable to the automotive industry, although the matter herein seems to be of a different complexity. For once, the agri-food supply chain has less depth than the automotive supply chain. Additionally, in the automotive industry there is no third-party certification required for the fulfilment of private

[2] In the agri-food industry private standards are developed by one company, bearing close resemblance to company standards. However, certification is required where growers get surveyed by an independent party on their compliance to those private standards.

[3] We see retailers in the agri food serving a similar purpose to automotive OEMs as they also need to ensure a high level of quality and compete in an oligopolistic market.

standards, but they rather act as a potential barrier to entering into trade relations with a buyer.

2.4 Research Objective

Due to the very specific power relations within the automotive industry and potential influence of company standards on the dynamics within the supply chain, we formulate our research questions:

- How do companies in the automotive supply chain deal with internal and external company standard?
- Does the supply chain position influence the ability of firms to handle external company standards?

3. Research methodology

To our knowledge, there is a shortage of studies concerning the role of company standards for automotive supply chains. This warrants a careful in-depth analysis for a thorough understanding of the topic as well as data triangulation (Yin, 2014). We hence used a two-step procedure by including both quantitative and qualitative data in our analysis. As we wanted to consider the German automotive industry, we considered the membership list of the German association of the automotive industry (VDA) to be the population for our analysis. Our population therefore comprises 606 companies either classified as OEMs, Suppliers or RMPs. Throughout our analysis we paid close attention to the measures of internal validity, construct validity, external validity and reliability (Gibbert et al., 2008).

In the first step we consider data from the second wave of the German standardization panel. This is an extensive online survey conducted in autumn 2013 with over 1600 participants in Germany (Blind et al., 2014). The questions were developed in collaborations with the authors of this paper. We provide a descriptive overview of answers from companies belonging to the automotive industry only. Based on the revelations of this quantitative analysis as well as our theoretical considerations we developed a semi-structured interview guideline (Yin, 2014) to gain a deeper understanding of company standards in automotive supply chains. This inductive approach is warranted to understand the meaning and the particular context that surround company standards within the supply chain (Maxwell, 2005).

For the first step of our analysis we extracted answers from the German standardization panel of companies identified as belonging to the German automotive industry. Overall 6 OEMs, 53 suppliers and 9 raw material producers provided answers on their standardization activities within the survey. Although we were able to gain some understanding from these statistics generated, they raise some further issues: First, all of the respondents of this survey were either members of the German Institute of Standardization (DIN) or the German Commission for Electrical, Electronic & Information Technologies (VDE). This could prove problematic because companies involved in formal standardization activities might have a biased approach towards company standardization. Second, the results revealed some particularities that deserved more attention.

In the second step we therefore generated a guideline for semi-structured interviews with experts on standardization within German automotive companies to get a more detailed understanding of the findings from the quantitative analysis. The companies were chosen to mirror the spread of companies in the population and we deliberately balanced the sample with regards to membership in the formal standardization organizations, size and product portfolio. We interviewed 4 OEMs, 13 suppliers and 4 RMPs. To construct validity, in each of the companies we interviewed either a member of the standardization departments or, if the company had no such department, an employee responsible for standardization, procurement or quality management. An overview of the companies and interview partners can be taken from table A.1. The telephone interviews with these companies were conducted within a three week time frame. The interview guideline was developed after a review of the literature and the quantitative analysis. Table A.1 in the appendix lays out the instrument for these interviews. All interviews were recorded, transcribed and coded. We used both attribute coding for the information on the participants as well as structural coding for the content related to each question (Saldana, 2009). Afterwards, we did a within-case (RMPs/Suppliers/OEMs) and between-case analysis (comparison of the three groups) (Yin, 2014) to reveal the evident relationships between the companies in the supply chain via company standards.

4. Findings

4.1 Use of ICS and ECS in the automotive industry

We first provide an overview of the results from the German standardization panel. 68 of the firms in the panel belong to the automotive industry (11.2% of the population). An overview of these firms' characteristics is provided in table 1.

	N	*Employees*		*Turnover (Mio €)*		*Productivity*	
		Mean	S.D.	Mean	S.D.	Mean	S.D.
OEM	6	172907	207581	75556	73329	0.70	0.14
Supplier	53	8908	17868	1241	2229	0.35	0.54
RMP	9	23655	35857	20481	24277	0.52	0.18

Tab. 1: Overview of the companies in the sample

We can observe that the OEM and RMPs have significantly higher numbers of employees, turnover and productivity (measured as turnover per employee) levels compared to the suppliers in the sample. 56% of the companies[4] have a standardization department, including all the OEMs and roughly half of the suppliers and RMPs. Most standardization departments are anchored within the R&D or QM-Departments and are responsible for the distribution of formal standards as well as the development and diffusion of internal company standards. More than 77% of the companies in the sample have spent above

[4] Please note that the difference in total observation results from missing observations.

10.000 € (28% above 100.000€) on internal and external standardization activities in 2012. Here, the OEMs spend at least 100.000 € on their standardization activities, up to above 10 Mio €; Suppliers and Raw Material Producers do not spend as much money; but almost all but one spend between 1000 € and 1 Mio €. Standardization hence seems to be a substantial issue in these companies.

The questionnaire also asked the companies how important they assess internal company standards (ICS) and external company standards (ECS) (see table 2). 100% of the OEMs found ICS very important. The RMPs also evaluated ICS highly important whereas the suppliers judged these a little lower. External company standards, however, become more important the further downstream we go – whereas OEMs rate them with little importance, raw material producers assess them with high importance. These differences hint at the need for discriminating between the effects of own company standards compared to external ones and reinforce the importance of our research questions.

	ICS			*ECS*		
	N	Mean	S.D.	N	Mean	S.D.
OEM	6	3.00	0.00	4	0.75	2.63
Supplier	50	2.08	1.35	49	1.86	1.32
RMP	8	2.50	0.76	6	2.50	0.84

Tab. 2: Rating of the importance of company standards for the company from -3 (very unimportant) to 3 (very important)

We further compiled information on the use of ICS and ECS in our sample, which is reported in figure 1. In our sample ICS are used by around 90% of the companies and also 90% of the companies need to fulfil ECS. Of the 53 companies that use ICS the majority (73%) uses a high number of CS (>11-100). Especially OEMs employ a high number of ICS, ECS a little less.

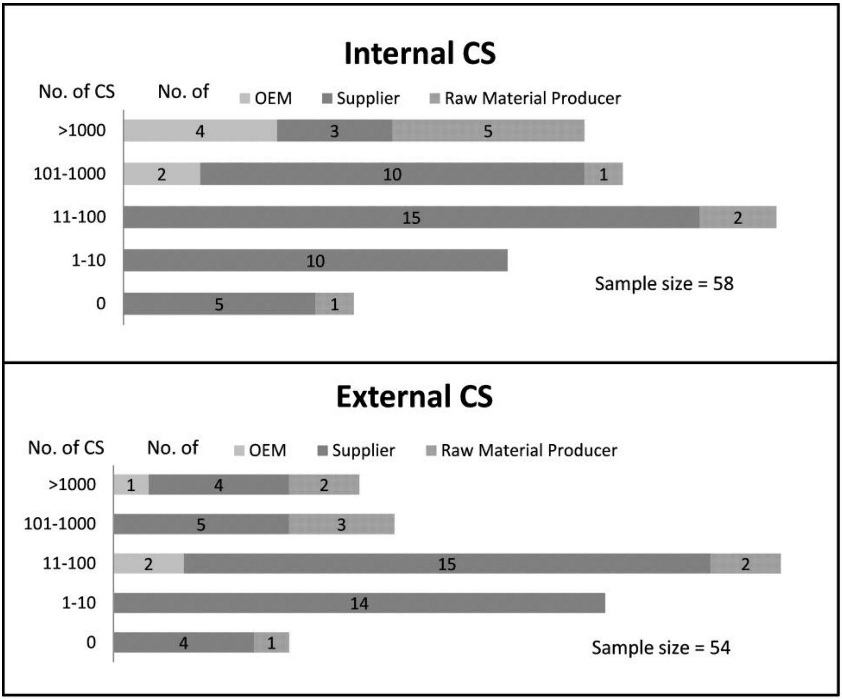

Fig. 1: The number of internal (ICS) and external (ECS) company standards used according to supply chain position

	Internal CS			*External CS*		
	N	Mean	S.D.	N	Mean	S.D.
OEM	6	2.33	1.21	2	1.50	0.71
Supplier	27	1.48	0.89	28	1.29	1.21
RMP	6	1.00	0.63	6	1.17	0.75

Tab. 3: Impact of company standard on the bargaining position with suppliers and buyers from -3 (very negative) to 3 (very positive)

Finally table 3 provides an overview how the companies judge the impact of company standards on the bargaining position with partners in the supply chain.

This shows that OEMs find their internal company standards to have a higher positive impact on their bargaining position; whereas suppliers and raw material producers judge this lower, although still positive. External company standards seem to have a less positive impact.

From this first descriptive analysis of company standards, additional questions about the use of company standards along the different positions within the supply chain arose. Therefore we carried out a further in-depth analysis by interviewing selected companies from the automotive industry. These findings will help us to understand what role company standards play within the supply chain.

4.2 Interviews

As can be seen in table A.1, all our interview partners were in adequate positions to comment on the role of company standards within their supply chain, as they are responsible for standardization, procurement or quality management in their company. Our sample consists of 4 OEMs and 4 RMPs as well as 13 Suppliers. All but one of the 21 respondents said that they were developing ICS. This supplier (SUP11) however stated that it is issuing testing instructions and other internal documents which can be classified as ICS. We will now review the observations from within the three groups of interest (OEMs, Suppliers and RMP) before we state the diverging results between the three groups.

All suppliers in our sample have OEMs as their direct customers, and some are additionally sub-suppliers to OEMs. Nearly all of the supplying companies reported to provide at least a significant share (more than 50%) of their ICS to external companies, which are mostly sub-suppliers or cooperation partners. Only SUP11, a manufacturer of chemicals, provides only a minor share (0.1%) to their outsiders (their customers). If a company provides only part of their ICS portfolio to external companies, they usually keep those ICS that consider internal process requirements, lead time and knowhow confidential. Topics regarding connecting elements, technical requirements (e.g. material requirements), testing and quality requirements are provided externally to suppliers or cooperation partner. All of the suppliers, to some extent, have to fulfil ECS from their customers, which are either OEMs or direct suppliers to the OEMs. The ease with which the companies can fulfil ECS varies between the suppliers, for example SUP5, SUP7 and SUP8 stated that they already produce to the highest quality level covering the quality requirements laid out in their ECS. Further, suppliers know that they have to fulfil ECS of their customers in order to overcome the market entry barriers: “If we do not fulfil the quality requirements of our ECS we will lose our position as supplier” (SUP6).

Many interviewed suppliers brought up the copyright issue which becomes problematic in case they need to pass on their ECS to sub-suppliers. The way some suppliers deal with this problem is to convert external requirements in the form of ECS into their own ICS. In some cases this means that the content of the requirements stays the same, but the formal appearance changes. Some suppliers are also able to bundle ECS of their different customers into one ICS. In other cases, ECS have to be split up into different ICS which can be passed on to different suppliers. One example: SUP5 reported difficulties with varying company standards for documentation: “Our customers demand different sampling documentation. Despite the fact that this is the same procedure, we have to do the documentation differently according to each of the ECS”.

The Suppliers see company standards as an important contractual basis and mandatory to enter into trade relations. We find that the goal for suppliers to provide their own company standards to their suppliers is for quality assurance. As with the copyright issue in passing on ECS, the issue of knowledge revelation is also apparent in ICS, as SUP9 states: “ICS are a transfer of knowhow and this can be dangerous, as our suppliers could provide our ICS to our competitors.”

The OEMs in the sample all provide their ICS to their suppliers. Two of the four OEMs in our sample even let suppliers access nearly all of their ICS (above 90%) while OEM3 permits suppliers to access all their ICS. Only OEM4 provides only 50% of their ICS to suppliers, as the other half are testing requirements for internal use only. The OEMs have to fulfil ECS only in exceptions, for example if they act in turn as suppliers to other OEMs (OEM3 and OEM2) or if they cooperate in specific projects. All of the OEMs explained that company standards have a high influence on their supplier relationship management, as they can provide transparency on the technical requirements and a contractual basis and lead to cost reductions. In providing their ICS, the OEMs want to ensure that their suppliers fulfil their quality requirements. OEM1 states: “with topics concerning quality, we develop internal company standards. This cannot be done externally [e.g. in formal or consortia standardization], because then everybody would be required to fulfil our standard and this might be too expensive for some”. Knowhow, however, does not seem to be such an issue in the external provision of the OEM’s ICS, as OEM 1 states “if something is standardized in our company this is usually already known by industry insiders“[5].

The upstream RMPs themselves develop ICS that in parts are provided to their customers, RMP2 even states that they sometimes develop their ICS in accordance with their customers. The RMPs however also stated that they fulfil some ECS from their customers. An interesting aspect raised by RMP1 and RMP4 is that frequently information asymmetries between the RMP and its customers exist; for example do the suppliers demand testing procedures in their company standards that cannot be fulfilled by the RMP or where this leads to higher costs. This can lead to increases in costs. RMP3 also stated that they usually fulfil the highest quality that is required in their ECS, regardless of lower requirements in other ECS.

Comparing the three types of companies is the heart of our analysis, as we are interested in the links in the supply chain through company standards. Figure 2 provides an overview of the three types of cases how company standards diffuse through the supply chain we encountered.

[5] Industry insiders refers to the technical experts in the industry, especially in other OEMs.

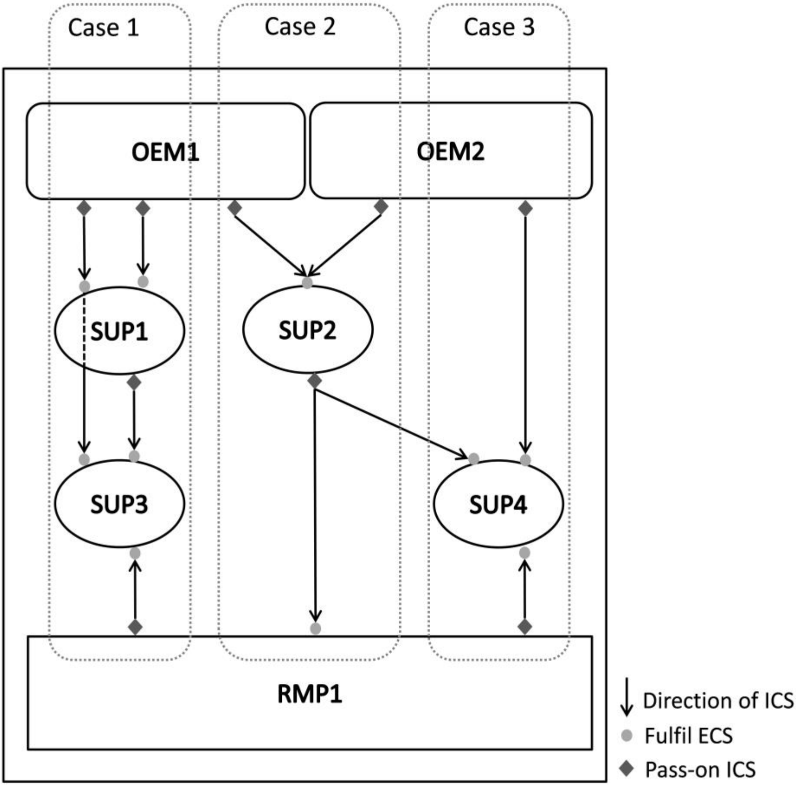

Fig. 2: Exemplary cases of the diffusion of company standards through the automotive supply chain

In the first case, the dashed line through SUP2 is an illustration of what in earlier talks with a development engineer of a major OEM has been called a “standard worm”: the fact that one standard is rarely applicable on its own but usually draws a whole “tail” of additionally references of applicable standards; which might themselves reference additional standards. Although some suppliers conceal the origin of their ECS to their sub-suppliers (therefore the dashed line), they pass the requested standard from the OEM upstream. As the RMP also pass their company standards to their own customers, the suppliers that are in the middle of the supply chain have to deal with both the information codified in upstream and downstream ECS, as is exemplified in supplier 3 in the figure. Especially suppliers with lower power see the fulfillment of ECS as mandatory in order to be in trade relations with their buyers.

Case two provides an example of the fact when the supplier bundles ECSs of their different customers together and issues them as ICS to their sub-suppliers. E.g. as SUP9 states: “if we have similar standards that are requested by more than 70% of our clients it makes sense to incorporate them in our own standard rather than making a special solution for all the others”. This means that the requirements stated in ECS of different customers are combined into one ICS which is set at the highest requirement level. Hence, all customers receive the same level, even if they have asked for a lower requirement level. They might only pay for the lower requirement level but with the simplification or cost reduction issues during the production process, they still get the higher level requirement. This unified standard is then also provided to sub-suppliers or even RMPs. Some requirements in form of ECS of customers need to be divided into many different ICS which than can be passed on to the respective sub-supplier.

The third case illustrates how ECS can contain codified information from various stages of the supply chain. As the suppliers in the automotive industry state not only to deliver to the OEM directly but also to suppliers of OEMs, the same supplier can act as both a direct supplier and a sub-supplier within the supply chain. This means that the ECS come from various stages and hence knowledge transfer is taking place from these various stages of the supply chain.

5. Discussion

Our objective was to identify how companies in the automotive supply chain deal with company standards. We discriminated between internal and external company standards. From the quantitative analysis, we found that OEMs rate the importance of internal company standards for their company highest. External company standards, however, seem to be more important upstream with RMP than downstream with OEMs. There was also an indication that company standards have a positive impact on the bargaining power with customers and suppliers, regardless of the supply chain position. From this analysis we can infer that company standards seem to play a role for managing a firm's supply chain. A more finely granulated analysis reveals that especially technical and quality issues are codified in ICS and passed on for quality assurance.

5.1 Supply chain position and company standards

It is striking that both OEMs and RMPs pass on ICS to suppliers in the mediating position between them. This also contradicts traditional theory, which suggests that knowledge flows one-directionally backwards in the supply chain (Beamon, 1998). This could be related to the issue that ICS have a positive impact on the bargaining power of firms; at the same time, especially strong player, located at either end of the supply chain (OEMs and RMPs) are able to burden their standards on the weaker players in the middle. The results suggest a positive two-way relationship between the bargaining position in the supply chain and therefore the market power and the impact of exercising ICS. One possibility suggests that strong players in the market (e.g. OEMs, RMPs and large suppliers) exercise such standards to keep the weaker players weak. This link should therefore be carefully considered in the management of the supply chain. The results however also suggest, that generally all suppliers have the chance to accumulate heterogeneous information from both upstream and downstream positions, thereby providing power residing in the holding of information on part of the supplier.

5.2 Quality levels and company standards

We further found that some suppliers fulfil the ECS with the highest requirement and thereby meet the required quality of all other ECS automatically. For the suppliers, this reduces complexity, as they do not have to take care of each individual ECS, and increases the production volume. But this comes at the expense of higher production costs for the supplier. On the other hand this reveals that if OEMs set a lower quality standard for their components (e.g. to save costs) and provide this to their supplier, they could potentially provide an advantage and get hold of a supplier that also sells to other OEMs with potentially higher quality requirements. This would mean that despite asking for a lower quality, their components fulfil a higher standard. SUP7 for example provides a case where the customers (OEMs) of a supplier did not know that they were getting the same standard as their competitors. But, as pointed out by OEM1, however, general industry insiders are already aware of the demands of their competitors at the OEM level.

5.3 Copyright issues and company standards

When part of the production is outsourced, ICS are passed on to sub-suppliers but also ECS of customers. To conceal for which customer the product is produced, companies change the formal appearance of ECS but leave the content the same. This needs the approval of the customer. Copyright issues might even forbid the passing on of ECS altogether. In this case the sub-suppliers might need to obtain the ECS from the original customer (e.g. OEM) themselves.

5.4 Implications for supply chain management

As the handling of ECS by suppliers varies, this can have important implications for supply chain management. Some suppliers are able to use their bargaining strength to discuss ECS and eventually manage to alter them in their favor, while others have to fulfill the requirements of ECS without such a possibility. Some suppliers are able to bundle multiple ECS into one ICS thereby making use of economies of scale as a matter of variety reduction.

We also found that some information asymmetries exist on the content of company standards. ICS might include redundant testing procedures, for example, which unnecessarily raises the costs of the products. It is therefore important to consider the benefit of imposing certain ICS on suppliers, if the supplier themselves have a better understanding of the matter. As OEM1 said: “you should not restrict your supplier too much through tight requirements, so that too little flexibility is left for him to realize own ideas. He might find a material which leads to lower production costs [and further to a lower price].”

6. Conclusion

This paper analyses the usage of company standards along supply chains in the German automotive industry. By considering existing studies, for example on the agri-food supply chain, the purpose of this paper was to explore how companies in the automotive supply chain deal with internal and external company standards. The main reason for imposing company standards on supply chain partners is to assure quality. The study also sought to identify how the position within the supply chain matters for the dealing with such standards. We find that the bargaining strength of larger companies has a positive impact on the ability to put forward its requirements in supply chain relations through company standards. We further find that the position in the supply chain matters: rather than a one-directional flow of company standards from downstream to upstream companies of the supply chain, the suppliers in the middle are the weakest players that have to consider company standards of the OEM as well as of the RMP.

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Appendix

A.1 Overview of the interview respondents

Abbr.	Position in company	No. employees	Type of company	Business description
OEM 1	Manager; standard. department	100,000-150,000	Producer of premium cars	Design, assembly, manufacture and distribution of premium cars on a global scale
OEM 2	Manager; standard. department	250,000-500,000	Producer of premium cars and trucks	Design, assembly, manufacture and distribution of cars and trucks on a global scale under different brands
OEM 3	Manager; Standard., Technical Translation	25,000-50,000	Producer of trucks and commercial vehicle	Design, assembly, manufacture and distribution of trucks and commercial vehicles on a global scale
OEM 4	Manager; standard. department	>500,000	Producer of small, medium and premium cars	Design, assembly, manufacture and distribution of cars on a global scale under different brands
SUP 1	Staff member; purchasing dept.	1,000-5,000	Manufacturer of car body parts and engineering apparatus	Production of system solutions and ready-to-fit components for the body panel

Abbr.	Position in company	No. employees	Type of company	Business description
SUP 2	Staff member; standard. department	10,000-50,000	Manufacturer of vehicle parts	Develops, produces and distributes mechatronic components and systems for vehicle doors, seats and body
Abbr.	Position in company	No. employees	Type of company	Business description
SUP 3	Manager; Standard. department	150,000-200,000	Manufacturer of automotive components	Develops and produces tires, brake systems, automotive safety, powertrain and chassis components
SUP 4	Staff member; standard. department	1,000-5,000	Gearing and brakes manufacturer	Develops and produces brakes and gearing systems
SUP 5	Manager; Standard. department	1,000-5,000	Manufacturer of electric components	Researches, develops, manufactures and distributes electronic connectors and fittings
SUP 6	Responsible for standardizati on	10,000-50,000	Manufacturer of car parts and vehicle lighting	Production of vehicle lighting and electronics systems and development of vehicle diagnostics and thermal management

Abbr.	Position in company	No. employees	Type of company	Business description
SUP 7	Manager; Standard. department	500-1,000	Manufacturer of car communications systems	Develops and produces telecommunication technology and radio systems
SUP 8	Staff member; standard. department	50,000-100,000	Manufacturer of engine components	Researches, develops and manufactures system solutions for engine parts as well as air and liquid management for vehicles
SUP 9	Responsible for standardization	5,000-10,000	Manufacturer of radiator systems	Develops and produces radiator systems for vehicles
SUP 10	Standard. responsible; Engineering dept.	10,000-50,000	Manufacturer of engine components and radiator systems	Develops and produces exhaustion systems and engine components
Abbr.	Position in company	No. employees	Type of company	Business description
SUP 11	Quality management officer	10,000-50,000	Manufacturer of chemicals	Production of chemical components for bonding, reinforcing and protection

Abbr.	Position in company	No. employees	Type of company	Business description
SUP 12	Responsible for standardization	5,000-10,000	Producer of structural components and assemblies	Manufacture of large metal stampings as well as exterior surfaces
SUP 13	Responsible for standard.; product marketing	50,000-100,000	Wholesaler of screws and installation material	Producer of metal equipment and development of storage solution
RMP 1	Head; technical product management	10,000-50,000	Producer of coatings, sealants and polycarbonates	Develops and manufactures materials and polymers
RMP 2	Responsible; testing procedures	1,000-5,000	Manufacturer of lubricants	Produces lubricants, hydraulic and biodegradable products
RMP 3	Head; technical product management	10,000-50,000	Producer of steel and components	Producer of steel products and steel components
RMP 4	Head; technical product management	5,000-10,000	Manufacturer of carbon and ceramic components	Researches, develops and produces composites, ceramics and sintered metal

Tab. A.1 Overview of the interview respondents

A.2: Semi-Structured Interview Instrument

1. Respondent and company information (closed questions)
   - Company name
   - OEM /Supplier/RMP
   - Number of employees
   - Name of the interviewee
   - Position of the interviewee
2. Short introduction and overview of content.
   Introduce research. Explain the terminology of the study: Internal Company Standards (ICS) and External Company standards (ECS). Try to capture their confidence with the topic.
3. Use of ICS and ECS in the company (open-ended questions)
   - Is your company developing ICS?
   - What share of ICS is passed onto external organizations?
   - Who are these external organizations?
   - What is the topical difference between confidential internal company standards and those provided to these organisations?
   - Does your company comply with ECS?
   - What kind of organizations provides ECS to your company
4. Handling of ECS in the company (open-ended questions)
   - What is the effect of compliance to ECS of different organizations?
   - What hindrances and possibilities results from the compliance to ECS?
   - How does your company deal with these?
   - What influence do ECS have on the ICS developed in your company?
   - Are you providing your ECS also to your suppliers? If so, are you altering the topics in these ECS?
5. Company standards and supplier relationships (open-ended questions)
   - What influence do company standards have on your relationships with your suppliers?
   - What aims is your company trying to reach in passing in providing ICS to other organizations?

Investments in Electro Mobility for Freight Traffics in the Field of City Logistics: A Profitability Analysis

Sabrina Gries, Christian Witte, René Föhring and Stephan Zelewski

Abstract

Electro mobility is considered to be a pioneering trend in the field of road traffic to reduce the emissions of greenhouse gases. Because of technical restrictions, which limit the range and loading capacity of vehicles, electro mobility is mostly discussed with regard to passenger cars. However, recent developments raise the question whether electro mobility can be also used promisingly for local freight traffics of the so-called "city logistics". Interesting are especially transports on the “first” and “last mile” of supply chains with combined transports. However, electro mobility has only then potential as a future trend if the profitability of investments can be demonstrated.

The profitability of investments in electro mobility is being examined. The costs of three diesel versus three similar electric commercial vehicles are calculated for a typical case of application in city logistics. The analyses cover three scenarios that represent alternative investment options for the application of electro mobility: the complete purchase of electric commercial vehicles, the partial purchase combined with renting the battery as well as the complete vehicle leasing. Drive-specific features like e.g. the smaller range of electric commercial vehicles compared to diesel commercial vehicles are especially considered. It is shown that already today the regarded electric commercial vehicles prove to be economically attractive in some of the examined scenarios. Moreover, it is elucidated which expectable changes in future within the circumstances of city logistics will promote investments in electro mobility.

Keywords: city logistics, electro mobility, freight traffic, profitability analysis

1. Electro Mobility and City Logistics: an economical challenge

Electro mobility is considered to be a pioneering trend in the field of road traffic to reduce the emissions of greenhouse gases. Because of technical restrictions, which limit the range and loading capacity of vehicles, electro mobility is mostly discussed with regard to passenger cars. However, recent developments raise the question whether electro mobility can be also used promisingly for local freight traffics of the so-called "city logistics". Interesting are especially transports on the “first” and “last mile” of supply chains with combined transports.

In the aforementioned application fields, which in the following will be sub-sumed under the term "city logistics" for the sake of convenience, commercial vehicles with electric powertrain (electric commercial vehicles) possess some attractive characteristics towards conventional commercial vehicles with diesel drive (diesel commercial vehicles). Firstly, ecologically harmful emissions of greenhouse gases are being reduced considerably. This applies most of all if the driving power of electric commercial vehicles arises from sustainably produced electric energy like e.g. wind energy or solar energy. Secondly, electric commercial vehicles contribute to a notable reduction of the environmental burden through traffic noise in populous areas, especially in city centers. Thirdly, electric commercial vehicles can receive a privileged access to city centers for reasons of environment protection (e.g. fine dust pollution) or traffic abatement (e.g. at night and in the early hours) if the passing of city centers by diesel commercial vehicles is either principally or at least at definite daytimes forbidden or is significantly increased in price by means of raising an emission dependent city toll. Finally – and fourthly – it can have a positive effect on the reputation of a logistics service provider if it demonstrably realizes the majority of its transports of goods on the road with the help of electric commercial vehicles. From the perspective of the often postulated "green logistics" the logistics service provider can benefit from its contributions to the reduction of emissions of greenhouse gases and from the traffic noise both through additional transport requests (quantity effect) and through higher transport prices as an eco-premium (price effect).

In the light of such advantages it can surprise on the first glance that electric commercial vehicles are still barely used in business practice. The usual objections against electric commercial vehicles – range is too low (with one battery charge) and the vehicle load capacity is too low (because of the high own weight of the batteries) – do not have an important relevance in the field of city logistics. Especially the range argument cannot convince since the tour distances in city logistics lie beneath 100 km, i.e. a range that can be managed by an electric commercial vehicle with one battery charge without any problems.

Experiences from first pilot applications of electric commercial vehicles and conversations with logistics experts indicate that the main obstacle with regard to the employment of electric commercial vehicles in business practice lies in the widely held preconception that the significant investments in electric commercial vehicles as well as in the necessary infrastructure for running electric commercial vehicles would not pay off from a business point of view. However, it lacks in economically sound profitability analyses in which the technical peculiarities of electric commercial vehicles are being taken into account and in which the different business options for the purchase as well as the usage of electric commercial vehicles is being analyzed.

In order to close this gap in the analyses, this paper will examine with the help of a profitability analysis under which circumstances electric commercial vehicles prove to be advantageous compared to diesel commercial vehicles in the field of city logistics from a business point of view. The focus of the analysis lies in the vehicle cost accounting approach in order to adhere to established specialized literature and also to business practice. In future papers, this cost oriented analysis focus shall be extended by a proceeds perspective for the assessment of e.g. reputation effects.

2. Principles of a profitability analysis on the basis of the vehicle cost accounting

2.1 Overview of the vehicle cost accounting

The vehicle cost accounting constitutes one of the oldest and most widely used calculation instruments in the logistics field. For the vehicle cost accounting a "standardized" calculations schema is being used that also underlies this paper. However, it cannot be fully described here due to the brevity required. Instead, it is referred to a detailed description of the calculation schema in Gries and Zelewski (2013, pp.2–3) that was developed based on Oppenberg and Schimpf (2004, p.83).

The vehicle cost accounting divides into two parts: the variable (kilometer-dependent) and the fixed (time-dependent) vehicle costs. If the entire variable vehicle costs per annum are divided by the annual mileage, one receives the kilometer rate in euro per kilometer. The fixed vehicle costs cover the driving personnel, the fixed vehicle costs and the general expenses per annum. The summation of these three items yields under consideration of the operating days per annum the daily rate in euro per day. At the end of the vehicle cost accounting one receives the total costs of one vehicle per annum from the sum of the variable and fixed costs.

With the kilometer rate, the daily rate and the total costs, a comparison of different commercial vehicles as well as of different purchase and usage options for commercial vehicles can be made. For the sake of convenience, the purchase and usage options for commercial vehicles will be referred to as investments modes in the following.

The details of the following vehicle cost accounting were devised within the framework of the joint project E-Route. They are fully documented in the paper of Gries and Zelewski (2013, pp.3–11 and pp.15–25). Also, there are to be found comprehensive evidences for the numerous assumptions regarding cost influencing variables that are necessary for a realistic vehicle cost accounting. In accordance with a paper giving an overview, only the basic procedure as well as the key results of the vehicle cost accounting for the use of diesel versus electric commercial vehicles will be presented in the following chapters.

2.2 Basics of a calculation for diesel and electric commercial vehicles

When investing in commercial vehicles, a business managing director has several options. Within the context of this paper the vehicle purchase and the vehicle leasing of diesel as well as similar electric commercial vehicles will be regarded. Additionally, for electric commercial vehicles, the special option of buying a vehicle combined with leasing a battery will be examined. However, when buying an electric commercial vehicle there is still not the possibility to buy each model in any way mentioned. Therefore, for each investment mode one diesel commercial vehicle will be compared with a similar electric commercial vehicle in which case this investment mode is possible.

For the comparison calculation the following similar commercial vehicles will be compared with each other: the diesel model "IVECO Daily box-type van 35S11V" and the electric model "IVECO Daily Electric box-type van 35S", the diesel model "Mercedes-Benz Vito 110 CDI KA/L 3200" and the electric model "Mercedes-Benz Vito E-Cell KA/L" as well as the diesel model "Renault Kangoo Rapid dCi 90" and the electric model "Renault Kangoo Z.E.".

The profitability analysis will be conducted exemplarily for a fictive forwarder that delivers goods for a midsize trading company. The goods are being delivered on two tours per day, on six days a week. For this, an annual mileage of about 40,000 kilometers is necessary. In the case of an annual mileage of 40,000 kilometers and 300 operating days per year, the used vehicles drive about 133 kilometers per day. The electric commercial vehicles chosen for the comparison have a range of 130 to 170 kilometers with a fully charged battery as specified by the "new European driving cycle" (NEDC) according to the manufacturer´s data. The actual range depends on the driven speed, the individual way of driving, the vehicle load capacity, the outdoor temperature, the usage of electrical loads and the topography. The charging time takes between 5 and 9 hours when

the battery is fully discharged. In the outlined scenario this is no obstacle for the delivering of goods. The payload of 625 to 850 kilograms and the load volume of 2.4 to 12.0 cubic meters of the here regarded commercial vehicles also suffice for the delivery of customers.
As further calculation data for the vehicle cost accounting the following are taken as a basis: an operating life of the commercial vehicles of 4 years respectively, a leasing term of 24 months respectively as well as a tire mileage of 40,000 kilometers. A fuel price of 1.479 euro per liter and an electricity price of 0.1402 euro per kilowatt hour are being assumed
(Gries and Zelewski, 2013, p.5).
The first pool of costs in the vehicle cost accounting is made of the variable vehicle costs. The items amortization, battery leasing and leasing rate will be elaborated on further in the text along with the respective investment mode. In the case of diesel commercial vehicles, the fuel costs are being determined by the consumption in liter per 100 kilometers multiplied with the average diesel fuel price in the year 2012 and are divided by 100 in order to receive the costs in euro per kilometer. The costs for electric commercial vehicles are being determined in the same manner. Here, the consumption of kilowatt hours per 100 kilometers and the average electricity price in the year 2012 are taken as a basis. For lubricants and oils an amount of one percent of the fuel costs is being set for diesel commercial vehicles (Wittenbrink, 2011, p.14). In the case of electric commercial vehicles there are no costs for lubricants and oils as they are not used for these vehicles. Along with the individual commercial vehicles it will be elaborated on the costs for tires. For the maintenance and repair of the vehicles, half of the amount of diesel commercial vehicles will be assumed for electric commercial vehicles since an electric motor with about 300 parts has far fewer components than a combustion engine with about 1,400 parts and thus requires less maintenance (Lienkamp, 2012, p.33; Kampker, Vallée and Schnettler, 2013, p.47). The calculation basis is made up by the vehicle specific maintenance and repair costs that are to be expected on average in the case of an annual mileage of about 40,000 kilometers.

Any other operating costs are also counted among the variable vehicle costs. These include all further costs that are directly ascribable to the vehicle and that depend on the covered kilometers. In the case of an annual mileage of about 40,000 kilometers, a lump sum of 200 euro per year is being set for other operating costs for all vehicles.

The next pool of costs is made of the fixed i.e. the time-dependent vehicle costs. This pool of costs is divided into driving personnel costs, fixed vehicle costs and general expenses.

The driving personnel costs are being calculated for all vehicle types with the same amounts as they are not vehicle specific. The driver wage is assumed to be 20,000 euro gross per year since in many cases temporary drivers are employed in the field of city logistics (Wittenbrink, 2011, p.58). 500 euro per year is assumed as Christmas bonus. An addition of 20 percent on the gross wage is made for social costs. It is assumed that per vehicle costs arise for only one driver.

For the fixed vehicle costs, the motor vehicle tax for diesel commercial vehicles has been calculated with the help of the online tool "Kfz-Steuerrechner" of the federal ministry (http://www.bundesfinanzministerium.de/SiteGlobals/Functions/KfzRechner/cartax.html, Stand: 2013-07-02). Vehicles with a purely electric drive and a registration date between the 18th of May 2011 and the 31st of December 2015 are exempted from the motor vehicle tax for 10 years. In the case of a later registration date until the 31st of December 2020 an exemption from the motor vehicle tax of 5 years applies. After that, the motor vehicle tax is being calculated on the basis of the admissible total weight like for other light commercial vehicles. However, it is to be noted that this sum is being abated by half.

The costs for the motor car insurance have been determined in the best possible way. Nevertheless, these costs may lead to a distortion of the calculation results since not all electric commercial vehicles are listed with the insurances and thus have to be calculated with similar values of diesel commercial vehicles.

In Germany, only heavy commercial vehicles have to pay a freeway toll. Thus, the freeway toll does not need to be considered for the here regarded light commercial vehicles for distribution transports on the "first" and "last mile" in the field of city logistics.

It will be elaborated on further costs, which make up the fixed vehicle costs, along with the alternative investment modes.

Among the general expenses are above all the administration costs. The costs for the administration of the vehicles, which especially covers the disposal of the vehicle operation, have to be divided on all vehicles in the car pool. This happens through a fixed percentage of the vehicle operating costs. The vehicle operating costs are made up of the kilometer-dependent (variable) costs as well as the time-dependent (fixed) driver personnel costs and the fixed vehicle costs. For the calculation of the general expenses, 16 percent of the vehicle operating costs are being set.

2.3 Options for the purchase and usage of commercial vehicles

For the pure vehicle purchase, the IVECO Daily box-type van 35S11V (diesel commercial vehicle) and the IVECO Daily Electric box-type van 35S (electric commercial vehicle) will be compared with each other. The model-specific calculation data are compiled in table 1 and will be explained briefly further on.

In the case of the vehicle purchase, the net purchase price without tires, the net purchase price of the tires, the circulating assets and the necessary operating capital are being used for the determination of the capital binding. The net purchase price of the vehicle is needed in order to calculate the amortization amount. Here, the net purchase price without tires and without value added tax is set, because the tires normally feature another operating life than the vehicle and because the value added tax in business practice is mostly treated as a "continuous" item that is not relevant to the calculation. For the tires a net purchase price of 200 euro per tire is being assumed.

Using the circulating assets, the financial advanced payment of the forwarder is being considered before the payment of a trading company for the transport services come about. For this item, a lump sum of 200 euro per ton of admissible

total weight of the vehicle is being set as fixed circulating assets averaged per year (Fiedler, 2007, p.75).
The operating assets are the capital fixed by the company of a vehicle. It is compiled by the averaged fixed capital assets and the averaged fixed circulating assets. For the averaged fixed capital assets, half of the net purchase price including the tires is being set. For the interest of the operating assets a rate of 7.5 percent is being assumed.
In order to calculate the amortization amount, the net purchase price without tires is being divided by the planned operating life (amortization period) in accordance with an easy, thus transparent linear amortization. This amount is being divided into the variable and fixed vehicle costs. In the case of commer-cial vehicles for the local traffic, a high percentage of 70 is being ascribed to the fixed i.e. time-dependent vehicle costs as a "devaluation", and a smaller percentage of 30 to the variable vehicle costs (Fiedler, 2007, p.77).

Independent variables	IVECO Daily box-type van 35S11V	IVECO Daily Electric box-type van 35S
Net purchase price without tires	30,230 euro	80,200 euro
Net purchase price of tires	800 euro	800 euro
Circulating assets	700 euro	700 euro
Operating assets	15,865 euro	40,850 euro

Tab. 1: Capital binding of the vehicle purchase

For the vehicle purchase with battery leasing, the Renault Kangoo Rapid dCi 90 (diesel commercial vehicle) and the Renault Kangoo Z.E. (electric commercial vehicle) will be compared with each other. The battery, however, can be only leased for the electric model. In the case of the diesel commercial vehicle it

concerns a normal vehicle purchase. The model-specific calculation data are compiled in table 2 and will be explained briefly hereafter.
In the case of this investment mode, the same information is necessary in order to determine the capital binding for the diesel and the electric commercial vehicles as for the vehicle purchase. However, in case of the electric commercial vehicle information on the battery is added. The battery leasing is completely classified with the fixed i.e. time-dependent vehicle costs. For the tires a net purchase price of 200 euro per tire is once again being assumed.

Independent variables	Renault Kangoo Rapid dCi 90	Renault Kangoo Z.E.
Independent variables	17,610.52 euro	21,956.48 euro
Net purchase price without tires	800.00 euro	800.00 euro
Net purchase price of tires	387.20 euro	425.20 euro
Circulating assets	9,398.86 euro	11,590.84 euro
Operating assets	0.00 euro	2,513.28 euro

Tab. 2: Capital binding of the vehicle purchase with battery leasing in case of the electric commercial vehicle

For the vehicle leasing, the Renault Kangoo Rapid dCi 90 (diesel commercial vehicle) and the Renault Kangoo Z.E. (electric commercial vehicle) as well as the Mercedes-Benz Vito 110 CDI KA/L 3200 (diesel commercial vehicle) and the Mercedes-Benz Vito E-Cell KA/L (electric commercial vehicle) will be compared with each other. The model-specific calculation data are compiled in table 3 and will be explained briefly hereafter.
In the case of the vehicle leasing, only the leasing costs are being set regarding the capital costs. These costs are being ascribed to a hundred percent to the time-dependent vehicle costs and thus increase the fixed vehicle costs and the consequent daily rate of a vehicle (Wittenbrink, 2011, p.49). In return, the variable vehicle costs decrease in case of this investment mode.

Vehicle	Leasing rate (euro/month)	Battery leasing (euro/month)
Renault Kangoo Rapid dCi 90	598.28	0.00
Renault Kangoo Z.E.	724.39	209.44
Mercedes-Benz Vito 110 CDI KA/L 3200	455.86	0.00
Mercedes-Benz Vito E-Cell KA/L	999.00	0.00

Tab. 3: Capital binding of the vehicle leasing

3. Results of the profitability analysis

For the profitability analysis of the vehicle cost accounting, the kilometer rate, the daily rate and the total costs of the vehicles are depicted in the following table 4. For the above described fictive forwarder, the Renault Kangoo Z.E. with a battery leasing of 43,794.03 euro of total costs per year is most cost-effective for a vehicle purchase from a financial point of view. The Mercedes-Benz Vito E-Cell KA/L is the most cost-effective commercial vehicle with 0.0403 euro per kilometer regarding the kilometer-dependent costs. This advantage becomes important when a company needs a commercial vehicle that has to manage an infinite deal more than the annual mileage of 40.000 kilometers per year as assumed here. In the case of the disposal of the vehicle, however, it has to be taken into account that the Mercedes-Benz Vito E-Cell KA/L has a range of only 130 kilometer with a fully charged battery according to the NEDC and after that has to be charged for at least five hours in order to restore the full battery capacity. With a daily rate of 124.43 euro the Renault Kangoo Rapid dCi 90 is the most cost-effective commercial vehicle regarding the time-dependent costs when buying a vehicle.

Vehicle	Investment mode	Kilometer rate (euro/km)	Daily rate (euro/day)	Total costs (euro/year)
IVECO Daily box-type van 35S11V	Vehicle purchase	0.2590	139.13	52.096.65
IVECO Daily Electric box-type van 35S	Vehicle purchase	0.2683	170.60	61,911.98
Mercedes-Benz Vito 110 CDI KA/L 3200	Vehicle leasing	0.1514	127.34	44,260.24
Mercedes-Benz Vito E-Cell KA/L	Vehicle leasing	0.0403	145.58	45,287.81
Renault Kangoo Rapid dCi 90	Vehicle purchase	0.1762	124.43	44,377.34
Renault Kangoo Z.E.	Vehicle purchase battery leasing	0.1066	131.76	43,794.03
Renault Kangoo Rapid dCi 90	Vehicle leasing	0.1232	136.42	45,852.65
Renault Kangoo Z.E.	Vehicle leasing	0.0455	145.85	45,573.76

Tab. 4: Results of the profitability analyses on the basis of a vehicle cost accounting

Even if the profitability analysis was conducted exemplary with the help of the vehicle cost accounting only for a fictive forwarder, it is still shown rather obviously that the currently still high battery costs and the higher acquisition costs (purchasing prices partly including, partly excluding the battery) of electric commercial vehicles affect the profitability of the electric models negatively as opposed to a diesel model.

When buying a vehicle, the battery costs as a component of the clearly higher acquisition costs have an effect on the kilometer-dependent (variable) as well as on the time-dependent (fixed) vehicle costs due to the amortization of the acquisition costs. This means that the kilometer and the daily rate as well as the total costs are higher with an electric commercial vehicle than with a similar diesel commercial vehicle.

When leasing a vehicle, whereby the leasing costs affect only the time-dependent vehicle costs, the electric commercial vehicle has a cost advantage towards a similar diesel commercial vehicle because of the lower kilometer-dependent costs. However, it has a cost disadvantage because of the higher time-dependent costs. The high battery costs of the electric commercial vehicle are covered here in the leasing rate that has only an effect on the time-dependent costs as a special "cost-pusher". The effects working in opposite directions in the case of the vehicle leasing – relatively low kilometer-dependent and relatively high time-dependent costs for the electric model compared to the similar diesel model – lead to the fact that no general statement of advantageousness in favor of the electric or the diesel model is possible. For the investment mode of the vehicle leasing regarding the ultimately deciding total costs, table 4 shows in an exemplary way that the electric model is once inferior (case „Mercedes-Benz“), but proves to be superior in another case (case „Renault Kangoo“).

If one does not take into account the battery costs in case of the electric model, acquisition costs emerge for both kinds of commercial vehicles that do not differ greatly from each other. In case of the investment mode of the vehicle purchase with battery leasing for the electric model, this advantage is being taken. As a consequence, the electric model in case of "Renault Kangoo" regarding the ultimately deciding costs proves to be economically advantageous if the commercial vehicle is being acquired excluding the battery and the battery is being leased while the similar diesel model is being fully purchased in a conventional way. Moreover, the forwarder has the advantage of not having to bear the usage risk of the battery on their own.

4. Conclusion and outlook

The profitability analysis based on the vehicle cost accounting has shown that the use of electric commercial vehicles in the field of city logistics – contrary to the widely held prejudice – by no means proves to be an economically disadvantageous investment in general. It rather depends on the situational operating conditions of the respective individual case to be analyzed whether the diesel or alternatively the electric commercial vehicle proves to be economically superior. For the here exemplarily regarded, fictive individual cases of a forwarder it becomes apparent that electric commercial vehicles lead to clearly higher as well as to approximately the same, under favorable terms even to lower investment costs than diesel commercial vehicles depending on the respective investment mode.

Especially noteworthy is that in case of the investment mode of the vehicle purchase with battery leasing for the electric commercial vehicle, the cost advantages with the variable vehicle costs can have a positive impact without the cost disadvantages of the high battery costs completely compensating these cost advantages. Therefore, it is desirable that more vehicle manufacturer of electric commercial vehicles offer this investment mode. However, this applies only as long as the climate change policy and the transport political objectives are being shared, and if as many transports of goods of transportation with climate-damaging emissions of greenhouse gases as possible, like e.g. diesel commercial vehicles, are redeployed onto other means of transportation without emissions, like e.g. electric commercial vehicles (or also railways or inland vessels).

In future, the here portrayed profitability analysis based on the vehicle cost accounting shall be further developed along three main lines.

Firstly, the "static" comparative cost calculation should be expanded by a "dynamic" investment calculation in the sense of the "life cycle costing". With this, an adjustment from "calculated" costs to "real" payments has to come along in order to capture economically correctly especially interest effects within multiannual investment and planning periods.

Secondly, next to costs or payments as negative performance indicators also proceeds as positive performance indicators should be taken into account. This applies above all to additional proceeds that may result from the quantity and the price effects of an enhanced reputation based on "green logistics". Furthermore, additional proceeds may be generated if an integration of electric commercial vehicles into the "vehicle-to-grid concept" (Bretzke and Barkawi, 2012, pp.141–142; Fournier, et al., 2014, pp.67–76) is successful. Here, the batteries of the vehicles serve as a temporary storage for electricity from renewable energies, like e.g. from wind power plants. This concept supports the expansion of renewable energies since wind and solar farms have to be partially shut down at the present time because they produce more electricity than can be fed into the electricity grid. By taking the positive performance indicators into account, an extension of the profitability analysis to a determination of the "total value of ownership" happens.

Finally – and thirdly – an extension of the profitability analysis by a non-monetary determinant of the economic success should be considered. Thereby, it can concern reputational effects that can admittedly be measured with the help of a reputation survey, but are only very hard to convert into additional proceeds ("monetize"). But also other non-monetary effects come into consideration, like e.g. the basic or the depending on the time of day accessibility of inner cities for the delivery of customers. In order to factor such effects in, in an economically convincing way, it needs further analysis methods "beyond" the established investment calculation. A promising approach in this direction presents the method PROMETHEE that is currently being looked into regarding its applicability for an extended profitability analysis in another research project (Cinibulak and Zelewski, 2014).

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Information Flow Analysis of the Container Discharging Process

Susanne Kellberger

Abstract

Information technology is no longer the limiting factor but rather the enabler for the analysis of enormous amounts of data and the transformation of data into information. However, there is a lack of information quality due to wrong, late or imprecise information. The adequate quality of information is crucial for logistics processes due to accompanying information flows in order to properly handle the flow of goods.

This paper will takes a closer look at the discharging processes of import and transshipment containers and the information which is transferred simultaneously between the involved stakeholders. An information flow analysis is conducted including a description of the single steps of the discharging process. Special attention is paid to step three: the selection of the appropriate yard block. In regard of process efficiency this step forms the most critical one. A decision tree reveals the necessity of high information quality. An analysis of the relevant UN/EDIFACT messages enables a combination of the information with the four process steps in a process information flow matrix.

Due to a research gap regarding the connection of information flows and process efficiency within that maritime context, the aim of the paper is to contribute to fill that gap by increasing the transparency of the discharging process at container terminals. This research is important to identify the state of the art regarding current EDI communication between terminal operators and shipping lines from the terminal point of view before and during the container discharging process. This paper forms the basis for the subsequently following research which will further model and simulate these processes in order to quantify the impact on process efficiency by improving the information quality.

Keywords: container discharging process, information flow analysis, information quality, process efficiency

1. Introduction

A vessel on the Asia-North Europe route loads containers at terminals in Asia for discharge at terminals in Europe. Further containers are discharged and loaded at terminals on the way. Due to the number of terminals involved it is very complex to have an always updated version of the stowage plan. With such a complete plan all terminals involved could stow their containers to the vessel with as few shifts as possible. In addition they could discharge their containers directly or only with minimal movements of other containers. The manual stowage plan (or bayplan for container vessels) is a series of diagrams consisting of each cross-section of the vessel and a list of possible locations on the ship and its contents. Traditionally the bayplan was transmitted between container terminals and ship planners by fax which often was a 60 pages long document. When container ports received such a bayplan for a vessel, all the information had to be inserted manually into the terminal's ship planning tool for further processing. This operation could take an experienced operator several hours, was prone to errors and the information passed was not always up-to-date (Garstone, 1995).
Nowadays terminal operators do not have to rely on telephone, fax or email communication when they share information with their clients, the shipping lines. A high number of different terminal operating systems (TOS) is available that support the terminal in all processes by connecting all departments and systems involved, electronically sharing information with them and supporting decision finding by proposing solutions based on internal rules. These TOS receive information via different interfaces like electronic data interchange (EDI) or more specific via UN/EDIFACT messages in a raw form that is not yet readable and

translate the data into information for the benefit of the terminal operator. The seamless information flow is essential in order to assure efficient processes. Highly flexible logistics chains, with fast response to customer demands, require a precise information flow for tracking, planning and control. Information logistics require the right information to be in the right place at the right time in the right quality.

In daily terminal operation not all necessary information is available at the moment when it is requested. Especially the means and modes of the on-carriage transport are relevant for the decision where to store the container in the yard before it is picked up again. However they are not provided regularly (Jürgens et al. 2011). This lack of information often leads to unproductive restowing and therefore inefficient processes (Hildebrand 2011). Unproductive moves like reshuffles occur when access to a container is only possible after others on top of it have been removed. According to Steenken et al. (2004) the most important reason for reshuffles is wrong or incomplete information about containers to be stacked.

In accordance with the structure of messages and possible segments of information that are transferred between the shipping lines and the terminal operators all requirements could be fulfilled if all information would be provided. It has been demonstrated by Svilen (2013), that misdeclared information can lead to severe incidents when the weight of a container is e. g. actually 5 times as high as the declared weight.

However there is little scientific literature about these information flows, their content and when they are sent and requested. In order to demonstrate the potential of different levels of information quality, the information flow of the storage process needs to be analyzed. An overview of decision problems at container terminals and various approaches to solve them is given in Vis and de Koster (2003). Their findings from the literature include many sub processes and their specific decision problems from berth allocation, via stowage planning on the vessel, routing and scheduling of vehicles for horizontal container yard transport, distribution of empty containers to ports, up to crane scheduling.

Storage strategies are though well described by Chen (1999) for export containers. By focusing on export containers, the demand for information was rather neglected by him for import containers. The research gap of inbound containers has not been filled since then. In addition to that, the connections between the physical container discharging processes on the one hand and the information flow between the two most involved stakeholders on the other hand have not yet been considered in the literature as well.
The aim of this paper is to increase the transparency of the container discharging process at container terminals from the terminals point of view in terms of information flows. This work helps to understand which information is relevant for which physical process and when and where it is exchanged.
Section 2 describes the applied method and section 3 presents the findings about the process steps and the respective information flow. Section 4 puts the results in context and discusses them while section 5 provides suggestions for further research.

2. Method

In order to narrow the scope an appropriate process is selected. The maritime container logistics comprises of many potential processes that could be analyzed. The part on which this paper is focusing on is the container discharging process from the terminal operator’s point of view. This includes import as well as transshipment containers. After specification of the selected process, the most relevant process steps are identified. These are further described in section 3.1. The process chart does not include all stakeholders in every detail but is rather limited to the two most important parties: The terminal operator as well as the shipping line and accordingly its liner agent. In the next step it is analyzed how these stakeholders communicate with each other in order to transmit the respective information. Certain EDI messages are used for that purpose. A closer look at these messages identifies those that are relevant for the container discharging process. In the next step the content of these messages, the segments of their structure and the order and timing of their transmission are analyzed. Finally a process-information-flow matrix is developed that brings together the information used and the steps of the analyzed process where the information is used. Within that matrix the reading or writing operations are indicated. This method is based on the process-information-flow analysis from O'Shea, Pawellek and Schramm (2013) with an adoption to the application of the specific container discharging process. These results form the basis for further research like the simulation of the ideal and the as-is situation which will demonstrate the potential that lies in the provision of information in the best possible quality.

3. Results

3.1 Process

The object and area of investigation is the process of discharging containers from a vessel and storing them in the yard area of the terminal at the exact position where they stay for the next 1-10 days. This includes import containers that are predetermined to be further transported to the hinterland as well as transshipment containers because both are stored in the stock. Hinterland processes are not considered neither is the main haulage by vessel. Export containers are collected from the hinterland of a port, stacked in the yard and transported to the apron before they are loaded onto the vessel. These loading processes include other stakeholders, request other information and are different from the unloading processes to a large extent. They are not covered by the following analysis.

The examined process starts with a vessel announcement and ends, with the storage of the container in the respective yard block. The block is not to be confused with “blocks” in automated container terminals with chaotic storage strategies. Here “block” refers to an area in the yard dedicated to containers with same or similar characteristics.

Shipping lines, their liner agents and terminal operators are the only stakeholders that are considered here, because they are in the focus of this process. The stakeholders are not further subdivided into roles or systems. Other stakeholders like customs, shipper, road or rail land transport operators are masked out.

Process step 1: Vessel announcement

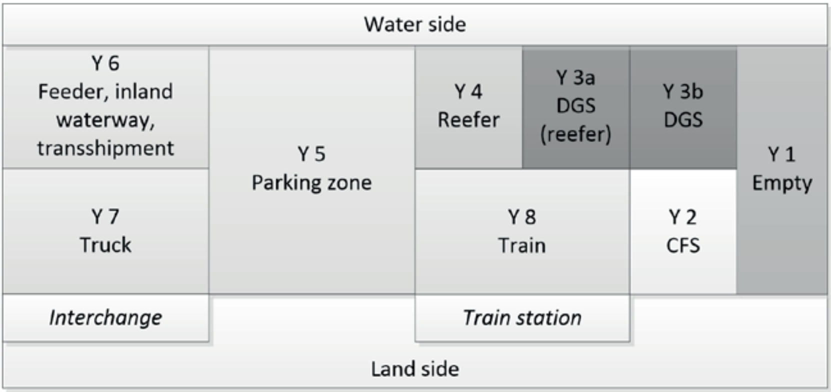
The process starts with a vessel announcement by the shipping line. This announcement is given the first time when the vessel is leaving the first port on the route and is renewed every time when changes occur in the time schedule. Reasons can be bad weather conditions or delays at other ports caused by strike, technical problems or organizational problems. The terminal indicates the receipt of the announcement afterwards and confirms the possibility to call the terminal. With regard to the container discharging process, this step assures that the containers are discharged from the right vessel.

Process step 2: Container discharge

In order to assure that the containers are discharged in the right port, the terminal needs to get information in advance that contains a list of containers that are to be unloaded and their position on the vessel. With this information it is able to plan the staff and equipment allocation to the vessel. Further, the TOS can calculate the best discharging strategy. With regard to the container discharging process, this step assures that the right containers are discharged from the vessel.

Process step 3: Transport to yard block storage

The storage yard has the function of a temporary buffer area for containers. It is organized in block sections in order to consider all specific requirements of different containers. Specific areas in the yard are reserved for containers with different characteristics, like e. g. the content and the hinterland transport mode. Often the yard is also separated into export and import containers. However, export containers are not discussed here. A symbolic layout of a general container terminal is drawn in Figure 1. This layout is to be used only as a rule of thumb as each terminal is different and the preconditions, purposes and restrictions are diverse. Every terminal requires a unique design and the following symbolic general layout is based on Brinkmann (2011) with influences from discussions with terminal planners. Damaged containers sometimes are also separated from the rest and brought to a reserved area, which is not included in



the following analysis.

Fig. 1: Symbolic general layout of a container terminal

The decision process where to store the container in the yard demands certain information and clear answers to different questions. Figure 2 summarizes the single steps of the container discharging process. The decision tree is developed in order to highlight the single decisions that need to be made within this process. The first step is to check if the container is empty or full. About 20 % of all transported containers are empty (United Nations, 2007). This is mostly due to imbalances in international trade. However, the share of empty containers is almost the same in a yard. Nevertheless, due to higher dwell-times and the possibility to stack them higher than full containers, empty containers are often stored separately with a higher density. This empty container block is symbolized here at Y 1.

If the containers are LCL (=less than full container load) and not FCL (=full container load), or are in carrier's haulage, they are brought to the container freight station (CFS) for stripping and re-stuffing in Y 2. The goods inside are temporarily stored in the warehouse, before they get commissioned in another container.

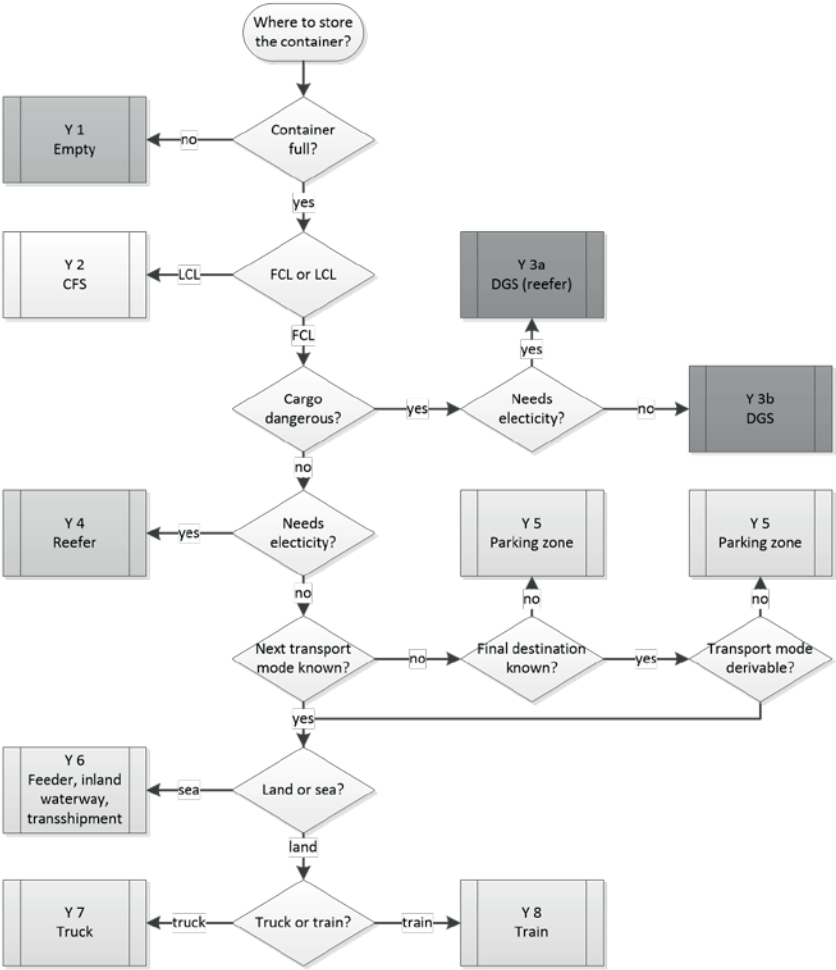


Fig. 2: Decision tree for container transport to specific yard blocks

Full containers in merchant’s haulage are stored separately when their content are hazardous materials or dangerous goods (DGS). They need to be stored in special areas to prevent accidents. These areas have a basin underneath in order to hamper hazardous materials to get into the groundwater. Some of them need to be kept at a certain temperature. Otherwise the quality of the product cannot be ensured any more or they could even damage the container by an explosion or at least by an expansion. Such containers are plugged to the electrical generator for temperature-controlling in Y 3a. All other dangerous cargo is stored in Y 3b, according to their specific requirements that are expressed by the hazard code identification IMDG (International Maritime Code for Dangerous Goods).

Containers without a special declaration often also carry temperature-sensitive goods like food or pharmaceuticals. These refrigerated containers (or reefer containers) therefore need electricity in order to regulate the inside temperature as requested. Thus, they are transported to and plugged in at the electrical generator of Y 4.

Following the decision tree in figure 2 all containers with dangerous or refrigerated goods, LCL and empty containers have been sorted and assigned to their specific areas. The next distinguishing feature is the hinterland transport mode. Unloaded containers are usually transported to yard blocks near to their on-carriage transport. However, in many cases (20-85 %, depending on the terminal and person interviewed) the next transport mode is not known. According to Steenken, Voß and Stahlbock (2004) for example the hinterland transport mode is not known by the terminal operator at 85 % of the containers in the moment of discharge. In these cases it can be checked whether at least the final destination is known and the transport mode can be derived from that information. If the final destination is not known or the transport mode cannot be derived from a given final destination, the container is brought to the parking zone Y 5 which is placed in the middle of the terminal.

If the transport mode is known or can be derived from the final destination, another question is to be checked: Will the next transport mode be via land or via sea? In case of transshipment containers or containers that will be transported by the mode inland waterway, the container is transported to Y 6, which is closer to the water side.

If the on-carriage transport is done via land transport modes, the last differentiation is done between road and rail. Y 7 groups all containers that are meant to be transported to the hinterland by trucks. This block is as close as possible to the interchange where all paperwork is carried out. Containers that use trains as on-carriage transport means are stowed in Y 8 which is located closer to the rail tracks.

Process step 4: Stacking within the selected yard block

As soon as the system decided in which area of the terminal the container should be stored the exact position of the container in the stacks needs to be found. However, there are some constraints for this decision. The containers volume gives a first indication: It is rarely possible to stack different types of containers on top of each other, because of the resulting instability of the stack. There is just one exception: A 40' container can be stacked on top of two 20' containers. The gross weight is another restriction that follows the rule that heavy containers should not be put on top of light containers. Thus, the containers have less weight the higher their position in the stack. Within the parking zone Y 5 there is flexibility which means that containers that most probably are carried by land transport will be put nearer to the land side than to the water side and vice versa.

The time when the on-carriage transport is expected plays another important role. If the container's estimated dwell time is very short, a top position in the stack is preferred for that container. In case that a longer dwell time is expected, the container is most probably put in a lower position of the stack so that other containers can be stacked on top of it. The lack of information about the time when the container is transshipped to the next transport mode often causes bottle neck situations according to Ilmer (2005). So he proposes a better coordination and communication between the shipping line and the terminal operators.

With regard to the container discharging process, this step ensures that the container is stored in the right position of the stack in the yard block.

3.2 Information

3.2.1 Communication between stakeholders

Before EDI was established as the standard for sharing information between all actors of a supply chain, it was daily business to use telephone, fax or letters for this purpose. Later emails have replaced the slower postal letters where possible but still a manual action was necessary to trigger information exchange. This form of communication with the terminals' clients, the shipping lines, facilitated the appearance of errors due to the media breaks. Today many IT systems help to keep track of all relevant processes, share necessary information with other stakeholders in advance and minimize transmission errors due to less media breaks.

TOS support those terminal processes by connecting all involved departments and systems and electronically share information with them. These TOS receive information via different interfaces like EDI or more specific via UN/EDIFACT messages. UN/EDIFACT (the United Nations rules for Electronic Data Interchange for Administration, Commerce and Transport) comprise a set of internationally agreed standards, structures and guidelines for the electronic interchange of structured data, between information systems since the late 1980s.

The development of those EDI standards was closely monitored by the industry. Different interpretations of these standard messages in various implementations resulted in a lack of interoperability. The growth of international e-commerce requested a solution for this problem and for that purpose members of the Transport Group harmonized the message implementation guides and improved user manuals in 1995. This International Transport Implementation Guidelines Group (ITIGG) produced guidelines for all modes of transport and developed recommendations which provided software developers with a series of tools to assist in designing applications which can be used for worldwide electronic trading. The Shiplanning Message Development Group (SMDG) is an official pan-European user group with stakeholders from the maritime industry, like

container terminals, shipping lines and related companies that develop UN/EDIFACT messages as international standards for the maritime industry. Its focus is on container-related messages, i.e. stowage plan, load, discharge and inland transport.
All previous mentioned organizations aim to harmonize messages used in the transport sector, so that the same message specifications can be used and interpreted anywhere in the world in the same way.

3.2.2 Relevant UN/EDIFACT messages

An EDI message is a set of structured data for transmission by electronic means, prepared in a computer readable format and capable of being automatically and unambiguously processed.
For the maritime container transport a multitude of UN/EDIFACT messages can be and are used to communicate and share information. From over 180 possible messages the six most relevant ones are chosen for the analysis of the container discharging process: CALINF, BAPLIE, COPRAR, MOVINS, COARRI and VESDEP. The following figure 3 gives an overview of those messages, in which order they are exchanged and who the respective sender and receiver are. The BAPLIE is actually sent twice during that process. The first time is indicated in figure 3 and the second time an updated version of BAPLIE is sent from the terminal to the shipping line and other following terminals right after the discharging process. This repetition is not part of this analysis.

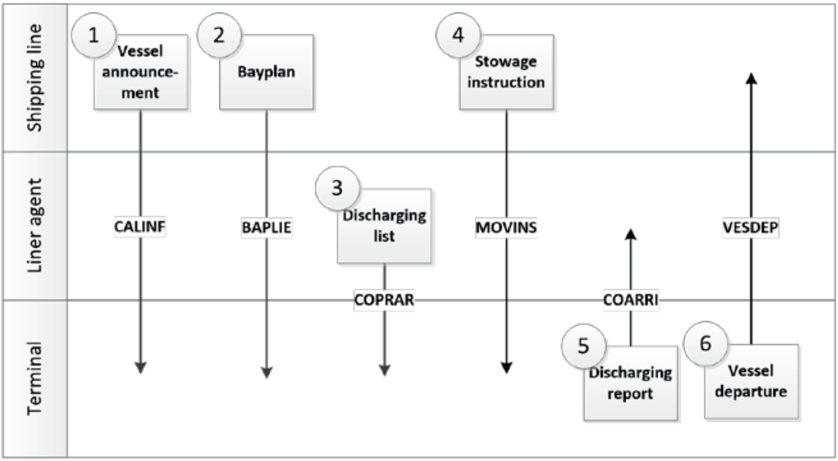


Fig 3: Relevant UN/EDIFACT messages for the container discharging process

The names of these messages often arise from their actual meaning and shorten it to 6 letters. The full names are listed in Table 1.

1. CALINF	Call Information
2. BAPLIE	Bayplan/Stowage plan
3. COPRAR	Container Discharge/Loading Order
4. MOVINS	Stowage instructions
5. COARRI	Container Discharge/Loading Report
6. VESDEP	Vessel Departure

Tab. 1: Meaning of the names of UN/EDIFACT messages

3.2.3 Common segments of the messages

In UN/EDIFACT each message consists of a header section with information identifying the vessel and a body section with a group of segments which in the case of BAPLIE for example is repeated for each container on board and contains relevant information about the container. Table 2 shows that many of the segments that form the body of these messages contain similar content.

A segment...	CALINF	BAPLIE	COPRAR	MOVINS	COARRI	VESDEP
to specify total numbers	•					•
to specify the document or message to which the current message relates		•		•		
to specify a reference to the whole message, and its date and/or time	•		•		•	•
to indicate the main carriage means of transport			•		•	
to identify locations related to the means of transport			•		•	
to identify a party and related contacts	•	•	•	•	•	•
to identify a contact and its communications related to the party	•	•	•	•	•	•
to identify the means of transport and related details		•		•		
containing information about dangerous cargo		•		•		
to specify dangerous goods details			•		•	
to specify contact information			•		•	
to specify the planned on-carriage details			•		•	

Tab. 2: Common segments of the messages

CALINF and VESDEP for example provide both summaries and total numbers. All of the messages include segments to identify partners, their contact details and how this party should be communicated to. BAPLIE and MOVINS both give information on dangerous goods while COPRAR and COARRI provide even more details on those dangerous goods. They also give details on the planned on-carriage transport.

3.2.4 Individual presentation of the UN/EDIFACT messages

CALINF (vessel announcement)

The first UN/EDIFACT message CALINF is sent from the shipping line to the terminal operator and announces the vessel to call at that port (see UN/EDIFACT, 2000b). It contains general information about the vessel like the reference voyage number, the operating shipping line and the water displacement dimensions for the berth allocation. Information about the route like the previous and next port of call as well as the estimated time of arrival (ETA) / departure (ETD) are also provided. In table 3 all segments that only belong to the CALINF message are listed. They cover details for the arriving vessel and the total number of containers to be discharged.

A segment...	CALINF	BAPLIE	COPRAR	MOVINS	COARRI	VESDEP
to specify details for the arriving means of transport	•					
to identify locations related to the transport details	•					
to specify supplementary information and to describe totals to be discharged	•					

Tab. 3: CALINF segments of UN/EDIFACT container messages

BAPLIE (bayplan)

In order to best plan the efficient use of equipment some key data about the cargo to be discharged needs to be provided. At least 24 hours prior to the arrival of the vessel at the port, the shipping line has to send the bayplan to the terminal operator's head office. Where the discharge and load of containers is planned based on that document.

The BAPLIE-file is the document a message with a lot of information (see UN/EDIFACT, 2000a). The following non-exhaustive enumeration focuses only on the most interesting ones. Per port of discharge a summary is given regarding the number, dimension and weight of all units, whether they are full or empty, dry or reefer container and contain dangerous goods or not. Each container is also described by its ID number, the place of delivery or at least the port of discharge (POD) and the exact current position on the vessel.

Container terminals always have a port scope of two ahead. So the next coming port is informed via BAPLIE UN/EDIFACT message in case there are containers on board that will be transshipped to another third port so that the next port has the chance to stack them in their yard properly and consider the transshipment.
A complete bayplan of the containers onboard the vessel is prepared and transmitted. All terminals on the vessel's route need this information for planning purposes some time before the vessel berths. Therefore updates of the bayplan are sent to all of the ports of call as soon as the information has changed as a result of operations in the previous ports. This process is repeated every time when the vessel leaves another terminal. According to SMDG it is estimated that over 50.000 BAPLIE messages are used per day worldwide. Both segments of table 4 belong to the BAPLIE message. These segments contain information about the type of containers and their stowage location onboard.

A segment...	CALINF	BAPLIE	COPRAR	MOVINS	COARRI	VESDEP
containing information about the equipment and/or goods and its stowage location onboard a vessel		•				
containing information about the type of equipment		•				

Tab. 4: BAPLIE segments of UN/EDIFACT container messages

COPRAR (container discharge order)
On a physical level the vessel berths at the assigned place. Latest at this time the order to discharge certain containers is sent from the liner agent to the terminal via a COntainer-PRe-ARrival message COPRAR (see UN/EDIFACT, 2000d). Based on this message, the container terminal can start discharging the containers from the vessel.
The COPRAR message contains the following information amongst others. The country of origin as well as the port of loading, the coded port of discharge and ideally the UN country code for the country of destination. There is room for the provision of the contact data of the recipient of the goods. For the discharging process it is crucial to know the container status (import or transshipment), the container ISO code, the mode of transport for the on-carriage transport, the

temperature setting for reefer containers, the container weight (gross and tare), stowage instructions and special requirements for yard stowage, hazard code identification (IMDG) and the coded indicator of full or empty containers. The codes are necessary because free texts cannot be interpreted by computers and therefore hinder the automatic transmission of information which is the main purpose of the usage of EDI.

Not relevant for the process are for example the seal number, the description of goods, and the customs code and paper number.

The segments of table 5 form the unique part of the COPRAR message. One segment is about the containers to be discharged and the other about the following on-carriage transport.

A segment...	CALINF	BAPLIE	COPRAR	MOVINS	COARRI	VESDEP
to specify containers that are to be discharged			•			
to specify locations related to the on-carriage transport			•			

Tab. 5: COPRAR segments of UN/EDIFACT container messages

MOVINS (stowage instructions)

The shipping line gives the terminal operator the instructions which containers are to be discharged from the vessel and which stowage instructions have to be considered. This EDI message, called MOVINS (see UN/EDIFACT, 2000e), is transmitted from the shipping line to the terminal. It contains information about the containers to be discharged and their stowage location on board of the vessel. It further includes details like off-standard measurements (e. g. overheight, overlength, overwidth), the temperature setting and range and information about dangerous cargo in great details.

As can be seen in table 6 MOVINS has the most extensive list of segments. The segments provide information about the containers to be discharged and many details like stowage location, temperature settings and attached equipment.

A segment...	CALINF	BAPLIE	COPRAR	MOVINS	COARRI	VESDEP
containing information about the container to be discharged and its stowage location on board				•		
containing information about the location, identification, type and handling details of containers				•		
to specify a temperature (and range)				•		
containing information about the number, type and identification of container to be discharged				•		
containing information about the number or the identification of attached equipment				•		
containing information about the number of packages and kind of goods				•		
to specify dangerous goods and additional information				•		

Tab. 6: MOVINS segments of UN/EDIFACT container messages

COARRI (container discharge report)

After the containers are discharged the head office generates the COARRI (COntainer ARRIval message) UN/EDIFACT message. This message is used to report to the shipping agent that the containers specified have been discharged from the vessel. For larger vessels with a high amount of discharged containers the COARRI can be transferred via so-called periodic reports every 15 or 30 minutes. This intermediate reporting enables faster pick-up of the discharged containers by inland carriers. It contains information about damaged containers such as the exact point of the damage on the container and the type of damage. This message also reports shortlanded or overlanded containers. In the first case it specifies containers that had to be discharged (according to the discharge order message COPRAR) but could not be discharged due to various reasons. The container details are only required if they differ from the details given in the respective order message. Overlanded containers are containers that have been unloaded, but are not on the discharge order COPRAR. In that case COARRI contains the full container details with as much information as possible (see UN/EDIFACT, 2000c). It further confirms the same details that previously have been given by COPRAR like physical dimensions, seal number, actual time of arrival and clip on units such as generator sets. The specialty of the COARRI message can be derived from table 7. The shortlanded or overlanded containers are specified in a segment, another identifies a location and the third specifies damages at the container.

A segment...	CALINF	BAPLIE	COPRAR	MOVINS	COARRI	VESDEP
to specify containers discharged (with consideration of shortlanded or overlanded containers)					•	
to identify a location or country related to the equipment					•	
to specify damage details related to the equipment					•	

Tab. 7: COARRI segments of UN/EDIFACT container messages

VESDEP (vessel departure)

The last message VESDEP does not really contain information that is necessary for any of the identified process steps. However it indicates the end of the discharging process and therefore closes the circle after the vessel announcement CALINF started it. As presented in Table 8 it contains one segment about the departing means of transport and another one about the next port of call (see UN/EDIFACT, 2000f).

A segment...	CALINF	BAPLIE	COPRAR	MOVINS	COARRI	VESDEP
to specify details of the departing means of transport						•
to specify a place or port of call of the conveyance						•

Tab 8: VESDEP segments of UN/EDIFACT container messages

3.3 Process information flow matrix

In the following table 9 all previously collected information is inserted in order to demonstrate the relationship between the UN/EDIFACT messages and the respective process steps. The “r” represents a reading operation and the “c” stands for “create” in a writing operation. The “x” in the right column is neither reading nor writing but rather not applicable here, because that information is not used during any of these process steps.

The first message (CALINF) has only little influence and the last message (VESDEP) has none regarding the discharging process. The information within the discharge order (COPRAR) and the discharge report (COARRI) are in many cases similar. The terminal operator rather confirms or corrects the given information in the COARRI report. This is especially necessary in the case of divergent information like in 0210 EQD (overlanded or shortlanded containers).

Process step 1 (right vessel) draws most information from CALINF, BAPLIE and COPRAR. Process step 2 (right container) needs the fewest reading operations while two come from BAPLIE and one each from COPRAR and MOVINS. The question of the third process step (right block) requests the most information. 15 reading operations are quite equally distributed between COPRAR and MOVINS with a little support from BAPLIE. The fourth process step (right position) mainly uses information from BAPLIE and COPRAR while two reading operations from MOVINS bring further specification regarding off standard measurements and more information concerning dangerous goods.

All writing operations occur only at the COARRI message.

Tab. 9: Process information flow matrix for the container discharging proce

PROCESS INFORMATION FLOW MATRIX

No.	Message	Reference	Information	Process: Vessel is berthing (right vessel)	Container discharge (right container)	Transport to block storage (right block)	Put down in the block (right position)	Nice to know (but process irrelevant)	# Write operations	# Read operations
1		0060 MEA	total measurements (gross weight)					x	0	0
2	CALINF	0070 EQN	the number of units	r					0	1
3		0180 DTM	estimated date/time of arrival and departure	r					0	1
4		0210 LOC	transport details (previous/next port of call,…)	r					0	1
5		0130 TDT	means of transport	r					0	1
6		0150 DTM	date and time	r					0	1
7		0160 REF	loading voyage number	r					0	1
8		0190 LOC	stowage location onboard the vessel		r				0	1
9		0200 GID	number of packages		r				0	1
10		0210 GDS	specification of the goods					x	0	0
11	BAPLIE	0230 MEA	physical weights				r		0	1
12		0240 DIM	off standard measurements (e.g. overheight)				r		0	1
13		0250 TMP	temperature setting			r			0	1
14		0260 RNG	temperature range			r			0	1
15		0300 EQD	container size/type				r		0	1
16		0320 NAD	owner/operator of container					x	0	0
17		0350 DGS	identification of dangerous goods			r	r		0	2
18		0130 LOC	place terminal within the port	r					0	1
19		0220 EQD	container status (import, export, transhipment)		r	r			0	2
20		0250 TMD	(Less than) Full Container Load (LCL/FCL)			r			0	1
21		0260 DTM	actual date and time of arrival and departure	r					0	1
22		0270 LOC	(final) place/port of discharge, place/country of destination			r			0	1
23		0290 DIM	physical dimensions (off standard)				r		0	1
24	COPRAR	0320 SEL	seal number					x	0	0
25		0360 DGS	UN-number/class of the dangerous goods			r	r		0	2
26		0410 EQA	clip-on units, such as generator sets			r			0	1
27		0440 TDT	on-carriage transport details (mode, means,)			r			0	1
28		0450 DTM	arrival/departure date/time of on-carriage transport				r		0	1
29		0480 LOC	on-carriage transport details (place of departure)			r	r		0	2
30		0190 HAN	type of handling (discharging or loading)		r				0	1
31		0210 LOC	information about stowage location		r	r			0	2
32		0250 DIM	off standard measurements (e.g. overheight)				r		0	1
33		0290 TMP	temperature setting			r			0	1
34	MOVINS	0300 RNG	temperature range			r			0	1
35		0380 GID	number of packages of the goods					x	0	0
36		0390 GDS	nature of the cargo					x	0	0
37		0430 DGS	identification of dangerous goods			r			0	1
38		0440 FTX	more information concerning dangerous goods			r	r		0	2
40		0210 EQD	equipment status (overlanded, shortlanded)		c	c			2	0
41		0230 GDS	broad classification of the goods within					x	0	0
42		0240 TMD	(Less than) Full Container Load (LCL/FCL)			c			1	0
43		0250 DTM	actual date and time of arrival and departure	c	c				2	0
44		0270 LOC	(final) place/port of discharge, place/country of destination			c			1	0
45		0300 DIM	physical dimensions (off standard)		c		c		2	0
46	COARRI	0330 SEL	seal number		c			x	1	0
47		0370 DGS	UN-number/class of the dangerous goods			c	c		2	0
48		0420 EQA	clip-on units, such as generator sets		c	c			2	0
49		0430 PIA	commodity code					x	0	0
50		0470 DAM	container damages (point and type)		c	c			2	0
51		0500 TDT	on-carriage transport details (mode, means,)			c			1	0
52		0510 LOC	on-carriage transport details (place of departure)			c	c		0	0
53		0520 DTM	arrival/departure date/time of on-carriage transport				c		0	0
54	VESDEP	0180 LOC	Maritime Mobile Ship Identifier (MMSI number)					x	0	0
55		0200 MEA	gross tonnage (of the vessel)					x	0	0
			# Write operations	1	6	8	4	0		
			# Read operations	8	5	15	10	0		

4. Discussion and conclusion

In a vision of optimistic experts and stakeholders of the process, supply chain visibility, just-in-time logistics and real-time information sharing is key for future freight transport. However, there are two prerequisites to be considered: The availability of stable and proven technological solutions on the one side and the willingness of stakeholders to share information on the other.
The first is constantly under development for all logistics processes and already applicable for the analyzed process in this paper by the availability of efficient telecommunication infrastructure like TOS and reliable standards by the agreement on certain UN/EDIFACT messages.
The second is rather a matter of political and company cultural issues and cannot be solved by plain technological solutions. It is one thing to have access to all information within one single company, but the true benefit from the latest technology will be experienced only when all strive to a global optimum. This would include the provision of information in the highest possible quality to supply chain partners whenever it is needed.
The consequences of the sharing or not sharing of information, reflected by different degrees of information quality can however be measured when the processes are thoroughly analyzed, modeled and simulated. This work has contributed to the first part by analyzing not only the process steps but additionally the information flows.
The process information flow matrix reveals that the terminal operator not at all is interested into the concrete content of the containers as long as it is not relevant for the transport or storage. That information, that is in contrast necessary to support the decisions in the process steps 1 to 4 have to be available in order to ensure a smooth and seamless discharging process. If certain information like the next mode and means of transport or the expected time of the on-carriage transport is missing, then the container will most probably not be at the optimum position. Unproductive moves will then result from that. As Steenken, Voß and Stahlbock (2004) stated the sort and store strategy is hardly

done for import containers in container terminals because lot of information is missing at the moment of discharge. There are strong indications that there is room for improvement of process efficiency when the information quality would rise. Enhancing yard management for unloaded containers and minimizing the number of reshuffling operations is only possible if the right information is available in the right moment with the expected quality.

This segment of terminal processes has been chosen, because the terminal operator is directly benefitting from a higher information quality in that process but it is the shipping line that owns the data and decides when is what information shared with whom. Indirectly the shipping line also benefits from a higher terminal productivity of the terminal operator.

5. Further research

The next topic for investigation is the actual real information demand from each stakeholder involved at each process step. This could be done by modeling, workshops or interviews. In the matrix most of the information has already been written when the message reaches the terminal. It is interesting to know at which previous step of the process this information is added first into the system.

The reading and writing operations are not distributed equally which means that much more information is needed by the terminal operator who requests this information from the shipping line.

For the container discharging case further research should examine to which degree the information available theoretically is really available at the moment of discharge. Furthermore it is necessary to know the probability distribution of the identified scenarios. This includes the frequency distribution of occurrences of the different ‘statuses’ of containers like e. g. FCL, empty, dangerous cargo or refrigerated containers. With that input the impact of different degrees of information quality on process efficiency should be simulated.

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Gradual Covering Location Problem with Stochastic Radius

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Abstract

In this paper, we consider the gradual covering problem when the coverage radius, is determined by a random variable with distinct distribution functions. In this model, it is assumed that the certain amount of coverage radius is not available and the potential coverage radius is used. Model will be solved using CPLEX method for different distribution functions. Then, the objective function values for the selected layout calculated by changing coverage radius between 100 randomly generated numbers with distinct distributions. The results are compared with the classical model of gradual covering. The results show that the proposed model will provide the desired results for a possible covering radius.

Keywords: covering radius, gradual covering, stochastic models, normal and uniform distributions

1. Introduction

One of the most common facility location problems is the covering problem. It's applications in the real world, especially in emergency services makes researchers enthusiastic to research in this field. In covering problems customers often receive services or goods based on the distance between facility and customer. For example in a distribution network a demand point covers when is in a certain distance of a distribution center. This certain distance is called coverage radius. The purpose of these kind of problems is to determine the optimal location and number of facilities in order to service all customers or prepare maximum coverage for maximum number of customers with a predetermined number of facilities and the lowest possible cost. The first case is called the Set Covering Location Problem (SCLP) and the second one is called Maximum Covering Location Problem (MCLP) [1]. One important assumption in covering problems is zero-one covering. It means that a demand point is covered just inside of the coverage radius and is not covered outside of it [2]. In classical covering problems generally the assumption of zero-one covering is not applicable in most of real cases. This defect can be omitted with gradual covering approach which is done through defining of a partial covering function or covering rate function. Lots of applications have been found for these problems; for example in a distribution network, allocated products to each distribution center by the producer can be computed according to a gradual covering. Rate of satisfaction of post office customers can be considered as another example. The customers will be satisfied with a certain distance, though after that their satisfaction will gradually be decreased. Other applications for physical cases are location of warning sirens for emergency services, telecommunication towers, and internet access points. According to recent studies, in this paper we want to resolve the gradual covering problem in discrete place with a stochastic gradual coverage function that uses stochastic radius with specified distribution. The nature of this coverage function is mathematical expectation and we will show the advantages of this function compare to traditional coverage function that called decay function. We solved the problem with some related parameters and considered in uniform, normal and exponential distributions of covering radiuses. We applied CPLEX solver to solve it which is an efficient method for discrete problems. The paper has been organized as following: in the next section, the literature of related approaches is reviewed. Then in section 3, the problem and structure of the model is discussed. After that the model is solved with both fixed and stochastic radius modes in discrete space and results are compared. Then in section 4 analyses of parameters are reported. Finally the conclusions are mentioned in the last section.

2. Literature review

The history of covering models is very rich and great. So we preferred to concentrate on a part that is more related to our approaches in this study. In this part we propose to introduce the studies have been done in the same fields that involves two different approaches. In order to review the literature of subject, it's necessary to review two related approaches separately.

2.1 Gradual covering

In 1983, Church & Roberts [3] introduced the gradual covering for the first time. They distributed a discrete model with a step-wise function. In this type of research for each facility, two types of coverage radius is defined; a radius with full coverage with r index and the other with partial coverage and index of R. Each demand inside the radius r *(*$d_{ij} \leq r$*)* will be fully satisfied. Demands between two radiuses *(*$r < d_{ij} \leq R$*)* will be satisfied partially. Demands out of radius R *(*$d_{ij} > R$*)* do not receive services at all [4]. This gradual covering calculates with a cover function which is positive and non-ascending called partial covering function or covering rate function. The proposed cover function produces values between zero and one according to distance between facility and demand point [4]. Berman & Krass [5] considered a network version of gradual covering problem and offered effective formulation and heuristic approaches. The model has been analyzed in discrete space and in network with a non-ascending general decay function by Berman et.al [4]. The planar version with linear function has been discussed by Drezner et al. [6]. In 2004, O. Karasakal & E. Krasakal [7] studied gradual covering model and named it partial cover. Eiselt & Marianov [8] considered gradual covering as a set covering problem. They considered quality of service as decision criteria. They although formulated model in order to maximize the minimum probabilistic cover. They showed gradual covering models have more flexibility than standard MCLP. Different kinds of functions are proposed for covering. The most common function is linear cover function. For instance, problem in the planar with linear cover function has discussed in Drezner et al. [6]. They considered cover between R and r linear and changed it to the weber problem forcing a special cost structure. They considered servicing cost according to the covering decay function as well. Between these mentioned radiuses the cost is increased linearly. Then they analyzed the problem and solved it by using branch and bound method. Eiselt & Marianov [8] drew different kinds of cover functions. Church & Roberts [3] and Berman & Krass [5] used cover function stepwise with break points *D1, D2,* and *D3* for explaining different levels of coverage. Pirkul & Schilling [9], Araz et al. [10] used quality of service function that is equal to cost of cover function of Drezner et al. [6]. Berman et al. [4] introduced formation of cover function which is not concave or convex. Introducing a gradual decline of cover, as like as fuzzy membership functions in fuzzy sets theory, these functions present a quantity of service quality in which zero indicates no service and one indicates full coverage. Pirkul & Schilling [9] optimized linear convex combination of coverage and weighted distance, which leads to an objective with a piecewise linear, linearly sloping function. They solved the problem by Lagrangian relaxation approach.

2.2 Stochastic problems

Stochastic approach in various issues is considered when problems in the real world contain uncertain parameters. In those location problems, several parameters including stochastic demand have been discussed so far. In 2004, Hwang [11] studied a special case of stochastic set covering problem for ameliorating and deteriorating facilities and determined minimum number of storage facilities between a discrete set of sites. So that the probability of each customer being covered is not less than a critical value. Then they formulated and solved the problem using integer programming. In 2010, Drezner et.al [12] presented a model in which inner and outer radiuses used in the gradual coverage were considered as random variables. Gradual covering models taking these assumptions present more realistic depiction of actual behavior in many situations. In 2011, Berman & Wang [13] discussed the gradual covering problem (GCP) when the weights of demand points are not deterministic and their probability distributions are unknown. They found the ‘‘minmax regret” location that minimizes the worst-case coverage loss and showed that under some conditions, the problem is equivalent to known location problems (e.g. the minmax regret median problem). In 2011, Berman et al. [14] analyzed the gradual covering location problem on a network with uncertain demand and in single facility state. They assumed two radii for each node and considered demand weights as discrete stochastic variables. They presented a model which locates facilities in order to maximize the probability of covered demand be greater or equal to a pre-determined threshold. In 2013, Amiri et al. [15] used a stochastic multi-objective programming under uncertainty for emergency services. In their study demands, purchase costs and transportation costs considered as uncertain parameters. In addition, the model considers uncertainty for locations where demand may increase and the risk of equipment damage in the event of a disaster relief centers exists.

In classic gradual covering model, full and partial coverage radius is considered to be fixed. But in reality, it is possible that the extent of covering radius for facilities be unknown because of environment conditions. In these cases, covering problem could be considered in a random mode. Berman & Krass [5] suggested that deterministic cover from closer facilities assumed certain and definite. Drezner & Wesolowsky [16] and Drezner & Drezner [17] interpreted partial coverage as probability of coverage and based on this assumption, calculated combinational coverage when probabilities are independent. In 2008, Berman et al. [18] offered a covering problem in which covering radius of a facility is controlled by a decision maker and the cost of achieving to a certain covering radius is a uniform function of distance in which the cost of placing a facility depends on the distance between facility and the demand point. They considered both discrete and planar versions of the problem for solving the problem of covering all demand points with minimum cost through finding number and locations of facilities and optimal coverage radius for each facility by heuristic algorithms. In 2010, Drezner et al. [12] discussed the gradual covering radius when stochastic radiuses and individual coverage are examined. In their model it is assumed that coverage radiuses have probability distribution functions and the amount of coverage in certain distance d is calculated as a mathematical expectation of coverage radius distributions. The model solved in planar case by BTST (big triangle small triangle) algorithm which is an effective approach for many planar location models. Similar models also have been presented in [4, 5] which uses shortest distance between facilities and demand points on a network. In [5] it is assumed that the gradual covering function is a decreasing step wise function of the distance. This assumption cannot solve the problem of discontinuities well. In [4] the gradual covering expressed as a decreasing general function which is not necessarily linear. In 2013, Drezner et al. [19] discussed a cooperative gradual covering problem in the discrete and deterministic space. They assumed that received coverage from each facility is a stochastic variable with a normal distribution.

In this paper we model gradual covering location problem with different type of distribution functions for radiuses using Drezner et al. [12] suggested covering function. To have a better conclusion about related works, previous studies have been summarized as Table1.

Author's name	Specification			
Church et al. [3]	Stochastic radius□	Planar□	Discrete■	Gradual■
Church et al. [20]	Stochastic radius□	Planar□	Discrete□	Gradual■
Pirkul et al. [9]	Stochastic radius□	Plana □	Discrete■	Gradual■
Drezner et al. [16]	Stochastic radius□	Planar■	Discrete□	Gradual■
Berman et al. [2]	Stochastic radius□	Planar□	Discrete□	Gradual■
Drezner et al. [6]	Stochastic radius□	Planar□	Discrete□	Gradual■
Karaskal et al. [7]	Stochastic radius□	Planar□	Discrete■	Gradual■
Araz et al. [10]	Stochastic radius□	Planar□	Discrete□	Gradual■
Eiselt et al. [8]	Stochastic radius□	Planar□	Discrete□	Gradual■
Berman et al. [21]	Stochastic radius□	Planar□	Discrete□	Gradual■
Drezner et al. [12]	Stochastic radius■	Planar■	Discrete□	Gradual■
Berman et al. [2]	Stochastic radius■	Planar□	Discrete□	Gradual■
Berman et al. [22]	Stochastic radius□	Planar□	Discrete■	Gradual□
Berman et al. [13]	Stochastic radius□	Planar□	Discrete□	Gradual■
Drezner et al. [19]	Stochastic radius□	Planar□	Discrete■	Gradual■
The present paper	Stochastic radius■	Planar□	Discrete■	Gradual■

Tab. 1: The summary of previous studies with different characteristics

3. Problem statement

Consider a set of N facilities is provided. In the maximum covering location problem, we look for a set of P facilities (P ∈ N) so that the total facility coverage should be maximized.If the coverage radius for each facility supposed to be a random variable with a specific distribution, therefore, total coverage received from a facility (i.e., physical signal strength and the light radius emitted from facility) should be calculated per the average of received coverage.

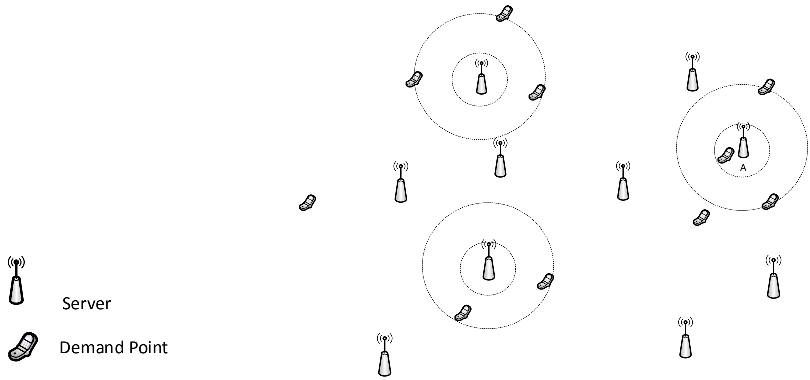


Fig. 1: The layout situation of a telecom service network

Figure 1 schematically shows the layout situation of a telecom service network. In that layout, three candidates out of the 10 candidates are selected for locating of telecommunication towers. Each telecommunication antenna provides maximum possible signal to the radius *r* and then signal strength is reduced gradually to the radius *R*. The following figure shows a network in situation where covering radiuses are changing with a probability distribution.

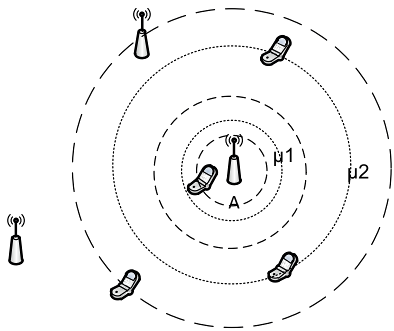


Fig. 2: A candidate tower with stochastic covering radius

As can be seen in Figure 2, in this case the demand placed anywhere within a distance between covering radiuses *r* and *R*, has a certain probability.

For example suppose that the signal power is changed as a random variable. Drezner et al. [12] suggested covering function as the expected coverage per various radii. In the gradual covering function, the amount of covering between *r* and *R* generally depends on the distance. According to [12] the coverage received from a facility can be calculated as follows:

$$cover(d) = \begin{cases} 1 & d \le r \\ \frac{R-d}{R-r} & r \le d \le R \\ 0 & d \ge R \end{cases} \qquad (1)$$

Therefore, the cover at distance d, and for distribution function of cover radii *c(d)* is:

$$c(d) = E(cover(d)) = \iint_{0 \le r \le R \le \infty} cover(d) f_{r,R}(y,z)dzdy \qquad (2)$$

So, if we assume that there is no dependency between the covering radius distribution functions *f_(r,R) (y,z)=ϕ_r (y)ϕ_R (z)* (Assuming full independence is somewhat inaccurate). Considering the coverage function, equation (1), equation (2) would be as follows:

$$c(d) = \int_d^\infty \int_0^\infty 1 \times \phi_r(y)\phi_R(z)dzdy + \int_0^d \int_d^\infty \frac{z-d}{z-y}\phi_r(y)\phi_R(z)dzdy \int_d^\infty \int_0^\infty 0 \times$$
$$\phi_r(y)\phi_R(z)dzdy = P_r(r \ge d) + \int_0^d \int_d^\infty \frac{z-d}{z-y}\phi_r(y)\phi_R(z)dzdy \qquad (3)$$

Equation (3) is the function suggested by Drezner [12] to calculate cover. Hereinafter, the equation (1) will be called 'decay function'.

3.1 Notation

Let:

i	Index for the set of candidate facilities for locating
j	Index for the set of demand points (customers)
r	Inner covering radius. The facility inside of mentioned radius can be fully covered
R	Outer covering radius. The facility outside of mentioned radius will be uncovered
$C(d_{ij})$	The proportion of coverage which facility i prepares for customer j in distance d_{ij}

W_j	The demand in point *j*
g_i	The cost of locating facility *i*
S	The adjustment factor to equal the cost unit and demand weight
X_i	Is one if facility locates on site *i* and zero otherwise
Y_{ij}	Is one if point *j* receives some services from *i* and zero otherwise

3.2 Model formulation

Given the above assumptions, the model is as follows:

$$max\, z = S\sum_{j=1}^{m}\sum_{i=1}^{n} W_j \,.\, c(d_{ij}).\, y_{ij} \;-\; \sum_{i=1}^{n} g_i\, x_i \qquad (4)$$

$$y_{ij} \leq x_i \;\; \forall i, j \qquad (5)$$

$$\sum_{i=1}^{n} y_{ij} \leq 1 \;\; \forall j \qquad (6)$$

$$\sum_{i=1}^{n} x_i \leq p \qquad (7)$$

$$x_i, y_{ij} \in \{0,1\} \;\; \forall i, j \qquad (8)$$

Objective function is composed of two parts. In the first part, the benefit of covering of all demand points is calculated and in the second part, the costs associated with the facility location are put forward. The objective function looks for maximizing net benefits. In this type of objective function, coverage radiuses with certain distribution functions are involved and unlike other cover functions, possible value of cover is calculated through the mathematical expectation. In all gradual covering models with cover function, value *c(ij)* is considered proportional to the distance of facility to service. Constraint (5) implies that each demand point can only be established with the covered facility. Constraint (6) each facility will be assigned only once to each demand point. Constraint (7) indicates that the number of located facilities is certain. Constraint (8) expresses the variables are binary.

3.3 Numeric solution of the model

In this section, the model for covering radius with various distribution functions will be solved, and then the results will be analyzed.

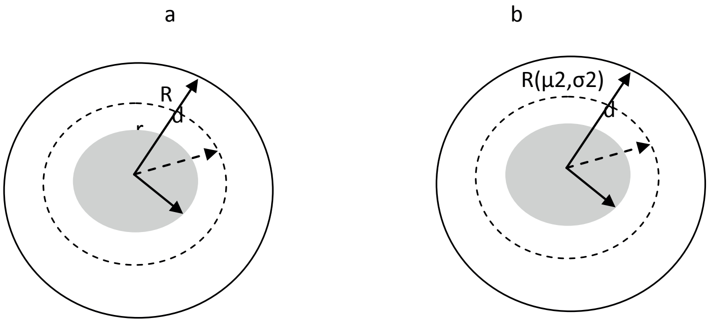


Fig. 3: Coverage area with fixed and stochastic radiuses

In Figure *3*, the shaded area indicating that the region is fully covered. Figure *3-a* reveals the general state of gradual covering problem. Figure *3-b* coverage radiuses have certain distribution functions. *d* is the distance between each demand point and the server facility.

To check the applicability and validation of the proposed model, random data for the covering radius were generated in three states. In the first state data were generated according to the uniform distribution while in the second and third states, data were generated according to the bivariate normal and exponential distributions respectively. Generated data have been plotted in figure *4*.

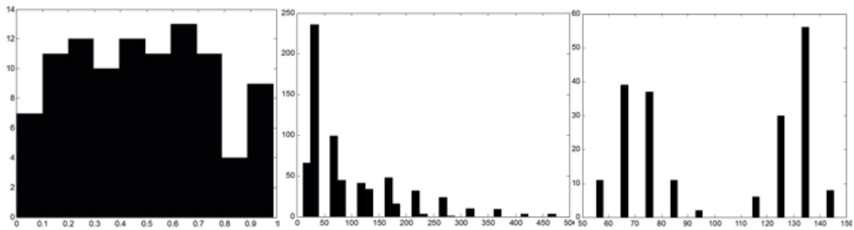


Fig. 4: Distribution function plots for randomly generated data with different distribution functions

The problem was solved twice. In the first one the problem was solved with specific covering radius which is one of the generated data and is called decay model, then in the second one the problem with expected coverage is solved which is called mathematical expectation. According to the network structure extracted by two models, the objective function values for all 100 random generated covering radiuses were computed according to two different network structures. The total differences between the two calculated objective function values (deviation) are calculated which is reported in Table 2. In the Table 2, *μ1* is the average of distribution of coverage radius *r*, *σ1* is the variance of distribution of coverage radius *r*. *μ2* is the average of distribution of coverage radius *R*, *σ2* is the variance of distribution of covering radius *R*. *β* is the parameter of exponential distribution. *r* and *R* are the inner and outer coverage radiuses at a fixed radius model. *ρ* is the correlation coefficient of normal distribution and deviation is the total difference in objective function values in 100 times of calculation. These differences are calculated through subtracting the cover function value of mathematical expectation from decay cover function, so positive values indicate better cover function values of mathematical expectation. The percentage indicates the contribution of positive differences out of total amount of differences between positive and negative values.

Distribution	*μ1*	*σ1*	*μ2*	*σ2*	ρ	β	*r*	*R*	*Deviation*	*Perce-tage*
Uniform a1=a2=μ1-σ1 =μ2-σ2 b1=b2=μ1+σ1 =μ2+σ2	*100*	*30*	*100*	*30*	*-*	*-*	*70*	*130*	*6550.813*	*80 %*
Normal (dependent variables)	*70*	*30*	*130*	*50*	*-*	*-*	*70*	*130*	*26592.85*	*100 %*
Normal (independent)	*70*	*30*	*130*	*50*	*0.6*	*-*	*70*	*130*	*19894.57*	*100 %*

Distribution	*μ1*	*σ1*	*μ2*	*σ2*	*ρ*	*β*	*r*	*R*	*Deviation*	*Perce-tage*
Exponential	-	-	-	-	-	*100*	*70*	*130*	*960.720*	*64 %*

Tab. 2: Performance comparison of decay and proposed model in a stochastic covering radius environment

Results in Table 2 shows that in the state of uncertainty and with stochastic covering radius, using estimated fixed radiuses amounts cannot be efficient enough. Moreover the proposed model performs better than the classic model in an uncertain environment. In the next part we are seeking to show how important parameters can effect on the problem. We do experiments with two more common normal and uniform distributions.

4. Sensitivity analysis of parameters for both Normal and Uniform distributions

In this section, by changing the parameters of the normal and uniform distributions the effect of changes can be analyzed. It's important to remind that in this comparison, differences are calculated through subtracting the cover function value of mathematical expectation from decay cover function. The tested values have been tuned according to other input parameters such as distance between nodes to be more realistic. Each test case has been evaluated about 500 to 800 times.

4.1 Uniform distribution with a mean and variance change

In the following graphs vertical axis shows summation of differences between objective function with decay cover function and cover function of mathematical expectation.

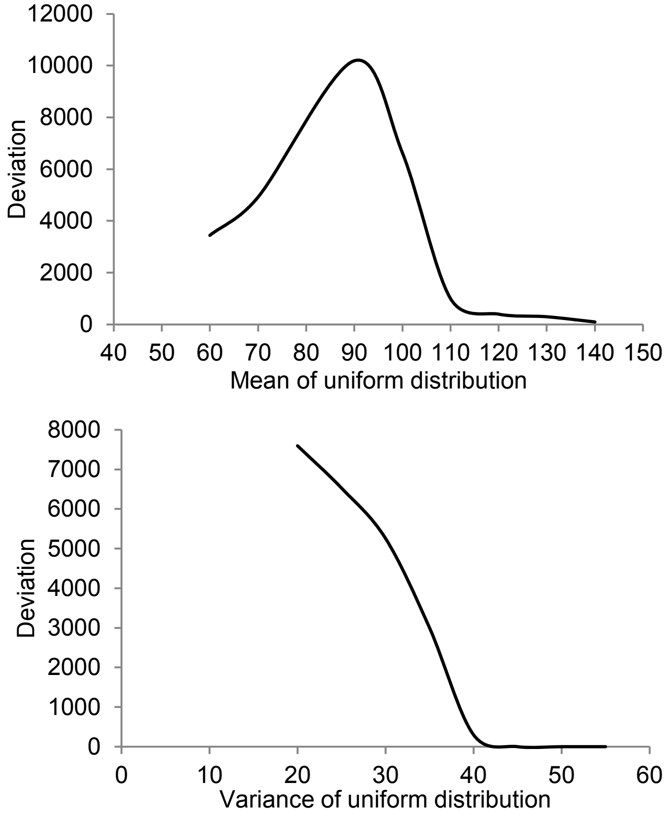


Fig. 5: Effect of changing mean and variance of radius with uniform distribution

Figure 5 shows deviation changes by increasing mean and variance of distribution. In the left hand side chart we increase both stochastic radius mean and the radiuses of decay model. Considering distance matrix, the maximum of distances between demand points and distribution centers is about 140. So according to following relation we expect sort of indifferentness does happen for deviation:

$$Max\{d(i,j)\} \leq b1(=b2=\mu 1+\sigma\ 1= \mu 2+ \sigma\ 2)$$

The trend as our expectation limits to zero too.
The lower chart shows a decreasing trend by increasing of variance. In this state we increase the variance of radiuses distribution in stochastic model and radiuses of decay model. It seems that the trend limits to zero about 140, witch with 100 for mean, it's happen about 40.To have a better conclusion we experimented the similar changing in the state that radiuses of decay model don't change. We fixed them on 70 and 130 and changed mean and variance of stochastic model. We expect after 70 and 130 see an increasing trend. As it appears in Figure 6 in upper part for changing of mean, there is some undulation around 100 where two means over lap and after that the trend grows up again. The analysis for variance has a little more complexity. As it seems in upper chart in Figure 6 before lower limit of decay model (it is 70) there is even negative amounts for deviation. Then we see an increasing trend with a fast slop. The summit of chart is the place that radiuses of both models overlap. After it, the trend goes down and about 140 for upper bound it starts to produce negative amounts again.

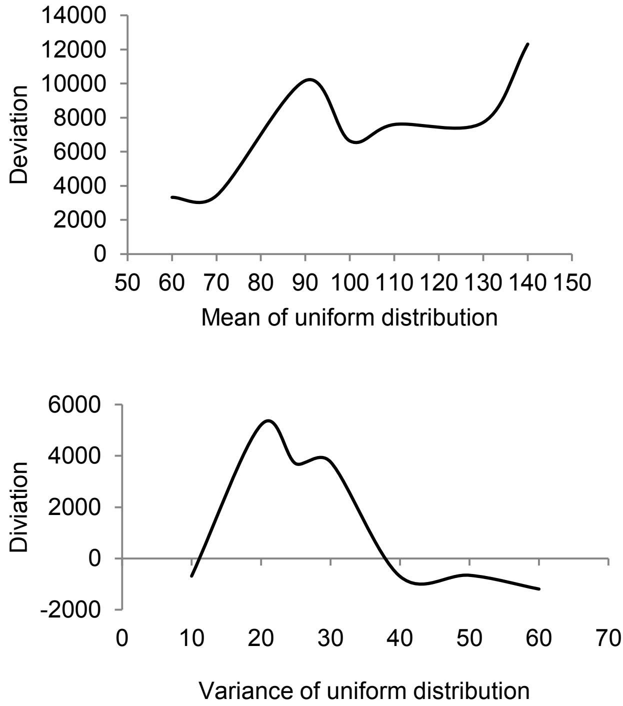
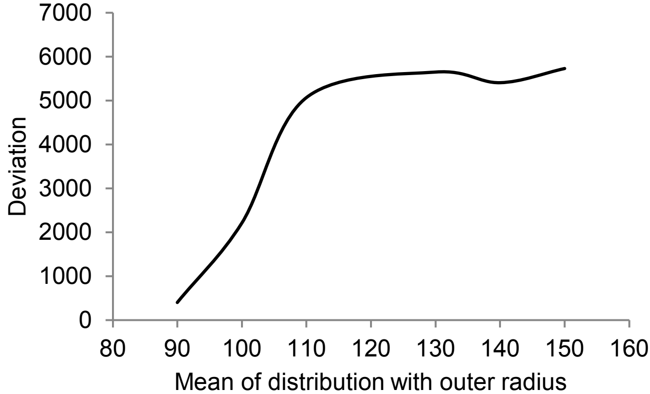


Fig. 6: Effect of changing mean and variance of radius with uniform distribution when the decay model radiuses don't change

4.2 Normal distribution with mean and variance change of outer radius/R

The charts in Figure 7 are results of changing both radiuses of classic model and stochastic radius model amounts. In upper chart when the outer radius for both modes increase, the deviation at first have an increase with a fast slop. After 100 we see very little changes in trend. It is the place where is closing to $\mu+z\ \alpha/2\times\sigma$ which is upper bound in normal distribution. But generally with increasing outer radius we expect an increasing behavior, because the space of gradual coverage is getting bigger. Deviation changes chart reveals a decreasing trend with a downfall in the middle. With a big variance for outer radius the probability of having very small coverage radius sustains. So it seems naturally we face a decreasing trend.



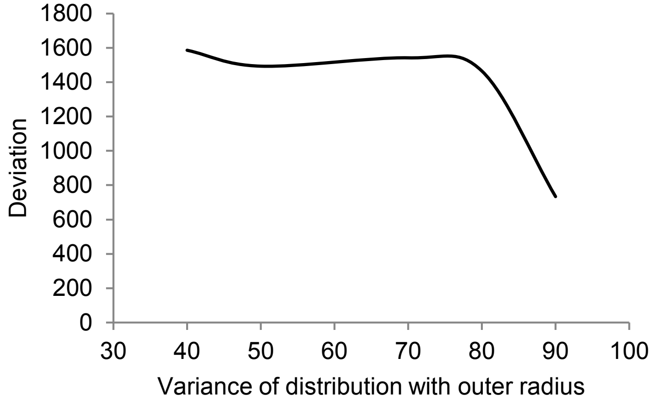


Fig. 7: Effect of changing mean and variance of radiuses with normal distribution

There is no discussable trend for inner radius changes, so we prefer to change parameters for both radiuses simultaneously.

4.3 Simultaneous changes in both the mean and variance within normal

In this part we examine simultance changing of mean and variance of both radiuses.

In Figure 8 the vertical axises don't have real numbers. It has omitted in order to shows the changes of both parameters with different values. In the upper chart both means of r and R radiuses have been increased, so the summation of variance between objective function with decay cover function and cover function of mathematical expectation has been increased too. It is obvious that with increasing mean of radiuses the coverage will get bigger and more demand points will cover. This event is more effective about stochastic radiuses, because variance of distribution can help too. So having an incremental trend is not out of mind. But there is a summit that shows a part of trend is under effect of inner radius changing.

In the lower chart, changing in trend is very smooth. When the variance of outer and inner radiuses change together, it is hard to say what exactly will happen. Because changing variance can cause to growing up the probability of having inner and outer radiuses. With all that, as trend shows, the resultant of these changes has a positive effect on deviation.

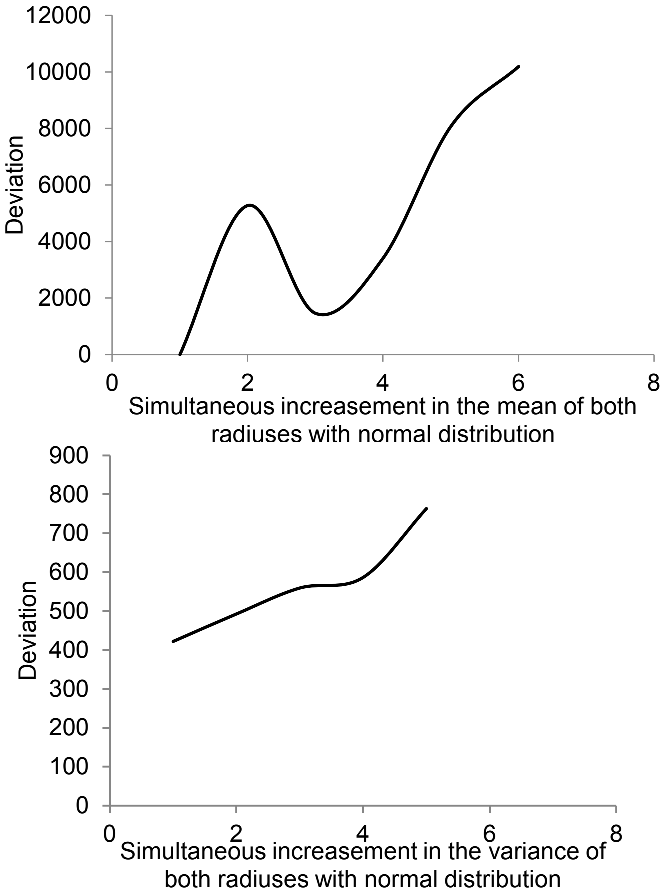


Fig. 8: Simultaneous changes in both the mean and variance within normal

4.4 Sensitivity analysis table

In Table 3 the observed results of parameter sensitivity are summarized. It is assumed that the testes parameter values are rising. Cells of the table represent the status of variance of objective function values regard to changing the parameter. The term Incremental points to an increasing trend and Decline points to a decreasing trend.

Distribution Type	Mean of *r*& *R*	Variance of *r*& *R*	Mean of *R* (outer radius)	Variance of *R* (outer radius)
Uniform	Decline	Decline	-	-
Normal	Incremental	Incremental	Incremental	Decline

Tab. 3: Summary of different sensitivity analysis results

5. Conclusions

In this paper, we reviewed gradual cover models that have been proposed so far. Then, we studied a type of problem in which covering radius change randomly. Using Covering function proposed in [12] and with entering the cost parameters, we studied location problem in various modes of distribution functions and in discrete space. In the real word we face some uncertainty in problems and ignoring most of the states of problem is not reasonable. Covering location problem with stochastic radiuses has attended to all possible states of the radiuses with considering average of possible values. We produced different scenarios for radiuses and tried to give solution of both stochastic and deterministic models to calculate objective function values. According to reported results when the radiuses are not fixed, stochastic radius model is more efficient for the problem. In sensitivity analysis part we examined changes of parameters effect for normal and uniform cases, that are very common distributions of natural events behavior. The results show when the distribution mean of radiuses are big the stochastic radius model is more effective than the classic model. As a future research considering the hierarchical covering problem in stochastic environment is proposed.

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Computing Dynamic Routes in Maritime Logistic Networks

Hervé Mathieu, Jean-Yves Colin and Moustafa Nakechbandi

Abstract

In this paper, we study the problem of finding the path that maximizes the gain toward one of several destination ports subject to uncertain information on the expected gain in each port. Although the cost of a ship trip between two points is usually predictable, some events may happen, thus impacting the cost. The price of goods to be delivered may fluctuate during the trip (thus impacting the gain), or the price to pay at the destination point can be higher than expected (in case of a strike for example). All of this has important economical consequences for the ship-owner and for the port on a long-term basis. In this context, it is important for a ship-owner to be able to react quickly when a destination port is no longer available. When a port terminal is on strike for example, ships are rerouted to other ports to be loaded and unloaded. We propose in this paper a simple and yet efficient algorithm to re-compute the path of the ship, when she is on the way, based on the computation of the longest path in a weakly dynamic graph, in order to maximize the global gain of the trip.

Keywords: dynamic graph, longest path problem, maritime network, route planning, time and costs factors.

1. Introduction

Static graphs have a long history of being used to efficiently represent static problems. In these problems, all the data are known from the start. The real world is not static, however, and the solutions to static problems may not always be used (Alivand, Alesheikh and Malek, 2008). Some data may change, or be unknown in advance. For example, the traversal duration of a location may depend on traffic density, the presence or not of traffic jams, work in progress, etc. that are all time dependent and usually hard to predict. Thus several approaches have been proposed to study parametric graphs (Ahuja, Magnanti and Orlin, 1993) and dynamic graphs (Boria and Paschos, 2011).

Fully dynamic algorithms, for example, are applied to problems that can be solved in polynomial time. They start with a computed optimal solution, and then try to maintain it when changes occur in the problem. They often propose sophisticated data structures to reach this goal (Demetrescu and Italiano, 2004). When the delay between a change and the moment a new solution is needed is very small, or when the problem itself is NP-hard, faster algorithms are needed. These re-optimizing algorithms usually start from an initial solution that is not optimal but is expected to be of good quality, if possible. As soon as a change is detected, they compute a new solution, trying to do it faster than classical algorithms. Or they compute a new solution as quickly as the classical algorithms but this resulting solution is better than the ones found by classical algorithms. These algorithms include meta-heuristics such as ants colony algorithms (Balev, Guinand and Pigné, 2007), or swarm algorithms (Bajgan and Farahani, 2012).

Another approach used is probabilistic. Probabilities are associated to some variables in the graph, such as the value of a weight, or the presence of a node or of a constraint, for example. The algorithms used in these problems usually compute a solution and then do some robustness analysis in the probability space (Fulkerson, 1962). Or they do a quick re-optimization of the solution once the parameters of the problem are perfectly known (Bertsimas, 1988; Jaillet, 1985).

In this paper, we study route planning in a maritime network (Joly, 1999). More specifically, we study the problem of finding the most interesting path toward one of several destination ports subject to uncertain information on the expected gain in each port. Although the cost of a ship trip between two points is usually predictable, some events may happen, thus impacting the cost. However, in most cases, only the final part of the trip is subject to change. The price of goods to be delivered may locally fluctuate during the trip (thus impacting the gain), or the price to pay at the destination point can be higher than expected. For example, it may happen that the dockers of a maritime port are on strike (examples of strikes include Le Havre-Rouen-Marseille 2008, Liverpool between 1995 and 1998 also known as Liverpool's Dockers' strike, Rotterdam 2013). Actually, the strike phenomenon in maritime ports happens on a regular basis all over the world. To have an idea of the strike impact on maritime traffic, we can quote the example of the Greek port of Piraeus : Piraeus' volume peaked at 1.6 million TEU (Twenty feet Equivalent Unit) in 2003, but strikes and unrest led to a throughput of only 433,000 TEU in 2008 (Notteboom, 2013). Moreover, "exceptional" events can make a destination port unavailable: bombing, blockade because of economical sanctions etc. It is then necessary to reroute a ship when its destination port is unavailable as soon as possible (Hamburg South Terminal, 2013). All of this has important economical consequences for the ship-owner and for the port on a long-term basis. Thus, when a merchandise ship has to stay docked in a port without being taking care of, it implies a money loss that can be important for the ship-owner: sailors' wages, ship rental, blocked merchandise, disrespect of deadlines for merchandise delivery (penalties), and extra fuel consumption. In this context, it is important for a ship-owner to be able to react quickly when a destination port is no longer available.

2. Problem Statement

Maritime Shipping Graph (MSG): To study this problem, we will consider a graph G = (V, E). V is the set of nodes, V = S ∪ P ∪ {D}, S = {1, 2, … s} is the set of stable nodes, P={X1, X2, … Xp} is the set of non-stable nodes (representing destination ports) and D is the destination node. E is the set of edges, and to each edge is associated a weight $w \in \mathbb{R}$. All the edges between a node of S and any other node are stable and their negative weights, that represent costs, never change. There is no edge between a stable node and D. However all edges leading to the final destination D in the graph are not stable and their weights may change at any time. The Xi nodes indicate the various ports available for delivery, and D is an added node indicating the abstract delivery of the load. Each edge between a node Xi and node D is non-stable and has a value xi, representing the current expected profit for delivering the load in port Xi. We call this graph a MSG, Maritime Shipping Graph (see figure 1).
The length of a path is the sum of the weights of its edges. Longest paths that do not include any variable edge may be computed with the Dijkstra algorithm.
For example, taking the simplistic example of a wheat cargo, starting from Argentina to Europe, it may pass through several points (such as the Horn Cap or the Panama Canal). The price to pay, in oil, time, fees and such is usually known and may be represented by a simple static graph. Once the ship is close to Europe, each possible port will have different and possibly changing profit due the local conditions (port availabilities, adding the cost of train or road transports, strikes…). The profit earned PE considered is:

$$PE = SP - LF - TC$$

with SP being the selling price at final destination, LF being local fees and expenses at final destination, and TC being travel costs to Europe.
For example on the graph of Fig. 1, starting from node 1, we intend to reach one of the final ports X1, X2 or X3. The profit expected from port Xi will be the price received for the cargo minus the cost to deliver it, minus the cost to go to the port.

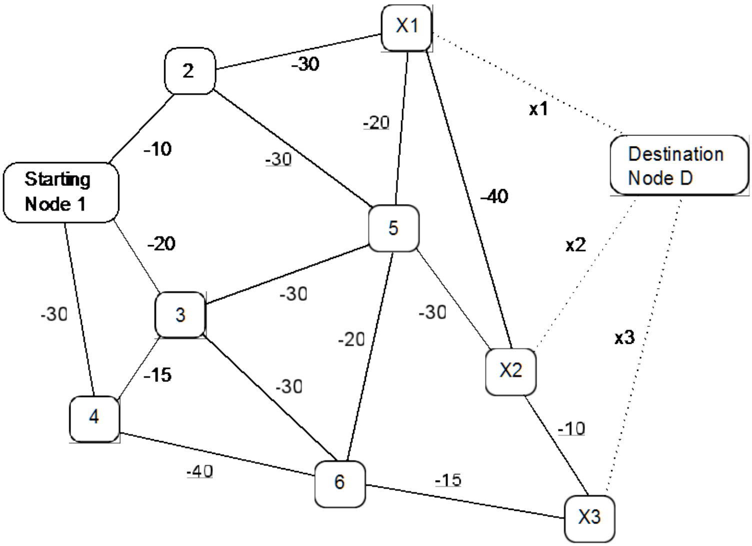

Fig. 1: Example of Maritime Shipping Graph with 3 variable edges (x1, x2, x3) to the destination D (dashed lines on the graph).{1,2,3,4,5,6} is the set S of stable nodes and {X1, X2, X3} is the set P of non stable nodes.

We aggregate the price received there for the cargo with the cost to deliver there in a non-stable value xi that is represented on the graph as an edge between node Xi and a virtual node D.

We are interested in the "One-to-All" Longest Path Problem (LPP),that is, finding the longest paths from one node to all other nodes of this graph. This must be done considering the weights of the non-stable edges. Preliminary results on the Shortest Path Problem (SPP) on weakly dynamic graphs with one variable edge were presented in (Colin, Ould Cheikh and Nakechbandi, 2013). In Nakechbandi, Colin and Ould Cheikh (2013) this result is extended to two variable arcs. In both results, alternative shortest paths or parametric routing tables are pre-computed for all possible values of the non-stable weights. Thus when the non stable

weights change, new optimal paths may directly and immediately be deduced and used without any further re-computations.
The LPP we study will use the model illustrated on Fig. 1. Each stable value is a negative value representing its cost, and the non-stable value of this kind of weakly dynamic graph is the price received for the cargo minus the miscellaneous local costs (including the effects of strikes, if any.)

3. Main results

3.1 The proposed algorithm

We present now the following algorithm to solve this problem:

Algorithm

Input: G=(V, E) is a MSG, with P being the subset of non stable nodes, and D being the destination

Output: longest paths LP(j, D) from any node j of G to D

For each non-stable node Xi of P do

Compute LPS(Xi) = set of longest paths that do not use a variable edge, from all nodes j, j ∈ V- {D} to node Xi using the reverse Dijkstra algorithm.

Let dXi[j] = the length of the path in LPS(Xi) that starts from j ∈ V- {D} of the graph.

End For

The longest path LP(j, D) from j to D is the path such that length (LP(j, D)) = max (dXi[j]+ xi , Xi ∈ P)

3.2 Example:We now apply the algorithm on the graph of Figure 1

The least costly distance from each stable node to each non-stable node is presented in Table 1.

Stable node to non stable node	X1	X2	X3
1	-40	-70	-65
2	-30	-60	-65
3	-50	-55	-45
4	-65	-65	-55
5	-20	-30	-35
6	-40	-25	-15

Tab. 1: distances from all stable nodes to all non stable nodes

For example, the value of the least costly path from node 3 to go to node X1 is -50, to go to node X2 is -55 and to go to node X3 is -45.

We now suppose that the current expected profits at the possible delivery ports are (x1, x2, x3) = (1000, 1100, 1200).

The length of the longest path (that is the one with the highest total profit) from node 3 to D is max (1000 – 50, 1100 – 55, 1200 – 45) = 1155. From node 3, the longest path will go to port X3 for delivery in the current conditions.

Now, if x3 falls to 1050 and the other values do not change, then the length of the longest path from node 3 to node D is max (1000 – 50, 1100 – 55, 1050 – 45) = 1045. From node 3, the longest path will go to port X2 for delivery in these new conditions.

3.3 The proposed algorithm

Theorem 1: Let G=(V, E) be a Maritime Shipping Graph, and { xi, with Xi $\in$ P } be the values of the non stable edges. Let dXi[j] the longest path without non stable edges from a stable node j to Xi , Xi $\in$ P. Then the length of the longest path from a node j to node D is max { dXi[j] + xi, with Xi $\in$ P }

Theorem 2: The complexity of the algorithm is O((m + n log n)p)with n being the number of nodes, m the number of edges and p the number of non stable nodes.One interesting use of this result is in the building of pre-computed parametric routing tables. These parametric routing tables include critical conditions that can easily be used to establish very quickly a new destination if the expected profit in any possible final destination crosses a computed threshold value.

We call critical conditions of a given node, the set of length functions associated to the longest paths to this given node computed by the algorithm. Because the functions of this set are constants, or very simple linear functions of the non-stable weights, they can be computed and compared very easily. Thus for each target node, the set of alternative paths can be stored along with the associated set of critical conditions. As soon as any variable weight changes, the critical conditions of the target node just need to be re-computed and compared. Then the new longest path may be chosen among the alternative paths stored for this node. No re-computation of longest paths is needed, no data beside the current values of the variable edges need to be exchanged, and all decisions may be taken locally.

The result found by the proposed algorithm can then be used to build alternative routing tables for each ship starting from any location of the graph. The same tables can then be used to route these ships to the most profitable destination at any time during its journey.

We develop the above ideas in the next part, using the example of Fig. 1.

4. Developed Example

We now again use the example of Fig. 1 with the current values (x1, x2, x3) = (1000, 1100, 1200) for the current non-stable weights. Applying the algorithm gives the distances, from all nodes to D, presented in the right part of Table 2:

	X1	X2	X3	Distance to D using (X1, D)	Distance to D using (X2, D)	Distance to D using (X3, D)	Best distance to D if (x1, x2, x3)= 1000,1100,1200
1	−40	−70	−65	x1−40	x2−70	x3−65	1135
2	−30	−60	−65	x1−30	x2−60	x3−65	1135
3	−50	−55	−45	x1−50	x2−55	x3−45	1155
4	−65	−65	−55	x1−65	x2−65	x3−55	1145
5	−20	−30	−35	x1−20	x2−30	x3−35	1165
6	−40	−25	−15	x1−40	x2−25	x3−15	1185
X1	0	−40	−50	x1	x2−40	x3−50	1150
X2	−40	0	−10	x1−40	x2	x3−10	1190
X3	−50	−10	0	x1−50	x2−10	x3	1200

Tab. 2: distances from all stable nodes to all non-stable nodes, and to D with (x1, x2, x3) = (1000, 1100, 1200)

Now, for any node, the length of its longest distance depends on the values of the non-stable edges. The possible lengths are summarized in Table 3.

Next, it is now possible to build a parameterized routing table in each node to go to D. In the parameterized routing table of a given node, which neighbor to use depends on which part of the max formula gives the highest result using the current values of the non-stable edges. Table 4 presents the parameterized routing tables of nodes 3 and 4 if we have (x1, x2, x3) = (1000, 1100, 1200). With these values, x3–55 in Table 5 at node 4 gives the highest result of 1145, so a ship at node 4 with the above conditions will go next to node 6.

We now start to compute the sensitivity of the result in each node, stable or not, only if one non-stable value changes. At node 1 for example, the best path to D has a length of 1135, and uses edge (X3, D) to D.

Node	Parameterized longest distance to go to D
1	Max(x1−40, x2−70, x3−65)
2	Max(x1−30, x2−60, x3−65)
3	Max(x1−50, x2−55, x3−45)
4	Max(x1−65, x2−65, x3−55)
5	Max(x1−20, x2−30, x3−35)
6	Max(x1−40, x2−25, x3−15)
X1	Max(x1, x2−40, x3−50)
X2	Max(x1−40, x2, x3−10)
X3	Max(x1−50, x2−10, x3)

Tab. 3: Parameterized longest distance to go to D

If current highest critical condition at node 3 is	Then go to neighbor node:
x1 – 50	5
x2 – 55	6
x3 – 45	6

Tab. 4: Parameterized routing tables of nodes 3 to go to node D, (x1, x2, x3) = (1000, 1100, 1200)

If current highest critical condition at node 4 is	Then go to neighbor node:
x1 – 65	3
x2 – 65	6
x3 – 55	6

Tab. 5: Parameterized routing tables of nodes 4 to go to node D, (x1, x2, x3) = (1000, 1100, 1200)

The second best destination port is X2, using edge (X2, D) to D, and has a length of 1030. The remaining possible destination is X1, using edge (X1, D) to D, and has a length of 960.

Now, for a different path to be chosen if only one non-stable value changes, two cases are possible. Either the profit at the best destination port falls so much that the second best becomes better, or the profit at one destination port that is not the best one climbs so much that it becomes the best one.

Comparing the values found in Table 2, and using the computed distance formula to go from any stable node to any non stable node, we can deduce that, at node 1 for example, the second best destination port becomes the best one if $x3-65 < 1030$, that is if $x3 < 1095$. We can also deduce that, at node 1, destination port X1 will becomes the best destination port if $x1-40 > 1135$, that is if $x1 > 1175$. And that, at node 1, destination port X2 will becomes the best destination port if $x2-70 > 1135$, that is if $x2 > 1205$.

We call these values (1175, 1205, 1095) at node 1 the critical values of node 1 for the prices at destination ports (X1, X2, X3) if (x1, x2, x3) = (1000, 1100, 1200). If any single profit change occurs from the initial conditions (x1, x2, x3) = (1000, 1100, 1200), then there will be no path change to consider if the new price is not above its critical value for a non best destination port, or is not below its critical value for the best destination port. Furthermore, if the local profit changes again many times whereas the other non-stable profits do not change, than there is no re-computation needed of any path and values.

5. Conclusion

In this paper, we studied the problem of finding the most interesting path (the one that maximizes the gain) toward one of several destination ports subject to uncertain information on the expected gain in each port and rerouting a ship when needed.

We proposed a simple and yet efficient algorithm to re-compute the path of the ship, when she is on the way, based on the computation of the longest path in a weakly dynamic graph, in order to maximize the global gain of the trip. Parametric routing tables are pre-computed, and critical values are deduced.

As a final remark, one can note that a particular pathological classical situation that may arise in this kind of problem is that the expected values between two possible final destinations may change several times such that the ship must alternatively follow a path along and edge from A to B, then back from B to A, several time. It is a well-known problem of sensitivity in dynamic problems. One idea of heuristic may be that the ship is not allowed to come back toward another destination port unless the total expected profit there is superior to the total expected profit before the last change. With this heuristic, it is not possible for a ship to travel forever between two ports, because the prices will not increase forever.

In the future, we intend to study the problem of finding longest paths in weakly dynamic graphs when some non-stable edges are not close to the destination node (passing through the Suez Canal for example).

We also intend to work on extending this result to the problem of arbitraging multi-deliveries when a ship at one time or another must reach several destinations successively.

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A Simulation-Based Decision Making Framework for the Anticipatory Change Planning of Intralogistics Systems

Mustafa Güller, Tobias Hegmanns, Michael Henke and Natalia Straub

Abstract

In many industries flexibility and changeability are becoming a more important characteristic for providing responses to fluctuating conditions without significant loss in time, costs and efforts. In order to cope with turbulences and the increasing level of unpredictability, future intralogistics systems have to feature short reaction times, high flexibility in processes and the ability to adapt to frequent changes. However, the flexibility planning of the design and operations of intralogistics systems as a mean for improved supply chain agility has been ignored. There are many forecasting methods in the literature that can be used to predict future conditions, such as market development, product portfolio or future customer expectations. Nevertheless, analyzing the impact of these forecasts on the performance and costs measures of intralogistics systems is still experiencing insufficient methodical and tool support. Anticipatory change planning can be a usable approach for managers to make contingency plans for intralogistics systems to deal with the rapidly changing marketplace. In this context, this paper proposes a simulation-based decision framework for the anticipatory change planning of intralogistics systems in order to cope with unpredictable events in the future. This approach includes the quantitative assessments based on the simulation in defined scenarios as well as the analysis of performance availability in terms of the degree of fulfillment of customer requirements. The implementation of the approach is illustrated on a new intralogistics technology called the Cellular Transport System.

Keywords: anticipatory change planning, performance availability, flexibility, simulation

1. Introduction

Most companies source globally, produce in various plants and serve customers all over the world with a complex distribution network that has several facilities linked by various activities. This globalization of supply chains brings some challenges as well as benefits. As supply chains become more global, they are becoming more vulnerable to business disruptions, and hence, they are usually slow to respond to changes (Tang & Tomlin, 2008). Outsourcing, e-commerce and volatility in the business environment are creating greater the risk of disruption. In addition, there have been large natural disasters that have the potential to severely affect the continuity of a supply chain (Chisropher & Peck, 2004). In this sense, flexibility to respond appropriately to these disruptions is essential to reduce the negative impacts of the occurrence of certain events associated with risks (Tang & Tomlin, 2008). Thus future logistics systems have to feature short reaction times, high flexibility in structures and processes, and the ability to react on unexpected events (Wilke, 2008).

Intralogistics systems are essential elements of the modern supply chain. The term intralogistics in general refers to the organization, control, execution and optimization of in-plant material flow, information streams and goods handling with the help of technical systems and services (ten Hompel & Heidenblut, 2008). Intralogistics systems are difficult to incorporate into an agile supply chain because of limited flexibility and their long-term physical build-up. In order to cope with new requirements, modern storage and material handling systems should combine the high quality of service of automated systems with the high flexibility of manual systems (Schmidt & Schulze, 2009). Conventional models often ignore the constraints imposed by intralogistics systems on the efficiency of the warehouse and production operations, thereby implicitly assuming that the

intralogistics system does not constitute a bottleneck or a limited resource (Crama, 1997). For most systems it was common to run for many years in the same configuration. However, increasing market dynamic causes frequently varying intralogistics' requirements. For this reason, it is often needed to change the layout in response to new market conditions after a couple of years. Companies that use automated material handling systems have reduced their investment in automated systems significantly, since the systems are insufficient to cope with changes in the requirements and processes (Furmans et al., 2011). Therefore, appropriate strategies for unpredictable environments require an inherent ability to make changes in the system. As a result, in today's fluctuating business environment, flexibility, responsiveness, and reconfigurability in the field of intralogistics are key characteristics, as well the level of automation, cost effectiveness and maximum throughput (Furmans et al., 2011).
There are unlimited numbers of potential events, trends, or occurrences that can happen in the future, such as uncertainty of the order arrival process, transportation disruption, machines' breakdown, increased customer expectations in terms of quality and delivery time, financial crisis, etc. In order to cope with unknown events that are assumed to be completely unpredictable, firms need to identify all possible high-impact events that might occur and make contingency plans to deal with them (Goodwin & Wright, 2010). The ability of a system to respond effectively an unpredictable event depends more on the decisions taken before the event than those taken during or after. In order to counter this problematic and its repercussions, forecasting and anticipation methodologies have been widely used techniques. The main limitation of forecasting is the low-ability to accurately estimate the occurrence of rare, high impact events because the future rarely moves in predictable or incremental ways (Goodwin & Wright, 2010) (Caplice & Phadnis, 2013). In other words, these events and their impacts are very difficult to predict using traditional forecasting methods since unpredictable events do not follow any historical patterns. Anticipatory management is a general concept used in several fields. The concept of anticipation was introduced by Rosen (1985). A system that make

decisions in the present on the basis of what may be happening in the future is called an anticipatory system. In other words, an anticipatory system is defined as a natural system that contains an internal predictive model of itself and of its environment, which allows it to change state at an instant in accord with the model's predictions. In traditional forecasting methods the past is the cause of the present. The major difference in the anticipatory system is their dependence on future states, and not only on past states (Rhodes & Ross, 2009). Hence, the anticipatory method may be quite useful for intralogistics systems to challenge the unpredictable high-impact events and to be better prepared for possible future developments.

In order to assess and compare the performance of intralogistics systems, there are different key figures in the literature, such as, the utilization which denotes the fraction of time in which the server is occupied, and the system throughput which is defined as the number of customers served in a single time unit (Huber, 2011). Other key figure used to calculate the performance of intralogistics systems is the performance availability. The performance availability is defined in VDI-Guideline 4486 as "the degree of fulfillment of processes agreed between contract parties in accordance with the requirements and deadlines and in compliance with the agreed basic conditions" (VDI10). This study presents an anticipatory change planning framework based on the performance availability to support the decision making process of intralogistics systems. The proposed approach integrates the quantitative assessments based on the simulation in defined scenarios. The efficiency of the framework is evaluated by considering a new intralogistics technology called the Cellular Transport System (CTS). This paper is organized as follows. After we present the definition and overview of the performance availability in section 2, the process chain modelling technique is briefly discussed in Section 3. Section 4 is devoted to introduce the simulation-based anticipatory change planning concept for intralogistics system. Experimental results of different scenarios are presented in section 5. Finally, conclusions follow in section 6.

2. Definition and overview of the performance availability

The term "performance availability" was first introduced by Wittenstein (2007). It is defined as the state of a system in which a process is carried out according to requirement and the required result can be completed on time. Four essential steps are defined to reach the performance availability (Maier, 2011):

1) Formulation of the business objective:

The new system has the task of the operator to facilitate the achievement of its business objectives or facilitate. Therefore it is necessary that these goals are concretely defined.

2) Formulation of logistics processes:

The business objectives are achieved by various logistics processes that are carried out successfully on the system. These processes must also be defined and quantified.

3) Formulation of boundary conditions:

In order to measure and evaluate the performance in a meaningful way, reliable boundary conditions must be defined, based on which the necessary resources can be scheduled.

4) The difference between consequences when process disturbances occur:

Two factors are defined in order to quantify the degree of fulfillment of the performance availability. If undesirable waiting times occur at the considered workplace due to a disturbance, the performance availability η_W of this workplace is calculated as follow (T_B is the observed time and T_W is the waiting time in observed period):

$$\eta_W = \frac{T_B - T_W}{T_B}$$

If the process is not completed at a certain time due to the lack of availability, the power availability η_L is calculated as follow (N is the total load and n is the delayed loads in observed time):

$$\eta_L = \frac{N - n}{N}$$

As mentioned in the previous section, an alternative definition of the performance availability is introduced in VDI-Guideline 4486. Based on this definition, the performance availability is the degree of fulfillment of processes agreed between contract parties (manufacturer and user) in compliance with the agreed basic conditions (VDI10, 2010). Nevertheless, the above definition is not used directly for the assessment of the performance of entire logistic systems. Every company tries to deliver some sort of service or product in order to satisfy their customer wants and needs. The creation of these products or the delivery of these services is achieved through processes. According to Klaus and Krieger (2009), a logistic process consists of a number of activities that is comprised of a measurable input, which is converted by a transformation into a measurable output. To meet business objectives, output of processes must be controlled by performance indicators, which usually involve efficiency and effectiveness metrics (Schmelzer & Sesselmann, 2008). Efficiency of logistic processes is often measured from dimensions such as, time, quality, quantity, product, and cost. Other performance dimension suggested in the literature is flexibility that provides the ability to adapt to both internal and external business changes.

It is critical that the agreement between the provider and customer must be aligned with the performance requirements of the system. Furthermore, performance metrics should be specified in a range in order to adjust to fluctuating conditions of customer needs. In flexible logistics systems, these fluctuating conditions in internal and external environment are already considered in the planning phase (Schuh et al., 2012). The system has to be ensured that these expected changes can be realized within a pre-defined and limited scope of action.

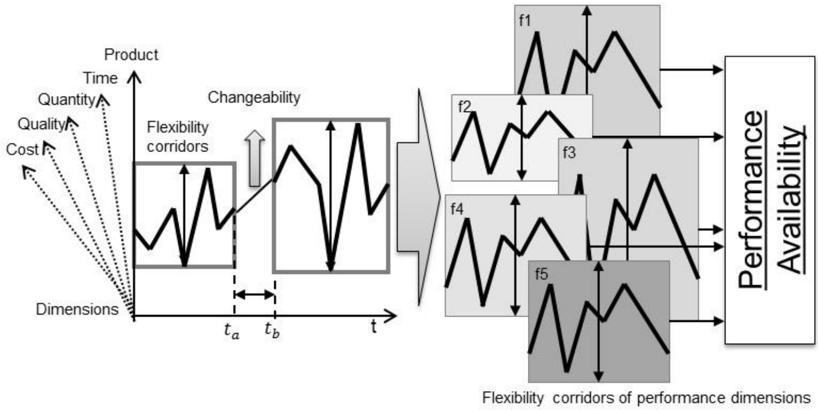

Fig. 1: Performance availability with flexibility corridors of performance dimensions

There is a flexibility corridor for each of the performance dimensions (quantity, quality, time, product, and cost). From the logistic process point of view, the performance availability reflects performance dimensions listed above as shown in Figure 1. There exist a large number of logistic processes modelling technique such as, Flowcharting, Petri Nets, OMEGA, Process Chain Modelling and Event-driven Process Chains. The following section describes the process chain modeling.

3. Process chain model of logistics systems

The process chain paradigm introduced by Kuhn (1995) is a model-based method for the visualization, evaluation and analysis of the processes within a system. The process chain model presents a process by the logical and chronological alignment of individual process chain elements alongside a timeline. It allows a time-oriented view of a business process. The starting point of this model is the general process chain element that defines the closed and bounded subprocess (Nyhuis & Wiendahl, 2009).

The components of each process chain element are sources, sinks, processes, resources, structures and control layers. The model with its 17 individual parameters describes logistic networks and explains their control mechanisms (Hellingrath, 2010). Figure 2 depicts a process chain element and its individual parameters. The source describes inputs of a process or process chain that represents material and information flows of logistic objects (Adaev, 2012). In other words, the transformation objects enter the element through the source. They are delivered to the system's environment through the sink as a transformed object.

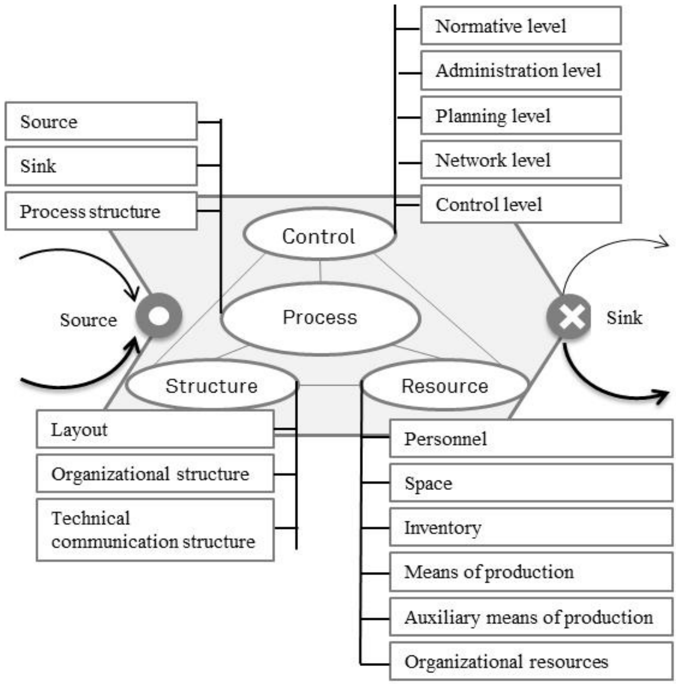

Fig. 2: Process chain element (Kuhn, 1995)

Processes describe the behavior of a logistic system and its internal operations (Uygun, 2012). The main task of a process element is to transform objects according to customer requirements. Processes are described by the parameter control, structures and resources. The main task of a process element is to transform objects. The parameter process is linked to the parameter resources that determine all necessary resources for performing the processes. The control layer, which is divided into five levels (normative, administration, disposition, network, and control layer), encompasses the rules-based coordination, regulation and monitoring of defined processes that ensure the overall functionality of the system (Adaev, 2012). The process chain model has been also used to develop a holistic, process-oriented planning model of complex logistics and production systems (Kuhn et al., 2007). The model consists of three planning levels, covers five planning phase and describes six iterative planning steps. The Figure 3 illustrates the planning steps graphically. The iterative process starts with the definition of the system load (Beller, 2009). In this step, the objects running through the system and the desired transformation performance are defined.

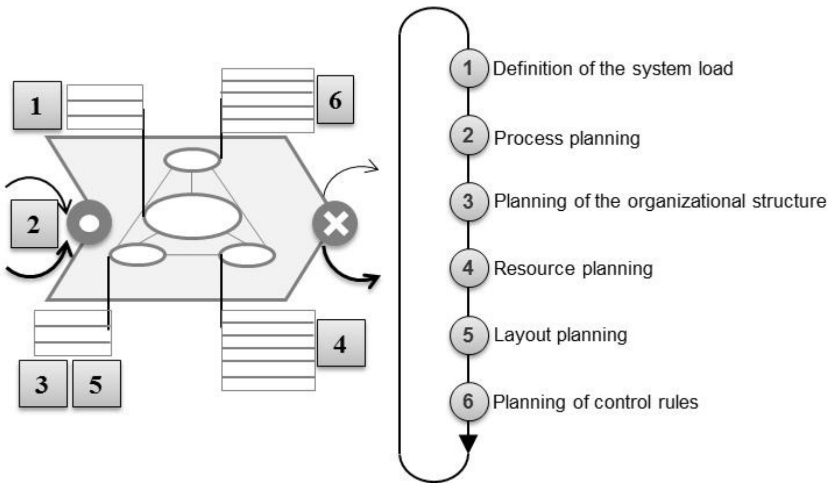

Fig. 3: Iterative planning steps for the planning of logistics systems

The systems load specifies the transformation objects in terms of type and quantity. The process planning describes the second step in the model. This step includes all sub-processes that are required in order to manage the previously determined system load and to transform the objects. The next step of iterative process is the planning of the organizational structure. The task of this step is to define an efficient organization and areas of responsibility based on the previously defined processes. The next step is dealing with the resource planning. In this step, the goal is the determination of the type and amount of the required resources with their specific characteristics. Resources contained within the process chain are: inventories, space, means of production, auxiliary of production, means of organization and personnel. The fifth step of the model is the layout planning that is built upon the previous planning results. The planning process of this level deals with the static planning of factory rather than dynamic planning. The last step of the iteration process is the planning of control rules. In this step, rules at five different levels are defined in order to control and manage the logistics systems.

4. Anticipatory change planning framework

4.1 Anticipatory system

Over the last decades, there has been a significant growth in interest in industry which seeks to foresee the possible future technology, development and market in order to be better prepared. A huge variety of techniques are applied to predict changes in future, ranging from forecasting to simulation, from planning to trend extrapolation, from future studies and scenarios to anticipatory systems (Poli, 2010). Anticipatory management is a general concept that have been proposed in fields as different as physics, biology, sociology, economy, political science and business management. In this approach, all decisions are made based on the possible changes of both internal and external operational environment. In other words, anticipatory management refers an ability of a system to make decision based on future events and redirection of the system by influencing the environment (Allgood, 2000). Furthermore, the anticipatory system considers the possible future consequences of actions taken today under the dynamic conditions. In the following section, the proposed anticipatory change planning framework is introduced.

4.2 A simulation-based anticipatory change planning framework for intralogistics systems

An anticipatory framework/model to support the strategic decision making process of intralogistics systems is first introduced by Uygun and Wötzel (2009). They propose several phases to harmonize the requirements of logistics and to support the changeability of production system. This paper extends their work with the performance availability and the quantitative assessment based on the simulation. The proposed simulation-based anticipatory change planning for intralogistics systems in this paper follows the steps illustrated in Figure 4. These frameworks include the consideration of which parameters of a process chain element to adapt for flexibility and changeability (e.g. layout, personal, space or resource) and how to accommodate potential change (iterative planning steps). The sources of a change planning are the change of the system load, cost pressure and change of the service (Uygun & Wötzel, 2009). In this context, various dimensions of change are defined, such as product, quantity, time, quality and cost (Nyhuis & Wiendahl, 2009).
The proposed simulation-based anticipatory change planning for intralogistics systems in this paper follows the steps illustrated in Figure 4. These frameworks include the consideration of which parameters of a process chain element to adapt for flexibility and changeability (e.g. layout, personal, space or resource) and how to accommodate potential change (iterative planning steps). The sources of a change planning are the change of the system load, cost pressure and change of the service (Uygun & Wötzel, 2009).

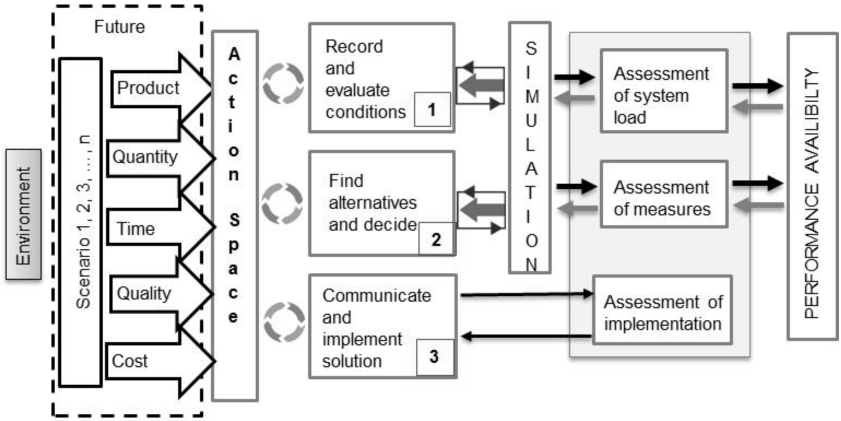

Fig. 4: Simulation-based anticipatory planning framework for intralogistics systems

In this context, various dimensions of change are defined, such as product, quantity, time, quality and cost (Nyhuis & Wiendahl, 2009).

The approach starts with the analysis of these change drivers based on the future scenarios within a company and the business environment. Afterwards, the future scenarios are transformed into the input data. By using different input-sets in the simulation model, it is possible to analyze a need for change in order to respond appropriately. Furthermore, this allows checking whether the flexibility corridor complies with the change drivers and the performance availability. If the flexibility of system is insufficient to deal with the change drivers, it has to be identified the required changeability in the second phase. In this phase, the changeability of the system and measures to adapt to the change are determined according to the process chain elements. The main steps of the second phase are illustrated in Figure 5. The final phase includes the identification of solutions based on the provided information from the simulation model.

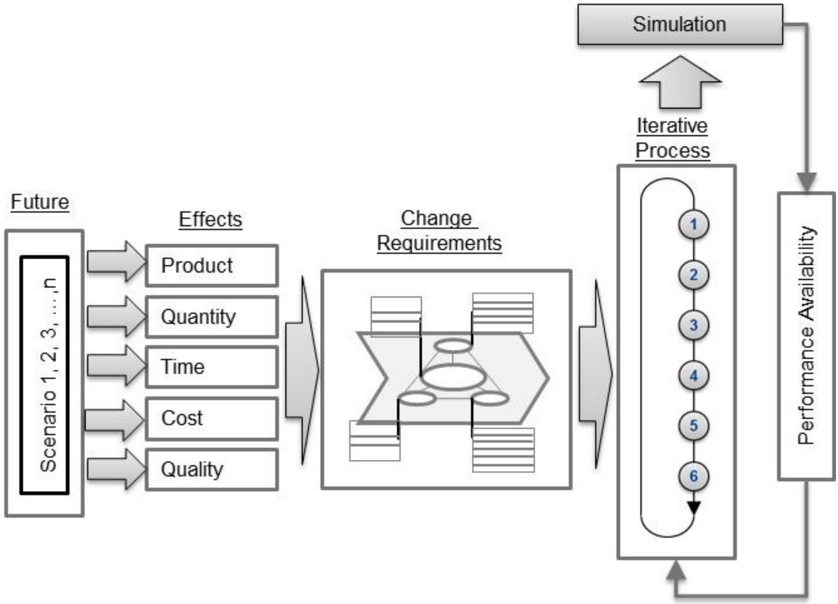

Fig. 5: Iterative planning process for the changeability of logistics systems based on process chain element

5. Case Study

The applicability of the framework was proved in a case study at an e-commerce small-sized distribution center which uses a new automated material handling technology called the Cellular Transport System (CTS). In e-commerce environment, there is always some time delay in demand fulfillment. According to Xu et al. (2009), reasons of this delay are some items not being in inventory, a picking backlog or queue of work at each warehouse and the priority rule to be picked and shipped first. Within e-commerce distribution, flexibility of intralogistics systems becomes more critical due to unpredictable demand characteristics of online orders in order to meet uncertain delivery requirements and customer expectations.

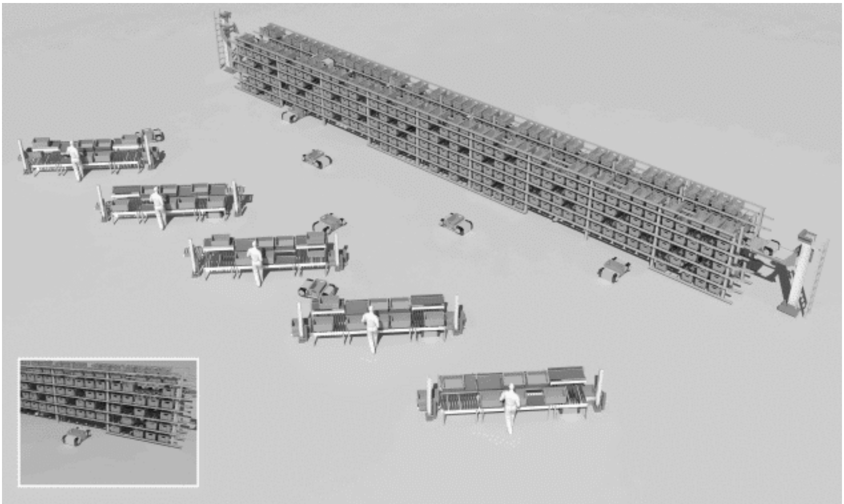

Fig. 6: The experimental area of Cellular Transport System with MSMs © Fraunhofer IML

The Cellular Transport System (CTS) is developed by Fraunhofer Institute for Material Flow and Logistics (IML). In order to cope with rigid design limitations, a group of dynamic, flexible mobile vehicles called The Multishuttle Move (MSM) are replaced with inflexible continuous conveyor systems. MSMs have open path navigation and enable adaptability during runtime of a system. The decentralized control of material flow is the essential characteristic of this new concept. The Multishuttle Move (MSM) is a novel fusion of conventional shuttle and automated guided vehicle system (Kamagaew et al., 2011). In this system, MSMs can move on rack levels as well as freely within the warehouse. In other words, all transports in the rack and the surrounding area will be covered with an autonomous vehicle swarm. This allows the Cellular Transport System to be easily expanded and to modify the system configuration depending upon the system requirements. Furthermore, the position of the picking stations can be freely adapted to the changing environmental conditions.

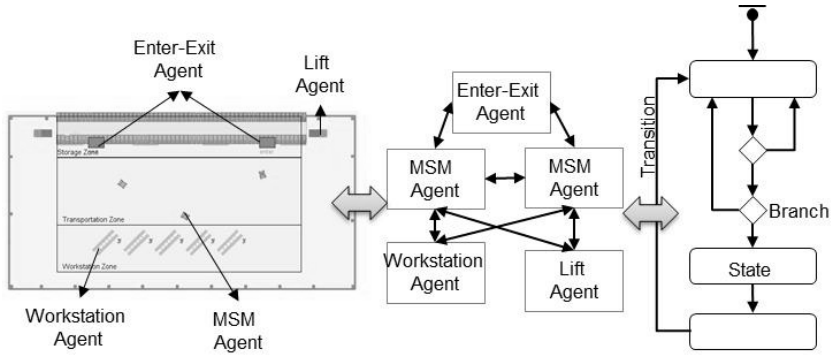

Fig. 7: Agent-based simulation of the Cellular Transport System

For a corresponding practice test, a trial hall for the application in smaller and medium-sized distribution centers was installed at Fraunhofer IML in 2011. The physical layout of the trial hall is 1000 m2 with length of 65 meter. The exemplary distribution center consists of a multishuttle shelving system with 5 tiers and specially developed pick stations. Figure 6 shows the physical elements of the Cellular Transport System. In order to manage the complexity of autonomous control of the Cellular Transport System, we have developed a simulation environment using agent-based modeling. The developed simulation model is composed of a set of agents that communicate to one another by asynchronous message passing. The different developed agents that are captured to model consist of MSM agents, Lift agents, Enter-Exit agents and Workstation agents (see Figure 7). We refer the reader to (Güller et al., 2013) for details of simulation model. The system is triggered by orders that enter the system at any time. An order is composed of order lines, where each order line consists of a particular item type. In other word, an order line represents a Stock Keeping Unit (SKU) type and the required amount of items for that SKU.

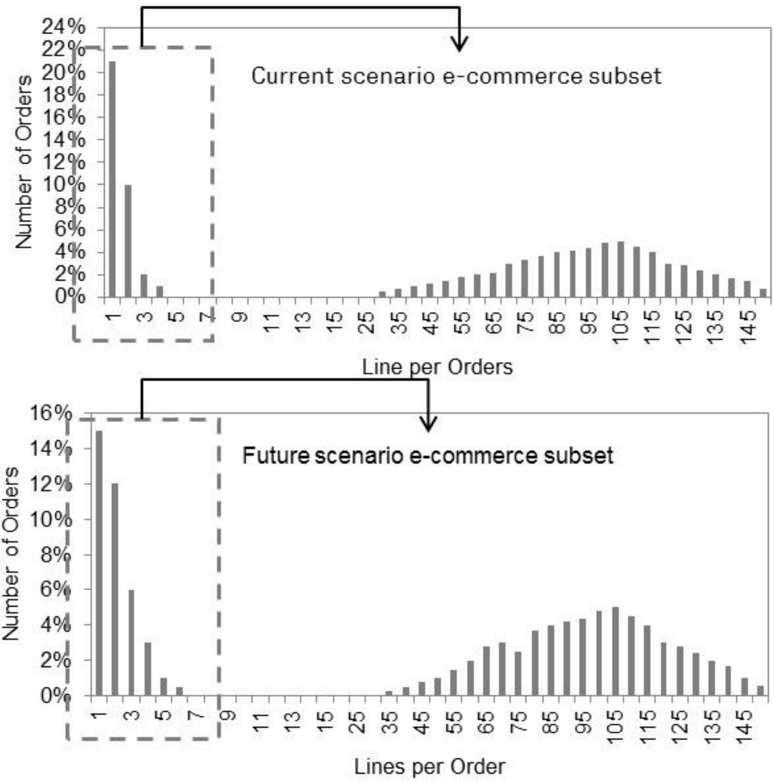

Fig. 8: Current and future scenarios for the distribution center

In e-commerce environment, there is always some time delay in demand fulfillment. According to Xu (2009) reasons of this delay are some items not being in inventory, a picking backlog or queue of work at each warehouse and the priority rule to be picked and shipped first. The other primary challenge that e-commerce distribution centers are facing is higher level of pick labor per item since each item involves a separate trip to the bin location, a separate pick transaction, and a separate trip to bring it back to the shipping area. In order to analyze to the contribution of our approach, it is essential to create appropriate scenarios. The definition of scenario covers both the description of current and a possible future situation. In the current scenario, 34% of total orders are online order. The proportion of orders with single line, two lines, three lines and four lines are 21%, 10%, 2% and 1% respectively. In the future scenario, 40% of total orders are online order. The proportion of orders with single line, two lines, three lines, four lines and five lines are 15%, 12%, 6% 3% and 1% respectively (see Figure 8).

The predicted changes affect the online sales volume and order line variety. In order to investigate the impact of change drivers on the performance availability and need for changeability in the system, the system load will first be analyzed by using simulation model. The target order throughput is 80 orders per one hour and the target maximum cycle time for an order is 360 seconds. The results for current and future system load are given in Table 1. As it can be seen in Table 1, the system is insufficient to deal with the future market condition. The next phase of the proposed anticipatory change planning framework is to determine the required changeability.

	Current	Future
Average cycle time (sec)	147	459
Minimum cycle time (sec)	64	71
Maximum cycle time (sec)	337	966
No. of Orders > 360 sec	0	61
Total time for 80 orders (sec)	4125	4607

Tab. 1: The analysis of current and future system load

As mentioned in the previous section, the changeability of the system is determined according to iterative planning steps for the planning of logistics systems. One of the changeability potential of the system described in the iterative process is the resource planning. At this step, the number of Multishuttle Move (MSM) in the system is increased. The effect of different number of MSMs on the system performance is illustrated at the following table.

	Future (5MSM)	Future (8MSM)	Future (10MSM)
Average (sec)	459	337	232
Minimum (sec)	71	86	65
Maximum (sec)	966	547	513
No. of Orders > 360	61	38	13
Total time (sec)	4607	4093	3898

Tab. 2: The effect of resource planning on the performance

The layout design of the warehouse has a significant impact on order-picking and traveling distances in the warehouse. In the next step of the iterative process, the layout planning will be analyzed. In particular, we are interested in the percentage of target throughput (80 orders per hour). We consider three configurations in order to assess the impact of different layout options on the system performance. We proposed a 60×10 (L) system for the single aisle configuration, a 30 × 10 (L/2) system for the two-aisle configuration, and a 60×10 system for the two-aisle configuration with the same length of the rack system (L). The results for different configuration are given in Table 3. As expected, the total number of throughputs increases from the one-aisle to the two-aisle case under the same storage capacity because of the reduction in the total travelling distance. As it can be observed, the maximum performance is reached after 10 MSMs at the two-aisle (L/2) system. When we compare the result of those scenarios, there is not a significant difference between the performance of one-aisle (L) and two-aisle (L) systems until 10 MSMs. After 10 MSMs in the system, the performance of rack configuration with two-aisle is better than a rack configuration with one-aisle.

MSMs	One Aisle (L)	Two Aisle (L/2)	Two Aisle (L)
6	71%	83%	70%
8	89%	98%	90%
10	93%	100%	95%
12	96%	100%	100%
14	100%	100%	100%

Tab. 3: Simulation results for the three configurations under study

6. Conclusion

The evolution in intralogistics systems put forward new challenging requirements. Today, flexibility, reconfigurability and high availability are important as well the level of automation, cost effectiveness, and maximum throughput. Due to dynamic changes and uncertain environment, such as order variations, product diversity, and load variations, intralogistics systems must be able to adapt to changing circumstances. However, the ability of a system to respond effectively an unpredictable event depends more on the decisions taken before the event than those taken during or after.

This paper describes a simulation-based anticipatory change planning approach for intralogistics system in order to cope with turbulences and the unpredictability in a future state. Simulation models offer an environment to test and quantify the alternative strategies as well as the analysis of performance availability in terms of the degree of fulfillment of customer requirements. Furthermore, a key element of this approach is the process chain model with iterative steps for the planning of logistics systems. The proposed approach is tested on a new intralogistic technology called the Cellular Transport System. Based on the provided information from the simulation model, the action plan including the identification of solutions is decided. Under given scenario, depending on the required performance availability, the number of the Multishuttle Move in the system is varied as well as the configuration of the rack system is changed. Further research might investigate how a controlling tool can be developed that combines the flexibility corridors of different performance dimensions.

Acknowledgment

The paper is based on the research results from the project "Paketantrag 672 Logistics on Demand- Subproject C4 – Simulation-based Anticipatory Change Planning of Intralogistics Systems" funded by the German Research Foundation (Deutsche Forschungsgemeinschaft, DFG).

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II.
Supply Chain Security Management

A Business Perspective

Supply Chain Security Measures - The Business Perspective

Magdalena Jażdżewska-Gutta

Abstract

Since 2001, supply chain security has become a vital issue for governments, international organizations, many business entities and scientific research. The governments and international organizations have introduced many regulations in order to make the trade flows more visible and protect them from unauthorized access. However, from the point of view of business sector, these regulations have sometimes a negative impact on supply chain activities. What is more, they are aimed mainly at protection from terrorism and smuggling of weapons of mass destruction, while the companies need protection in different areas, such as thefts in transit.

The aim of the study is to investigate the perceptions of managers on supply chain security threats and regulations, and to analyze the activities of the companies in the area of supply chain security management. The research is based on a survey conducted among 1200 exporters and importers from Germany and Poland. The survey reveals rather low awareness of security issues and that not many companies apply supply chain security measures. If they do, this is usually determined by customers and industry factors. They employ mainly reactive measures, such as buying insurance. Not many companies are interested in security certification. There are however some differences in the perceptions of German and Polish managers. The paper analyses these differences and proposes some measures that could be applied in order to protect the supply chains.

Keywords: transport chain security, supply chain security, supply chain security management, supply chain regulations

1. Introduction

Supply chain security in its present form emerged as a business, research and administrative issue after the terrorist attacks on September 11, 2001. The disruptions caused by such reactions as the post-attack closure of seaports and airports, affected a number of companies and their supply chains. The deliveries of many goods were delayed or cancelled, causing losses to business and the economy. Moreover, it occurred that the means of transport and entire transport network can be used by unauthorized persons for terrorist activity and smuggling of weapons of mass destruction. These events led policymakers from nation-states and international organizations to implement security policies for supply chains. They resulted in a number of regulations and security initiatives that are applicable to many supply chains around the world. These regulations are focused mainly on reducing the possibility of a terrorist attack through preventing unauthorized access to transport vehicles, containers and terminals, and through improving the supply chain visibility (Gould et al., 2010).

It was obvious that also business sector should be concerned about security issues. Many authors underline that recent global developments revealed the importance of supply chain security for all the supply chains and companies involved (Williams et al., 2009; Hintsa et al., 2009). European Commission recommended that security measures should be included by private industries in their daily operations (Commission of the European Communities, 2006). Hintsa and Hameri also point out that companies must also comply with the security regulations, which results in the changes of their organizational settings (Hintsa and Hameri, 2009). In order to secure their supply chains and to comply to the requirements of security regulations, the companies need to adopt specific security measures. However, the managers aware of the costs these measures involve, very often abstain from dedicating special resources to supply chain security (Williams et al. 2008).

The aim of the study is to investigate the perceptions of managers on supply chain security threats and regulations, and to analyze the activities of the companies in the area of supply chain security management. While there are a lot of studies on customs and maritime transport, and relatively little attention is paid to the companies trading with the goods, the main focus of this study is on the exporters and importers. The first section of the paper explains the motivation of the research. The second section contains literature review on supply chain security measures applied by companies. The next section presents the methodology of the research and empirical findings. The analysis is based on a survey conducted among representatives of 1200 exporters and importers from Poland and Germany. The surveyed companies are present in international and global supply chains. They represent countries which play a vital role in the transport and logistics map of Europe. For those reasons, the survey provides a good overview of supply chain security issues in the European background and allows to analyze how the exporters and importers perceive the identified imperfections. The last section comprises discussion, recommendations for the companies and conclusions.

2. Literature review

This section contains review of literature on supply chain security, risk and security measures. By integrating these areas it sets background for further empirical analysis.

2.1 Supply chain security and risk

Supply chain security can be defined as a “general system property characterizing uninterrupted performance of a supply chain functioning to achieve its goals under protection against external purposeful threats” (Ivanov and Sokolov, 2010). To achieve that state of uninterrupted performance, the companies and other entities must implement sets of security measures that are described as supply chain security management (SCSM). Closs and McGarrel provided also the definition of supply SCSM:

"Supply chain security management is the application of policies, procedures, and technology to protect supply chain assets (product, facilities, equipment, information, and personnel) from theft, damage, or terrorism, and to prevent the introduction of unauthorized contraband, people, or weapons of mass destruction into the supply chain." (Closs and McGarrel, 2004).

It is important to mention, that the above definitions cover man-made threats and exclude natural disasters and other typical supply chain risks, which were listed by Mason-Jones and Towill: demand and supply side risks, manufacturing process risks and control system risks (Mason-Jones and Towill, 1998). These risks are a part of supply chain risk management (SCRM) and SCSM is considered to be a part of this concept (Markmann et al., 2013; Williams et al., 2008). Supply chain risk management is defined as:

"a collaborative and structured approach to risk management, embedded in the planning and control processes of the supply chain, to handle risks that might adversely affect the achievement of supply chain goals." (Pfohl et al., 2010).

Thus, the analysis of security threats to the supply chain involves risk analysis. Risk should be considered in terms of probability and severity or business consequences of the event (Brindley, 2004). The basic tool for such an analysis is the risk matrix, which can be also used for classifying security measures (Knemeyer et al., 2009). The risk matrix has two dimensions – disruption probability and consequences (business impact) which divide the risk into at least four sections. This analysis concentrates on the two sections that contain the most common security threats to the supply chains.

The section of high-probability/low-impact risk represents events that are a part of every-day functioning of the company or supply chain (Sheffi, 2007). These are mainly operational risks, such as pilferage, thefts in transit, even attacks on drivers, takeover of the cargo by false carriers, fraud. Such events, as those mentioned above, are usually taken into consideration by the managers when developing security plans or risk management strategies. These risks are usually subject to insurance since they are quite common in business practice and easy to quantify.

The second group of risks covers catastrophic events that are characterized by low probability and high possible impact, such as terrorist attacks, organized crime, contraband of weapons of mass destruction and some others outside the scope of supply chain security – such as natural disasters. Such events can cause serious damage and negatively affect the functioning of supply chains.

The probability of such events is very low, for some firms the occurrence of such events is almost impossible. This is one of the reasons why companies usually ignore such risks, resign from developing and financing security plans and concentrate on the protection from low impact risks (Knemeyer et al., 2009).

Due to their properties, such events are also regarded as black swans (Aggarwal and Bohinc, 2012). Black swan events are unexpected, difficult to forecast and exert a significant impact on the supply chain and its surroundings (Taleb, 2007). The consequences of such event can be disastrous. The terrorist attacks on 9/11 are considered to be a black swan event.

2.2 Corporate vs. supply chain security

It is important to add that estimating the risks to the supply chain is different from making the same estimates on corporate level. While corporate security is focused on risk strategies to protect an organization from security threats (Arway, 2013), supply chain security focuses more on the flows and the outside of the company. This should involve security risk assessment of the suppliers, providers and contractors along entire supply chain. The risks are therefore not limited to the company itself and should be aggregated, taking into account all links. Given the above, the results of possible events may be greater than one can realize. The company that wants to minimize risks to the supply chain should get a closer look on every link.

2.3 Motives for introducing supply chain security measures

Speier et al. named several factors that influence the redesign of supply chains In terms of supply chain security. These factors include the mindfulness of the executives, supply chain complexity and risk associated with the product (Speier et al., 2011).

Williams et al. named four primary areas that create pressure for introducing SCS strategies – government, customers, competitors and society. Their research revealed that among these factors the government pressure affects the implementation of security measures the most (Williams et al., 2009). Pressure of governments is reflected in number of regulations, which can be mandatory or voluntary. The mandatory regulations require compliance from companies that want to participate in international supply chains. They are often seen as an obstacle to achieving higher efficiency and smooth functioning of supply chains. This is due to the fact that in many cases they raise cost and extend time of moving goods internationally. The voluntary programs often bring some benefits to the companies that decide to join them, and therefore can be regarded as facilitating tools rather than another obstacle.

The need for the cooperation between governments and companies was underlined by several authors (Sheffi, 2001; Rice and Caniato, 2003, Dulbecco and Laporte, 2005, Manuj and Mentzer, 2008). Ireland underlined also the important role of trust between customs authorities and trading companies for the sustainability of AEO Program (Ireland, 2011).

2.4 Proactive and reactive measures

In the area of SCSM there are two basic types of measures: proactive and reactive, which both have a significant meaning for the supply chain resiliency. Proactive measures include identification of threats, risk assessment, development of standard procedures and their implementation, as well as their evaluation and continuous improvement. They lead to minimizing disruption risk. Briano et al. underlined that the success of recovery after a catastrophic event happens, depends mostly on the actions that had been undertaken before the disaster occurred (Briano et al., 2009).

Reactive measures are the response to a disruption. Their effectiveness depends on the quality of introduced procedures, personnel actions that had been trained in drills and exercises, speed of eliminating the source of danger and its consequences. Insurance is an example of such reactive measures. Even if the insurance is bought before a disruption happens, its main goal is to minimize the loss and not to prevent the disruption.

The research by pwc (PWC, 2011) indicated that some managers discussed the importance and greater effectiveness of preventive over reactive security measures, while others suggested a balanced approach by combining both methods. This combination is the key to optimizing the costs and effects of security measures.

2.5 Costs and benefits of security measures

Introducing security measures by companies requires some expenditures to be incurred. These expenditures include expenses for physical security, technical equipment and its maintenance, additional personnel salaries, training, information processing and data analysis and communication (Allen, 2007).

However, security measures result not only in costs but also bring some benefits to the companies. Allen distinguished the following benefits of introducing security measures: lower exposure to losses resulting from WMD smuggling, terrorist activity, crime and fraud, higher reliability of entire supply chain and improved tracking of cargo (Allen, 2007).

3. Methodology

The data were collected from a questionnaire survey that took place between June and August 2013. The survey was conducted in the form of computer assisted telephone interview which allowed to achieve high response rates. On request the respondents were additionally given the link to the online survey in order to have a better insight into the survey. Interviewers responsible for the survey had been trained in the area of supply chain security in order to be able to explain more difficult questions to the respondents.

The questionnaire consisted of closed-ended questions with a given list of threats and measures. The answers to the questions were derived on the basis of previously conducted researches and literature. Such questions allowed better generalization of data, especially for such a big sample, and gave the respondents more ideas to choose from, in comparison to open-ended questions. In many questions, however, the respondents were also given the opportunity to add their own answers if they recognized the given examples insufficient. In most questions the respondents were to choose more than one answer. The questionnaire was prepared in two languages - Polish (for Polish respondents) and German (for German respondents), in order to avoid any misunderstandings resulting from language competences. The actual survey was proceeded by a pilot study that allowed to verify the survey questionnaire and eliminate the inefficiencies. Each interview took from 30-40 minutes depending on the interviewer.

The sample consisted of 600 companies from Poland and 600 companies from Germany. The companies chosen for the research were exporters and importers (within and outside the EU) of goods which places them as the links in international supply chains. The sample covered exporting companies (39,4% of the sample), importers (13,8%) and companies that both exported and imported goods (46,8%). All these companies were exporting or importing goods in such industries as food, wood, chemical, machinery, metal etc. Companies active in such fields as mining, building or services (apart from trade) were excluded as most of the questions in the survey related to physical movement of goods. The size of the companies was differentiated, from micro and small companies, that constituted 56,7% of the sample to big companies that represented 12,5% of all surveyed companies.

The respondents were either the owners of the companies (24,5% of respondents) or managers responsible for export, transport or logistics (27,9%), or employees responsible for export, transport or logistics (47,3%), depending on the structure of the company.

The countries were chosen for the research on the basis of their role in European transport sector. As most of the regulations come from the United States, the European perspective might throw a new light on this problem. Other criteria for choosing this country include relatively high importance of inland transport in both countries and relatively high importance of transport and logistics industry. Both Germany and Poland are transit countries which is an important feature concerning supply chain security. In terms of supply chain security, both countries hold relatively many AEO certificates, however there is a significant difference between them, as German companies hold more Certificates in the area of security, while Polish companies are mainly focused on gaining customs preferences, which might indicate that German companies are more aware of the security issues.

4. Results

4.1 Threats

In order to assess the perception of the managers on supply chain security threats, respondents were asked if the specific threat relates to their supply chain (table 1). Respondents could choose any threat they considered dangerous for their supply chains. Most companies indicated the following threats: thefts of cargo and vehicles in transit, thefts of goods in terminals and warehouses, overtaking the cargo by false carriers, breach of information security and counterfeit.

Threat	Germany				Poland			
	Mean	SD	Nr. of co.	Rank	Mean	SD	Nr. of co.	Rank
Pirate attack	2,50	1,732	4	1	3,11	1,423	27	3
Smuggling of WMD in the container where cargo was placed	2,43	1,813	7	2	2,90	1,611	29	8
Overtaking of cargo or vehicle for ransom	2,20	1,687	10	3	3,08	1,275	50	4
Thefts of goods in terminals and warehouses	2,20	,963	95	4	2,84	1,172	119	9
Terrorist attack	2,13	1,808	8	5	3,28	1,579	29	1
Breach of information security	2,06	1,111	47	6	3,23	1,389	57	2
Thefts of cargo or vehicles in transit	1,97	,900	86	7	2,91	1,037	168	7

Threat	Germany				Poland			
	Mean	SD	Nr. of co.	Rank	Mean	SD	Nr. of co.	Rank
Using the vehicle, where the co.'s cargo is placed, for smug. goods	1,90	1,221	21	8	2,83	1,372	47	10
Counterfeit	1,75	1,180	36	9	2,94	1,300	50	6
Overtaking of cargo by false carriers	1,52	,727	52	10	3,02	1,361	62	5

Tab.1: Respondents' perception of threats to the supply chains. Source of the figure: Own elaborations based on empirical research

Then the interviewees were asked to evaluate the chosen threats, using a scale from 1, which indicated very low danger to the supply chain, to 5, which indicated very high danger. Most of the threats were evaluated quite low in term of their severity to the supply chains. The highest ranking belongs to pirate attack (among German respondents) and terrorist attack (Polish respondents). However not many companies believe that these events might threat their supply chains. This might mean, that these threats are not taken into consideration by companies while preparing security plans. Following this assumption – not many companies might be willing to pay extra security fees to protect themselves from such disruptions.

4.2 Regulations

The research revealed that most companies do not consider these regulations as a burden. Only 10,2 % of Polish companies and 7% of German companies noted that the regulations are burdensome. Most of these companies mentioned bureaucracy as the main burden. Some companies mentioned also higher costs (more in Poland than in Germany), the necessity to provide too detailed information on the product, and extended time of delivery. One of the reasons for such low response in this matter is that exporters and importers usually use the services of freight forwarders and logistics operators for shipping cargo and often do not get a complete information on all the procedures and a detailed cost breakdown. Thus exporters and importers are not always aware of all security fees and documents that are required for transport process and may perceive security regulations as less burdensome than they actually are.

On the other hand, much more companies were affected by the security regulations (22,2 % of German and 26,8 of Polish companies), and, in most cases, the impact was negative. The most frequent responses included additional costs, longer delivery times, delays due to inspection of cargo and the need to employ additional persons to handle the security documentation.

Although security regulations are considered to have a rather negative impact on supply chains, there are also some benefits. However, most of the companies in the research did not mention any positive impact of security regulations on their supply chains. A few companies mentioned that with these security regulations the transport of cargo is more secure. This is done by reducing the risk of unexpected events that could cause serious damage or disrupt the functioning of supply chains. Thus, exporters and importers can benefit from the lower risk of major delay, damage to assets or loss of cargo.

4.3 Security measures

The respondents were asked if there were any specific internal security measures or security management system introduced in their companies. The answers are presented in table 2.

Less than 10 per cent of managers declared having a complex supply chain security management system. Almost 20 per cent of German companies and almost 30 per cent of Polish companies introduced single procedures. What is important, most of the managers claimed that their companies did not introduce any procedures at all. However, this might be caused by low level of knowledge on supply chain security as in the next question more companies declared having introduced some procedures in order to enhance the security of supply chains.

Has the company introduced any specific internal security measures or security management system?	Percentage of German respondents	Percentage of Polish respondents
Yes, we have introduced complex supply chain security management system	8,2	8,8
Yes, we have introduced single procedures or sets of security measures	19,5	29,2
No, we haven’t introduced any procedures	72,3	62,0

Tab. 2: Internal security procedures. Source of the figure: Own elaborations based on empirical research.

The respondents were also asked for the motives for introducing security measures (table 3). They could choose from a list of motives (more than one) or add their own answer.

The most important factors for both German and Polish companies were the requirements of public authorities and customers, and product and industry factors. Companies that represent strategically important industries, such as defense industry, or vulnerable industries such as pharmaceutical, are more dependent on industry factors than others. They are obliged to introduce specific security measures. Surprisingly, many managers, especially from Germany, mentioned that security measures are an element of company's general strategy or supply chain risk management strategy. On the other hand, the AEO certification, which might be expected to take a high position in the ranking, was evaluated as the least important motive. The survey reveals that European Union AEO certification program, is not of interest to the companies. Only 4,5 per cent of Polish respondents and 2,2 per cent of German respondents declared having AEO certificate. What is more, in most cases this was the Customs certificate (AEO-C), which does not directly cover the area of security.

Motives	Germany		Poland	
	% of respondents	Rank	% of respondents	Rank
As an element of our general strategy or supply chain risk management strategy	14,5	1	4,0	6
Product and industry factors	14,0	2	8,7	3
Requirements of public authorities	13,2	3	10,3	2
Due to customer requirements	13,0	4	15,5	1
Due to requirements of transport and logistics providers	11,3	5	2,3	7

Motives	Germany		Poland	
	% of respondents	Rank	% of respondents	Rank
Following competition or increasing competitive advantage	10,5	6	1,2	11
As an element of CSR strategy, for social benefits	8,3	8	4,2	4/5
Because not all areas of supply chain security are regulated	8,2	9/10	1,2	10
For benefits at customs clearance	6,0	11	2,0	9
For AEO certification	3,8	12	0,7	13
For reducing possible losses due to criminal activity	3,0	13	4,2	4/5

Tab. 3: Motives for introducing security measures. Source of the figure: Own elaborations based on empirical research.

4.4 Security measures

Knemeyer et al. described two fundamental features of security countermeasures: their impact on overall probability of catastrophic event and their impact on estimated loss that would be incurred from disruption (Knemeyer et al., 2009). The positive fact is that companies put more effort into implementing proactive measures that aim to minimize the probability of disruption, such as video monitoring, tracking of cargo, control of the carriers or subcontractors. However it is important to mention that many companies are not interested in any security measures. As a result they are more exposed to risk.

The survey reveals that there were significant differences between Polish and German companies in the area of security measures they implemented (table 4.). The interviewees could choose from the list of security measures (more than one answer could be chosen) or add their own answer. First of all, German respondents declared generally more security measures than Polish ones. German exporters and importers are more eager to incur high expenses for new technologies, such as video monitoring systems and using seals and intelligent containers. On the other hand, more Polish respondents declared buying insurance, which is only a reactive measure. Knemeyer claims that insurance as a reactive measure is used only for minimizing losses and does not influence the probability of a disruption (Knemeyer et al., 2009).

Personnel selection and training is another area where significant differences can be found. According to the survey, Polish managers attach less importance than German respondents to instructions and training for employees in the area of continuous monitoring of security, analysis of the profiles of candidates for work in terms of security, and unannounced drills and exercises. That area should be improved in both countries as the personnel is the key to supply chain security. Even the best technology does not provide the best security if there are no skilled people to make use of that. It is worth mentioning that the attitude of the personnel is the element of supply chain security culture and is vital for enhancing security (Williams et al., 2009 [2]). According to this philosophy, the supply chain security should become a priority for the employees. The survey shows however, that companies do not attach much importance to that issue.

The opinions gathered from the survey reveal also, that security measures are mainly focused on preventing the supply chains or single companies from high-probability, low-impact threats such as thefts. Other studies show, that in case of low-probability high-impact events companies usually decide to do nothing and accept the risk (Knemeyer et al., 2009, Chopra and Sodhi, 2004). Instead of concentrating on such risks, business attaches more attention to reducing costs and enhancing efficiency (Aggarwal and Bohinc, 2012).

Financing security measures is another important issue. Security can be financed by users, public or private sources (Dulbecco and Laporte, 2005). In case of security regulations, especially in sea transport, the most costs are incurred by transport companies which pass them to exporters and importers. Finally, this is usually the customer who pays for the security as the costs are hidden in the final price of the product. However, from the point of view of an exporter or importer, the security expenses in terms of compliance to regulations are costs that negatively influence the overall effectiveness of the supply chain and do not bring major benefits such as improving processes or creating efficiencies.

The survey reveals that this is the private sector who should take care of security, either on their own or with cooperation with governments or international organizations (table 5). The interviewees could choose from the list of entities (more than one answer could be chosen).

Supply chain security measure	% of German respondents	Rank for Germany	% of Polish respondents	Rank for Poland
Video monitoring systems	59,2	1	8,8	8
Seals and intelligent containers	50,2	2	20,5	2
Cargo insurance	35,7	3	71,3	1
Cargo tracking	30,7	4	20,0	3
Instructions and training for employees in the area of continuous monitoring of security	27,3	5	11,5	5

Supply chain security measure	% of German respondents	Rank for Germany	% of Polish respondents	Rank for Poland
Analysis of the profiles of candidates for work in terms of security	26,3	6	7,0	9
Control and risk analysis of suppliers	18,2	7	12,2	4
Permanent cooperation with suppliers and customers within the supply chain	15,3	8	11,3	6
Control and risk analysis of carriers, freight forwarders and other subcontractors	12,2	9	6,0	10
Guidelines for carriers on the use of guarded parking areas	10,2	10	9,2	7
Permanent cooperation with public entities for enhancing security	10,0	11	3,7	13
Protection of information and computer systems from unauthorized access	9,2	12	4,0	11
Direct control of loading cargo in order to avoid smuggling	8,7	13	5,7	12

Supply chain security measure	% of German respondents	Rank for Germany	% of Polish respondents	Rank for Poland
Complex risk identification and assessment in supply chain (security auditing)	5,8	14	2,7	14
Unannounced drills and exercises	5,2	15	1,5	15

Tab. 4: Security measures implemented by companies. Source of the figure: Own elaborations based on empirical research.

Who should take care of supply chain security?	% of German companies	% of Polish companies
Companies on their own	40,5	52,3
Companies in the cooperation with international organizations	31,6	19,3
Companies in the cooperation with governments	26,0	36,8
Countries and governments	13,8	14,2
International organizations	9,3	9,5

Tab. 5: Opinions on the entity which should be responsible for enhancing security. Source of the figure: Own elaborations based on empirical research.

The regulations do not protect the supply chains from every kind of threat and the companies need to act on their own. Fight with piracy is a good example of such activity. The governments send navy ships to protect commercial vessels from pirate attacks, however this is usually not enough and carriers hire private maritime security companies. The cost of protecting vessel is usually passed to exporters and importers by applying higher freight rates or special surcharges.

In order to enhance the effectiveness of security solutions and better protect the supply chains, companies need to build their own security plans and incorporate mandatory regulations into them. Companies should also manage the security across the supply chain, by tight control, especially in case of new business partners, and building long-term relationships and trust with other links in the supply chain. Another possibility is to join voluntary security programs. Such programs are also a cost for a company but are considered to bring also benefits, such as less controls at the border, gaining competitive advantage and improving the overall security.

5. Conclusions and recommendations

It became obvious that due to long-term trends of globalization, outsourcing and lean management strategies, the supply chains became more vulnerable to any disruptions. Due to the character of supply chains, the consequences of a disruption can be more serious than we expect, as the single threats to any company involved in the flow of goods sum up along the supply chain. It is thus important that companies attach enough importance to implementing supply chain security measures. However, the majority of surveyed exporters and importers underestimate the importance of supply chain security and many of them did not introduce any security measures. What is more, some respondents, especially from small companies, were not acquainted with the issue of supply chain security and did not know anything on certification programs such as AEO. This means that the customs authorities, international organizations and governments could put more effort into providing business with security information.

The surveyed companies concentrated mainly on high-probability, low-impact risks, while low-probability, high-impact risks are by them ignored or absorbed.

They try to implement proactive measures but also attach much importance to insurance which is a reactive security measure. There is a significant difference between the decisions of Polish companies on buying insurance and implementing other security measures. German respondents, in turn, attached greater importance to using technology such as video monitoring and intelligent seals and containers.

The analysis of motives behind the introduction of security measures reveals that respondents take into consideration mainly obligatory issues, such as pressure of public authorities and product and industry factors, and pressure of customers. The latter element is not strictly mandatory but every company that wants to sell its products must take into consideration the requests from its customers. It is however worth mentioning that for German respondents the main motive for introducing security measures was the fact that this is an element of their general strategy or supply chain security philosophy, however they constituted only 14,5 per cent of all surveyed companies.

Another fact worth mentioning is that respondents underestimate the importance of personnel in enhancing security. This is the area where the most effort should be put. As mentioned before, the awareness of security issues helps to create supply chain security culture. The organizational culture is a crucial success factor for introducing supply chain security culture (Williams et al., 2009 [2]). However many, especially small, companies are missing this element. Total Security Management is another philosophy that can be introduced for enhancing supply chain security (Ritter et al., 2007). It originates from Total Quality Management (TQM) and allows to achieve higher security at lower costs due to the fact that security is built in the processes (Lee and Whang, 2003).

It is also worth mentioning that security solutions are expensive. Applying the TSM approach allows to lower the overall costs but still some expenses need to be incurred. In this context, usually the biggest companies become beneficiaries of the introduced security measures. Small companies will decide to ignore the threats even if they are still exposed to the risks as the expenses for security would be too high.

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Finite-Time Horizon Logistics Decision Making Problems: Consideration of a Wider Set of Factors

Petros Boutselis and Ken McNaught

Abstract

The newsvendor's problem (NVP) formulation is applied to many logistics problems in which the principal decision is the level of inventory which should be ordered to meet stochastic demand during a finite time-horizon. This type of decision makes demand the central variable to be examined and since the time horizon is finite, there is variable risk throughout the period. While the NVP formulation is applicable to many areas (e.g. retail business, service booking, investment in health-insurance, humanitarian aid, defence inventory for operations), modelling and research into the factors affecting demand and its uncertainty has been conducted mainly where the goal is to increase demand (e.g. price, rebate, substitutability). This paper describes ongoing work on modelling demand within the NVP framework where little prior specific demand information exists and uncertainty plays a crucial role. The suggested approach is to model demand and its uncertainty using other causally related, case-specific factors by applying Bayesian inference. Initial work in progress on a case study is outlined. In future the approach will be tested in several case studies and will adopt the innovative approach of Sherbrooke (2004) and Cohen et al (1990) for its validation, through which the model's outputs along with the real life demand data are provided as inputs to a simulation and the results compared. Thus the simulation's final output is the evaluation measure. The future expected benefit from this work is to offer decision makers an intuitive demand modelling tool within an NVP framework where modelling uncertainty is of great importance and past demand data are scarce.

Keywords: newsvendor, bayesian, risk, validation

1. Introduction

The newsvendor problem (also commonly known as the newsboy or single period problem) is one of the classical problems in operations management and has been extensively studied since the pioneering effort of Edgeworth (1888). A recent review of the area is provided by Qin et al (2011). The main question that it seeks to answer is how much of one or more types of commodity a ”newsvendor” should order, as an effort to deal with some unknown/uncertain and in some cases even risky future demand, given that the time horizon that he/she expects demand for it is finite[6]. If the newsvendor orders too much, the left-over items are usually assumed to have low or even zero residual value, while if the newsvendor orders too little, there is an opportunity cost associated with lost sales. Even though its name seems to limit its applicability to the case of a professional newspaper salesman under the dilemma of how many papers to order for the following day, its area of application is much wider and the lost sales component may be replaced, for example, with a more general shortage penalty. A list of existing and possible future areas of application includes the following:

[6] This paper differentiates the use of the newsvendor’s type of problems from what Nahmias (1989, pp 233) suggests who expands its applications to incorporate infinite periods. The main decision making issue that arises when the time period is considered “finite” is not just that it is a one-off case. On the contrary, it can include more than one period in between. The suggested idea of “finite” is that it is not practically possible to use any of the leftover inventories for subsequent periods after the “finite” planning one. Regarding the intention for “no inventory left”, it includes the cases in which all leftover inventory can be used but for a less profitable gain than if it was actually used within the examined period. Even though, the same idea of the newsvendor’s finite-period planning could be applied in a repetitive, infinite notion known as “myopic policies” (see for example Powell (2010), the problems dealt with by the newsvendor’s formulation are different due to the fact that after the period of interest (which in certain cases can be of unknown length) the periods which follow cannot be used to make-up for opportunity costs by keeping some of the left-over inventory. The examples provided will make this notion clearer.

1 Seasonal / fashion goods
2 Advanced booking in services such as hotels, airplanes, etc. In such cases the commodity that is managed/ordered is the number of places in the airplane or in the hotel and the finite period is the duration of the flight or the hotel season.
3 Amount of insurance money to invest for health etc. In this case the uncertain demand concerns future health issues and the type of commodity to decide upon in advance is the amount of insurance money that has to be invested. This demand will be realized not within a repetitive, infinite manner. A point to stress in this example is that past data on the demand do exist but only for similar cases.
4 Selecting spare parts for a product at the end of its production life, i.e. before it becomes obsolete[7]. Here, the uncertain demand is the number of spare parts that have to be produced, not as was done in the past when the system that used them had a long operational life and thus inventory could be held to cover future demands and backorders could be issued for unfulfilled ones, but for a shorter, finite period since the production line will stop.
5 Deciding on the water reservoir level on an island that is isolated and waits for replenishment for the summer period. Obviously the commodity that has to be decided upon is the amount of water to be stored, given that it has a shelf-life shorter than the next examined period. The demand can be known with adequate precision from past / historical data, however, extreme weather forecasts or a new differentiation in the relative tank capacities could ask for a new formulation of how this demand could be realized.

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[7] As Khouja (1999) stresses "…, the reduction in product life cycles brought about by technological advances makes the SPP (Single-Period Problem ie the newsvendor's one) more relevant", and obsolescence costs and management is an issue of great importance to large organizations like the MOD.

6 Large military operations “Last Order”, i.e. how much to order when a decision to withdraw from an operation has been taken. In these cases decisions on ordering any amount of a certain commodity have to be taken wisely since whatever is transported out, unless used, will also have to be transported back.

7 Humanitarian aid in multiple places that have suffered disasters. As Chakravarty (2014) stresses, such cases include an increased risk since prior values of lead times and supply chain efficiency may have changed due to distractions to the supporting infrastructure. In his work Chakravarty (2014) studies scenarios that deal with limited resources and develops a model in which an initial capacity based on demand forecast is built and further capacity is added when additional information on demand is available. The suggestion in this case is that such efforts could benefit from an NVP formulation.

8 The load of a shipment within a supply chain. The amounts and mixtures of commodities loaded each time are usually not completely known in advance and have to be either consolidated in full loads and thus result in accumulating inventory costs and increased lead times for some of the items as they wait in the warehouses to be gathered, or depart in half-loads and thus increase transport costs. For some commodities it is space[8] allocation that has to be decided in advance before the commodities “arrive” and place a “demand” for some space. What has to be decided is how much space will be allocated and when for a finite period of time that the actual demand for that space will be realized.

9 The “hedge contracts” that energy providers use in order to insure against the risk of unknown demand.

[8] The commodities provide data which are prone to change in number and type, while space (or space per value to differentiate among commodities which will compete for the same space area) is a more generic variable.

2. Modelling demand in the newsvendor's problem

Demand is the main problem for the newsvendor. He/she has to predict or even affect its value in order to be able to optimize his/her set objectives.

2.1 The importance of modelling demand uncertainty

In the classical infinite-horizon inventory systems in which demand needs to be modelled like the continuous review, or the periodic review ones, the length of the risk period is more or less controllable by the manager. This risk period is considered as the period during which the decision maker wants the amount on hand and the amount ordered to be *enough*[9] so that the commodity does not run-out until the arrival of that next order. It is a period of risk because during that, any demand fluctuations cannot be faced immediately by a new arrival but by only just hoping that what is on hand and what is expected to arrive soon will be able to cope with these fluctuations. In inventory systems like the Continuous Review, or the Periodic Review, this risk period affects the inventory planning and the level of inventory kept has to be increased by a safety stock. This stock can be subsequently adjusted according to new different demand data or decisions on budget or service levels. Therefore, in these policies there is the opportunity to improve unsatisfactory performance by applying adjustments.

In the case of the newsvendor's problem, the whole period from the time that the order is placed until the time that the problem is over is a period of risk. Even when there are cases in which some small corrections[10] can be made on the way until the end of the examined period the same risks/dilemmas hold for the newsvendor: to order neither too little nor too much since in either case he/she

[9] This notion of "enough" is the one used to define *the service level* for the infinite inventory management systems. However, in newsvendor type problems it cannot be considered as such. This is because the actual idea of a safety stock is one of the things that the optimum newsvendor's solution wants to avoid, ie not to have left-overs.

[10] Even though the sequential filling of the inventory has many practical applications it is not a common research subject. For relative work and discussion see Murray and Silver (1966) and Khouja (1999).

will have unwanted opportunity costs. Furthermore, when the examined period is over there is no opportunity to make up for unsatisfactory performance. Consequently, in the newsvendor's settings demand uncertainty should be considered for the whole period of the problem[11].

As Porteus (2002) notices, what needs to be minimized is the combination of the holding and shortage costs, ie what will be provoked by the *variation of the demand* below or above its expected "deterministic" value.

2.2 Models of the newsvendor's demand problems

What has previously been shown is that at least within the newsvendor's problem setting, uncertainty plays a vital role and therefore should be considered within any relevant model. The demand models used in the literature mainly fall into 6 categories:

1. Those that use functions in order to investigate the dependency of the demand on other factors, mainly the price and thus see how these factors can be used so that they can drive demand.
2. Those that model demand by considering scenarios of possible values but without considering any probability distribution for these values.
3. Those that model demand using certain probability distributions and calculate their respective parameters from past demand data or from Subject Matter Experts (SMEs).
4. Those that model demand using certain probability distributions and calculate their respective parameters using Bayesian inference from "fresh" data.
5. Those that model the values of demand using uncertainty theory.
6. Those that model the values of demand using fuzzy logic.

[11] For another comprehensive discussion on misleading managerial results/decisions when not incorporating uncertainty in the demand see Shih (1979, p. 688).

2.2.1 Using functions to model demand

Functions have been used to model and investigate the dependency of demand on other variables, mainly the price. Within a functional form, the uncertainty has been considered in the literature in either an "additive", "multiplicative", or "additive-multiplicative" modelling approach[12]:

a. (Polatoglu 1991) and (Qin, et al. 2011)refer to the previous work of (Mills 1959) who expresses demand D(p,ε) by taking the sum of the expected demand as a function of the price d(p), plus a random variable ε which is independent, and has a zero expected value: $D(p,\varepsilon) = d(p) + \varepsilon$. The name convention used for this type of model is the *additive model*. However, as Polatoglu (1991) reasonably argues, in that way there is a strong assumption that the variance of the demand is constant and independent of the price. This is not always correct of course. It is reasonable that there were will be cases in which comparatively very low prices will have a different effect not only in the expected demand but also on its variance. Additionally, Polatoglu (1991) and Zabel (1970) emphasize the fact that the use of a function which relates demand to the expected price via a linear function with a negative coefficient, allows for negative values of the demand unless there is a further assumption on a lower limit to the values of the prices. On the same issue Zabel (1970) further emphasises the need to make sure that the probability of getting negative values due to the additive density function is set to zero.
b. A similar type of treatment of the demand is obtained by representing it with a *multiplicative model* (Qin et al. 2011; Chen, Yan and Yao 2004; Zabel 1970). The structural difference between this and the additive one

[12] Huang, Leng and Parlar (2013) have created a very comprehensive table for the used functional forms (Table 1) in which they include the Linear, Power, Hybrid, Exponential, Logarithmic and Logit deterministic demand functions. Furthermore, in their (Table 2) they have also included a list of the stochastic equivalent functions which are frequently applied in the newsvendor types of problem setting.

is that the random factor is now multiplied by the function of the expected price $D(p, \varepsilon) = d(p)\varepsilon$. The random variable is again independent of the price but is now multiplied by the main part and has a mean of 1. However, as is again reasonably stressed by Polatoglu (1991), in this way the variance of the demand is dependent on the square of the product of the random term and the expected value of the price and as a result as prices keep on rising, the variance decreases at a much faster rate.

c. A combined additive-multiplicative model incorporates both notions in a function which has the form of $D(p) = d(p, Z) = \alpha(p)Z + \beta(p)$, (Young, 1978). In this generic form p is the price and Z is a random variable with price independent cdf, $\alpha(p)$ and $\beta(p)$ are decreasing functions of the price. Therefore, the additive model can be obtained by setting $\alpha(p) \equiv 1$, so the prices affect only $\beta(p)$, ie the location of the demand distribution, while the multiplicative model can be obtained by setting $\beta(p) \equiv 0$, which means that the prices influence the demand scale. However, as Kocabiyikoglu and Popescu (2011) point out, even in this general formation the additive-multiplicative models make restrictive assumptions that drive the newsvendor's problem results, such as a monotonic relationship between price and demand variability, while empirical studies show that such relationships may not hold and thus the theoretically formed functions often have a poor performance.

The above counter-intuitive elements in the modelling approaches to uncertain demand give further ground to criticism when they are examined and evaluated in the same problem areas. In a number of papers there has been consideration of:

- The newsvendor's selling price (for example Qin et al., 2011; Arcelus, Kumar and Srinivasan, 2005; Petruzzi and Dada, 1999; Polatoglu, 1991),
- The portion of the "supplier's price discount" to be passed from the newsvendor to the end customer (for example Qin et al., 2011; Petruzzi and Dada, 1999).

The suggested decisions relative to a deterministic model differ when the demand uncertainty is represented within an additive and within a multiplicative model.

In order to deal with these ambiguities Kocabiyikoglu and Popescu (2011) introduced a unified framework. Their model has the general form of $D(p) = d(p, Z)$, with p again being the price and Z a random variable with price independent cdf, which makes no assumptions regarding the effect of price on the variability of demand and furthermore can incorporate other functional forms of the relationship between demand and price, apart from the additive, multiplicative and additive-multiplicative ones, such as the attraction models (eg power, logit), willingness-to-pay (WTP), etc. Furthermore, they introduce another concept, the Lost Sales Rate (LSR) with which they try to capture a framework in which the study of decisions on price and inventory level can take place when the demand uncertainty has to be taken into consideration. They define LSR to be the complement of the demand CDF (and therefore the probability of lost sales). Additionally, LSR elasticity is defined with the use of both price and inventory level and thus, for a given quantity, it combines the sensitivity of lost sales given its building factors of inventory and price. Therefore, their significant contribution with regards to the problems previously mentioned is that they identify which combinations of price and inventory level lead to LSR elasticity being monotone.

However, questions on the root causes of the differences in the results originating from the different treatment of the demand uncertainty, ie through additive, multiplicative and additive-multiplicative functions remain, and the reasonable arguments of Polatoglu (1991), Zabel (1970), Kocabiyikoglu and Popescu (2011) and other authors have not been adequately addressed, apart from stating that there should be specific restrictive assumptions applied in each case.

2.2.2 Using scenarios to model demand

In these cases demand is represented by considering scenarios with different possible values but without assigning any probability distributions.

This approach has been developed by Vairaktarakis (2000). He argues that reasonable probability distributions of demand can be almost impossible to determine in cases when the decision situation is unique and there is little or no historical data. Furthermore, he stresses that when probability distributions are used, the problem can become too difficult to solve and the assumptions that are then introduced to make it tractable can turn it into a “mediocre representation of reality”.

Vairaktarakis’s (2000) suggested approach to modeling uncertainty is through the different possible scenarios/values that the demand can take and then applying robust decision theory criteria to assist the decision maker. If demand is continuous then a range of values can be used instead. He then solves a constrained optimization problem to suggest the optimum order level.

One of the assumptions considered in this case is that possible demand values for each item are defined based on the understanding of the manager on “the sources that affect uncertainty (such as market and competitive environment)” (Vairaktarakis, 2000, p. 214). The author thus implicitly states that the elicited scenarios/values of demand will be considered and used under the assumption of different values of factors which have an effect on demand. However, as the functional models have shown, the mean demand can take different values according to the relevant factors which sometimes can vary a lot. Furthermore, the number of different factors to be considered can possibly make the elicitation of demand values a difficult task for the manager.

On the same issue Vairaktarakis (2000, p. 215) suggests that the values for the demand should only contain likely realizations unless the decision maker wants to hedge the operational risk against some extremely unlikely scenarios. This assumption is inherent to this applied modelling approach since it does not imply any different weight/probability to the different possible scenarios/values and thus it would consider an equal weight to very unlikely scenarios/values. However, in cases where there is little prior experience, the decision maker may be reluctant to define which of the different values/scenarios are very unlikely.

At another point the author states: “stocking decisions for subsequent periods are independent of decisions made in previous periods” (Vairaktarakis, 2000 p 215). This assumption is not always realistic. Prior stocking decisions affect demand and obviously posterior stocking decisions as well, and have been studied extensively (Huang, Leng and Parlar, 2013). Furthermore, this assumption reduces the valuable opportunity offered to the decision maker to learn from past experience and it is not the way that people tend to work in practice (Cyert, DeGroot and Holt, 1978; Harpaz, Lee and Winkler, 1982).

2.2.3 Using probability distributions to model demand

In these cases demand is modeled by the use of certain probability distributions, with parameters estimated from past demand data.

Extensive work has been done by Braden and Freimer (1991) who have worked on providing a selection of demand distributions for the newsvendor models. Their work is developed under the realization that the demand may not be perfectly known from the sales that follow. This is because sales can be a mixture of exact and left-censored observations of demand. The term “left-censored” is used to show that since there will be cases in which customers do not find the product because all of the previously ordered quantity has been sold-out and therefore the newsvendor’s estimate of the demand is that it is at least as much as his initial order. Braden and Freimer (1991) have shown that the exponential family of distributions is applicable to such type of mixed observations.

As was mentioned earlier and pointed out by Vairaktarakis (2000), this approach can suffer from difficulty due to the sometimes complicated demand probability functions, while it is quite difficult to elicit probabilities when there is little past data and experience. Regarding the latter, an additional drawback of the approach is that it does not use data from other factors that have a causal relationship with the demand and may be easier to obtain. Such factors could be like the ones implied by Vairaktarakis (2000) who asked the experts to conceptually consider drivers affecting demand uncertainty related to the market and competition, an approach which on the other hand is used in the functional models.

2.2.4 Using probability distributions to model demand and Bayesian Inference to refine the probability parameters

Here, demand is modelled again by the use of certain probability distributions; however, their parameters θ_i follow prior distributions which are updated to posterior distributions using Bayesian inference from "fresh" data. The chosen probability families can include those suggested by Braden and Freimer (1991), while the initial parameters can be obtained from approaches like:

- Reliability analysis as suggested by Petrovic, Senborn and Vujosevic (1988),
- "Objective Bayes" suggested and practically tested by Sherbrooke (2004)[13]
- "Empirical Bayes" implemented by Scarf (1959) and Robbins (1964)

One of the early, very important works in this area was that of Murray and Silver (1966) who examined the optimum sequential production of fashion goods with the demand being unknown but updated by the use of Bayesian inference over time. A different application was developed by Cyert, DeGroot and Holt (1978) who studied an approach to reducing risk in investments. Their suggestion was to find how decision makers could make sequential investments that could gather information useful for subsequent decisions. The information they were looking

[13] It should be noticed that Petrovic, Senborn and Vujosevic (1988) and Sherbrooke (2004) refer to low demand and high unit price items and even though the suggested policies are for the infinite-time horizon problems this does not differentiate the suggested approach to the modelling of demand.

to obtain was the profit gained (or lost) and thus their respective prior probability distribution could be refined into a better informed posterior by the use of Bayesian Inference. Their work was continued by Harpaz, Lee and Winkler (1982) who again used Bayesian inference to model a perfectly competitive firm's learning from experience and thus reducing its uncertainty on demand.

The attractiveness of learning in facilitating decision making prompted several other researchers to work on this idea. Azoury (1985) used two finite horizon inventory models, one for consumable and one for reparable items and showed that solving the Bayesian problem by applying dynamic modelling, under certain conditions is no harder than if the distribution parameters were known. Eppen and IYer (1997) applied the same modelling approach for fashionable goods in order not only to optimize the amount of order but also to suggest how much to divert to the owned outlet stores. Their model is developed by the use of historical data and buyer judgement and is solved through stochastic dynamic programming. Furthermore, Berk, Gurler and Levine (2007) show that a two-moment Bayesian modelling of demand parameters distribution works adequately both in theoretical and operational applications.

However, the same issues apply as the ones referred to in the last category.

2.2.5 Using uncertainty theory to model demand

The users of this approach argue that when there are not enough sample data only the experts' belief degree of the underlying distribution can be used, and within that there can be considerable bias. In order to deal with experts' belief degree in modelling demand uncertainty Ding and Gao (2014) adopt and apply the Uncertainty Theory developed by Liu(2007)[14].

[14] This theory was further expanded by Liu (2009)

2.2.6 Using fuzzy logic to model demand

In this case uncertainty is modelled by considering demand values as fuzzy variables. One of the works in this area was that of Ji and Shao (2006) whose main goal was to model the combined decision making of the manufacturer and the retailers and apply a hybrid optimization based on fuzzy simulation along with a genetic algorithm to optimize the expected profit.

2.3 Factors that affect demand and have been used to model it

This paper has found great value in the seminal work of Huang, Leng and Parlar (2013) who have thoroughly examined not only the functions but also the factors that have been used in order to model demand and not only for the newsvendor's problem formulation, and in the work of Khouja (1999) who has introduced a similar taxonomy specifically for the newsvendor's problem. The factors examined are:

1. Prices set either by the newsvendor or his/her supplier
2. Rebate
3. Lead-time that affects the customer's level of satisfaction
4. Space presented to the customer, thus affecting his perception of product availability
5. Quality
6. Advertising

One point worth noticing is that the literature's orientation has mainly been on examining demand's dependency on factors which can increase it. This obviously is true if the newsvendor is a retailer or manufacturer and primarily wants to optimize monetary objectives. However, there are cases when it would be preferable if the demand is the smallest possible. A number of factors that are relevant in such cases could include:

1. In the case of deciding how much money to invest in an individual's health, the quality of the state's health care programs

2 In the case of deciding on the final quantity of military supplies to deliver before a withdrawal, the level of enemy military presence in an area

3 The weather forecast in problems where water has to be provided to an isolated place

3. The application of Bayesian Networks to newsvendor problems

An important point regarding demand distributions has been raised by Sherbrooke (2004) in which he observes that the mean demand is "drifting" with time. The factors in each case that cause/impose this drift[15] can be analysed through engineering breakdown approaches using Subject Matter Experts' (SME) opinions. Consequently, there is an inherent gap in the approaches that use just probability distributions (3rd modelling approach) since they define them by the use of past data only. The same issue seems to exist in the use of uncertainty theory and fuzzy logic (5th and 6th modelling approaches). Vairaktarakis (2000) in his use of scenarios in the 2nd modelling approach asks the SMEs to consider the factors that define the values which demand can take but fails to account for the relative strengths of their effects and also prompts them to exclude very rare values of demand unless they want to hedge for them. On the other hand, Bayesian inference models (4th modelling approach) consider this drift effect but need fresh data on demand itself to do that, something that is rarely available in many of the newsvendor-type problems. Of all the previously discussed modelling approaches, only the functional ones take into consideration the main factors that define the context within which demand is considered. However, they also fail to adequately model the uncertainty and its effect on decision making which is of vital importance to newsvendor-type decisions. Furthermore, in order to work they need sufficient data which is

[15] E.g. the wear-out of the system, different environmental conditions, change in the system's use rate

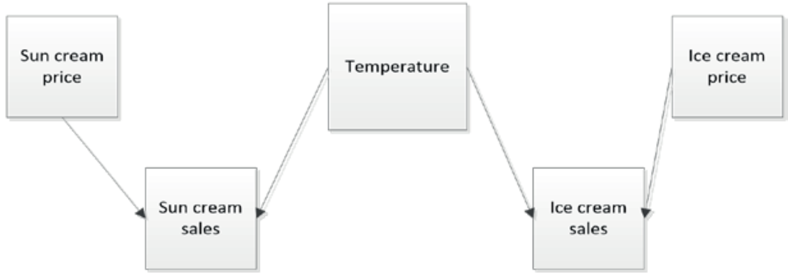
available mainly in market related applications but not in other areas within the newsvendor spectrum of problems.

What is suggested is to combine the consideration of demand uncertainty and the demand-defining context formed by causal factors, which are likely to take uncertain values as well. A natural way of doing this is to form a joint probability distribution of all the relevant variables. The modern probabilistic framework of Bayesian Networks (BNs) provides an efficient way of representing, building and manipulating such a distribution in order to perform inference of various types. Furthermore, based on our literature search, we believe that its application to newsvendor type problems is novel.

3.1 Requirements of a BN formulation

A BN (Pearl, 1998) is a directed acyclic graph (DAG) in which the nodes correspond to variables of interest in the modelled domain and arcs correspond to direct probabilistic dependencies. Absence of an arc between two nodes does not necessarily imply that they are completely independent but that dependence might be mediated by another variable, for example. It does imply that they are at least conditionally independent under some conditions. For example, a simple BN containing the five variables ‘daily ice cream sales’, ‘ice cream price’ ‘temperature’, ‘daily sun cream sales’ and ‘sun cream price’ is shown in Fig 1. Although the two sales variables are probabilistically dependent, there is no arc drawn between them since their dependence is a result of their common-cause parent variable, ‘temperature’ which does have a direct probabilistic dependence with each of them. We say that ‘ice cream sales’ and ‘sun cream sales’ are conditionally independent given temperature. In fact, the arcs from temperature to sales represent causal links but arcs in a BN do not have to be causal in general.

Fig. 1: Example of a simple Bayesian Network



The DAG for a BN, describing its qualitative structure and conditional independence assumptions, is most often elicited from a domain expert. Each node is also given a state space, which is often discrete for computational convenience. Truly continuous variables can be handled in various ways but are most often simply discretized. In order to operationalize the BN for quantitative modelling, however, we also need to assign marginal probability distributions to nodes which have no parents and conditional probability distributions to nodes which have parents. It is necessary to have a conditional distribution for every combination of a node's parent states. In some cases, functional relationships can be employed which eases this burden but in others we need to extract the various distributions one by one, making use of any existing past data and making up for gaps and deficiencies in that data through a process of elicitation with the relevant domain experts.

3.2 An example BN of a newsvendor type problem

Considering the case referred to in the introduction as military operations' "Last Order", suppose that the demand for a certain support item is expected to be directly affected by the following variables:

- "Equipment usage"
- "Operating hours"
- "Equipment losses"

In addition other variables will have an indirect effect and be included in the BN to make the model more complete and the probability distributions easier to specify and obtain from either data or SMEs.

It is obvious that the different values of these variables form different contexts within which demand can again take different distributions of values. Combining the likely demand distributions conditioned on the influencing variables with the prior distributions of the influencing variables themselves provides a coherent approach to modelling the demand. It also allows for the inclusion of related forecast variables in a straightforward fashion, e.g. relevant environmental forecasts such as temperature. The distinction between the forecast temperature which is known and the actual realised temperature which will be unknown when the order is placed is important in this type of model. As well as allowing the demand distribution to be updated when a new forecast is made, questions about the value of buying improved forecast information can also be addressed.

Based on the above example, a BN model could have the form shown in Fig 2. Since this paper is reporting on work in progress, our next task is to quantify this model by obtaining the required probability distributions which its structure suggests. For a specific equipment or commodity this will involve a combination of historical data analysis and elicitation from SMEs.

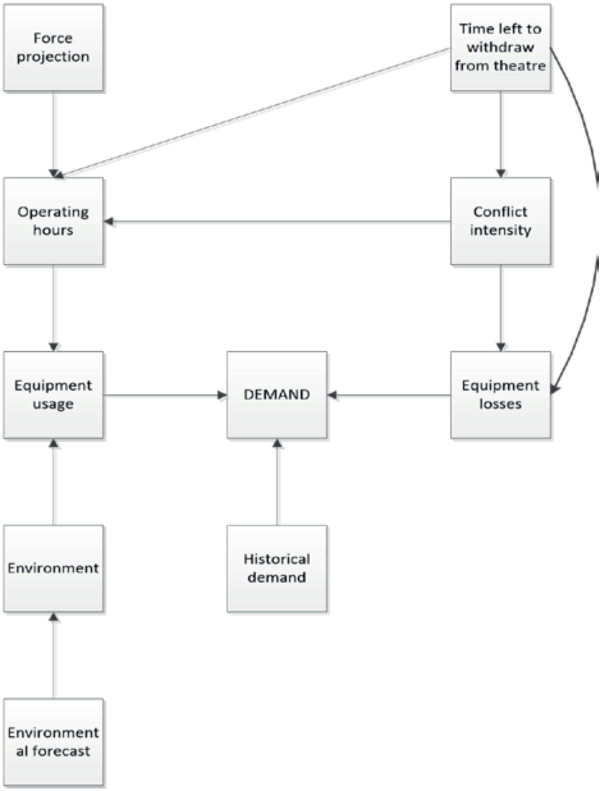


Fig. 2: Example of a Bayesian Network used to estimate demand and thus facilitate decision making in a military operations “Last Order” newsvendor-type problem

4. Approach to validation

An additional area of research that builds upon the results of demand prediction is the one documented by Ward, Chapman and Klein (1991) and further discussed in the seminal work of Khouja (1999). In both, the need is stressed to validate the different modelling results through practical studies. This need still exists as Huang, Leng and Parlar (2013) verify. Furthermore, Huang, Leng and

Parlar through their review on empirical studies they suggest the following measures of goodness of fit:

- The Standard Error of Estimate (SEE)
- The log-likelihood statistic
- Nonlinear Least Squares (NLS) with adjusted R2

However, these are still not what is implied by Khouja[16] since these measures are not intuitive to managers, and cannot be practically assessed.

A more practical and intuitive approach for managers is suggested and has been successfully applied by Sherbrooke (2004) and Cohen et al (1990). Through this approach future demand is initially estimated using a candidate demand model. The predictions are used in the inventory system to calculate the suggested level of spares. Then the actual demand which is known from past data (kept for the validation of the models) is used to calculate the attained availability through simulation. The best demand model is the one which gives the optimum measure of system performance when real data are used, thus, the measure of goodness of fit relates to the manager's objective itself. Furthermore, Sherbrooke (2004) also used as a complementary measure the estimated availability that the spares calculation model gave and then compared it to the "true"/attained availability to see if it was an optimistic estimate or not. Therefore, following this suggestion the following two measures of goodness of fit are suggested for research on practical cases:

1 The actual result that would be attained using the suggested method of modelling the demand within the context of each specific application of the model[17].

[16] Khouja (1999, p. 550) refers to the issue by saying: "Without some empirical work examining real life objectives of managers and the availability of information about demand, the practicality of these models cannot be assessed"

[17] For example if a Bayesian Network (BN) model of the demand was used in predicting the optimum space allocation in a transport problem, then the measure of the model's effectiveness would be the actual revenue acquired if the procedure would follow the suggestions of the model and the true demand was applied.

2 The predicted optimum estimate[18].

5. Conclusions

The newsvendor framework is applicable to a very wide problem spectrum. Several potential applications have been briefly described to give a sense of this. One of the major difficulties that its application poses is that compared to other infinite-time horizon management policies, consideration of demand uncertainty is of supreme importance to decision making. The traditional ways of modelling this demand have been outlined and some of the issues surrounding it discussed. In this paper, we propose the use of Bayesian networks to model demand in newsvendor type problems. This framework naturally permits consideration of a wider set of context-defining variables or factors which influence the demand. The usefulness of the BN approach is also enhanced in cases where little past demand data exists and decisions need to be taken by considering the relationship of demand with these context-defining variables. This paper is a report of work in progress and here we have only outlined the qualitative form of an example model relating to final supply of military equipment. The quantification of the model is the subject of ongoing work and will be reported in a future paper. According to our literature review the use of BNs in newsvendor type applications is novel.

Furthermore, in order to develop a BN, close cooperation of the analyst with the manager/SME is of fundamental importance in the procedure and therefore the validation approach has to be in accord with the decision maker’s intuition. This is why the BN applications will be validated using practical approaches and measures of merit such as the ones suggested by Shrebrooke (2004) and Cohen et al (1990) that relate to the real effectiveness concerns of the decision makers.

[18] In the previous example this would be how much revenue was expected by the application of the model.

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Powerful Leadership of National Government in Port Policy

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Abstract

Countries worldwide are reforming their port operation systems. For instance, Canada established the “Asia-Pacific Gateway and Corridor Initiative” and is implementing logistics policies, including railway/road modes under the powerful leadership of the national government and through efforts of both the public and private sectors.

In addition, the national governments of Denmark and Sweden established Copenhagen Malmö Port, which integrally manages the formally competing cross-border Port of Copenhagen and Port of Malmö.

By contrast, in Japanese port operation systems, the management and operation of all ports are fully under local public authorities, and the involvement of the national government is limited to allocation of port development budgets. The Great East Japan Earthquake in 2011 paralyzed the functions of local public authorities, and it became apparent that port management/operation by these local authorities was limited.

The authors analyzed the cases of port operation system reform conducted and verified the significance of leadership provided by the national government. As a result, a huge gap of international competitiveness and disaster response capability between ports in Canada and Denmark/Sweden was found, where national government policy affects the operational system significantly, and those in Japan, where all port operation is left to local public authorities and the government only exercises its leadership in the distribution of port development budgets. From the aspects of international competitiveness and enhancement of

the disaster response capability, port operation requires powerful leadership of the national government.

Keywords: management/operation, leadership, competitiveness, disaster

1. Introduction

The national governments of the world grope for how a port operation system with international competitiveness and strong resistance against large-scale natural disasters can be established. In other words, how should the national government exercise its powerful leadership to implement policies aimed at overall optimization instead of partial optimization?

The authors hypothesized that a method to solve this problem was that the national government should develop and implement a comprehensive policy and participate in the port management/operation. However, few studies have verified the importance of a government's leadership in port policies. This paper is the first research outcome obtained from an analysis of the significance of a government's leadership by comparing port operation systems of each country. This is in contrast to the many research outcomes on decentralization of authority or privatization that have been obtained along with the progress of decentralization of authority or privatization of port management/operations worldwide.

Previously, the change of the Canadian port policy is the typical example that the port policy switched by the administration change of the federal government in countries participating in the Group Eight (G8). Canadian port policy was on track to decentralization of authority/privatization, but they changed this approach as they realized the importance of the federal government's leadership. Therefore, in this study, the transition of Canadian port policy is reviewed first, and the background of the shift made by the federal government and the detailed government's leadership are then analyzed. Subsequently, port management/operation integration in Denmark, Sweden, and Japan are reviewed to verify the effect of the national government's involvement on international competitiveness.

On the other hand, functions of Japanese ports operated by local public authorities were paralyzed by the Great East Japan Earthquake in Japan in 2011. If an anticipated Nankai Trough Earthquake occurs, port functions may be paralyzed just as in 2011 under the current port operation system conducted by local public authorities. Today, horizontal/vertical division of work has been expanded in the global economy, and thus, paralysis of Japanese port functions may result in severe damage on the global economy. Accordingly, through the case of Japan, it was demonstrated that the national government's leadership can establish port operations resistant to large-scale natural disasters.

In addition, "reform" is defined in this study as a policy that changes the scope of the government's leadership. In detail, reform contains decentralization of authority, privatization, and orders from the government.

Furthermore, the Canadian port system was analyzed in accordance with the review conducted by Ircha (2001, 2002, 2008), Sharman, Brooks (2007), Debrie (2010), AAPA (2009), Heaver (2009), and Hall et al. (2011), and the results of a hearing investigation performed by the authors from Ms. Kazuko Komatsu who had been a director of board of both Vancouver Port Authority and Port Metro Vancouver as a representative of the Canadian federal government. The port management/operation integration in Denmark/Sweden was cited from Hirano (2009) who had been the first secretary of Embassy of Japan in Denmark. The analysis of the Japanese port system was conducted based on the achievement of Takahashi et al. (2013a, 2013b, 2014) who were officials of the Japanese Government.

2. Switch of the port policy by the administration change of government: Canadian Case

2.1 Reform of the Canadian Port System

The change of the Canadian port policy is the typical example that port policy switched by administration change of the federal government in countries participating in the Group Eight (G8). Authors focused on the relations of the administration change of government and the port policy and analyzed the influence that the administration change of government gave in the port policy. As a result, the federal government of Canada has executed a large-scale reform of the port policy three times to date.

Figure 1 illustrates the flow of the reform of Canadian port system. Notably, Canadian port reform policy was largely changed because of administration changes.

The first reform, executed before 1983, was transferred all ports under national management/operation to local public authorities, and privatization was conducted by creating public corporations. The management and operation system of the ports was systemized using public corporations; however, there are many limitations in this system.

The second reform set forth national marine policy in 1995, established Canada Marine Act in 1998, and developed port authorities to enable independent management and operations at major ports. However, because this reform imposed various constraints on the port authority while introducing an independent accounting system, significant facility investment became impossible because of funding problems; thus, port call opportunities by maritime companies were lost.

The third reform, which established the “Asia-Pacific Gateway and Corridor Initiative (APGCI)” in 2006 and implemented logistics policies (including railway/road modes with efforts of public and private sectors under governmental leadership), is currently in effect. The federal government altered the policy characteristics of the third reform of promoting decentralized and self-managed port operations, choosing to integrate three port authorities in the Greater Vancouver area and make major improvements to port/railway/road infrastructure. Regarding the alteration of the federal government's port policy, there was a serious sense of crisis in the administration arising from the trade competition between Canada and the United States related to the rapid growth of trade between Asian countries. Especially, the change of administration in 2006 became a distinctive watershed point. The Liberal Party of Canada privatized and aimed for a financially independent port operation before 2006; since 2006, the leadership of the Conservative Party of Canada changed this path to enabling the federal government to become powerfully involved with port operations and public works.

Liberal Party became the governing party
1963 Change of administration
1964 Establishment of harbor commission
The harbor commission was established and given management responsibility.
1979 Change of administration

Liberal Party became the governing party
1980 Change of administration
1983 Canada Ports Corporation Act
Past debts were cancelled and privatization was adopted.
1984 Change of administration

Liberal Party became the governing party
1993 Change of administration
1995 Declaration of national ocean policy
1998 Establishment of Canada Marine Act
Defining the port types, the port authority system was applied to major ports.

Conservative Party became the governing party, up to the present date
2006 Change of administration Declaration of the Asia-Pacific Gateway and Corridor Policy
This declaration made priming economic growth through soft/hard improvements in ports that serve as the gateway and railways/roads that serve as the corridor in response to the remarkable expansion of trade between China and the North American continent.

2008 Major amendment of Canada Marine Act
Incorporating financial improvements of port authorities and provisions of integration, three port authorities in British Columbia were integrated.

Fig. 1: Historical Transition of Administration Change and Port Reform in Canada

2.2 Characteristics of the Canadian federal government's leadership for the port management/operation

A significant change was made by the powerful leadership ability of the federal government after the administration change in 2006.

The APGCI announced by the Canadian government in 2006 was well received within the country. In the program’s first 4 years, the government implemented specific policies in order to improve the capacity and efficiency of “Gateways” (i.e., ports) and “Corridors” (i.e., railways/roads). Based on the APGCI, these policies are intended to produce synergistic effects, such as a combination of port/railway/road modes, implementation of public works through efforts of public and private sectors, integration of port authorities, and integration of concerned people in addition to respective independent effects.

Policies implemented in the APGCI ranged widely across port/railway/road modes, and the fact that the prime minister and responsible ministers visited Japan and China for top APGCI sales implies that the government responsibly exercised leadership by placing an exclusive minister for the implementation system. The powerful leadership of the government after the administration change was largely affected.

In addition, concurrently with the development of an integrated environment to streamline the management/operations of the port authority organization through amendments of laws and regulations (e.g., the Canada Marine Act), implementation of large-scale port works by public and private sectors became the driving force to reorganize port authorities into organizations with effective management/operations, because it is conducted on the premise of improvements of the financing capability of port authorities.

Figure 2 illustrates the configuration of Port Metro Vancouver (PMV). The federal government decided to strongly integrate three ports (i.e., the Ports of Vancouver, Fraser River, and North Fraser) on the west coast within the Greater Vancouver area through the federal government representative participating in a board.

Canadian federal government	1 member	Based on the recommendation of the minister of Transport Canada, appointment by the chairperson of the council
Person appointed by province government	1 member	Province of British Columbia
	1 member	Governments of western provinces (Alberta, Saskatchewan, and Manitoba)
Person appointed by local government	1 member	Representative of 16 neighboring cities, including Vancouver
Port user	7 members	After consulting with the industry, recommended by the minister of transportation and appointed by the chairperson of the council

Fig. 2: Board of Directors (11 members) of Port Metro Vancouver (PMV)

The port authority has a board, which is the highest organ of management/operation, and the board provides management/operation instructions to managers in the system. The board consists of 7 to 11 directors, who are appointed by the representative bodies. The federal government does not have a right and a budget on the port management/operation. However, a representative of the federal government is included in the board to reflect the intentions of the federal government.

In summary, the characteristics of Canadian federal government's leadership are the following:

a) Canadian port policy was on track to decentralization of authority/privatization, but they changed this approach as they realized the importance of the federal government’s leadership.
b) The federal government does not have a right and a budget on the port management. However, a representative of the federal government is included in the board to reflect the intentions of the federal government.

3. Switch of the port policy by the administration change of government: Japanese Case

3.1 Reform of the Japanese Port System

Figure 3 shows the transition of the Japanese port system. The Japanese government executed significant reform of port policy three times after 1950. The first reform, executed in 1950, left all ports including ports managed/operated by the country to independent management/operation by local public authorities. The second reform established the foreign trade port authority in 1967 and transferred the container terminal operation from local public authorities to foreign trade port authorities; however, the operation was transferred to the public corporation as the foreign trade port authority was dissolved in 1987. In the third reform, the Super-Hub Port Initiative was announced in 2004 and the International Strategic Port Policy was declared in 2011, and the container terminal operation was transferred from public corporations to private companies. The third reform continues to the present date.

By contrast, looking at the transition of port policy caused by administration changes from 1993 to 1994 and from 2009 to 2012, non-Liberal Democratic Party-related regimes affected port policies. First, the relationship between the port policy and the administration after 1950 is reviewed.

The current Port management/operation system is regulated by the Port and Harbor Act established under the instruction of the General Headquarters (GHQ) in 1950.

By contrast, logistics activities, which are port activities, involve not only the range of administration of local public authorities of the port but also a wider range operated under internationally agreed rules.

Thus, it is of interest to determine how these wide-ranging port activities have been realized while the roles of local public authorities were limited.

In 1967, the country newly established the foreign trade port authority act and setup two public authorities: Keihin and Hanshin. These public authorities solely undertook port administration of a number of port managers (local public authorities) and conducted construction and operation of a wide range of container terminals required for marine container logistics. However, the national government, which was aimed at a small government, judged that construction by public authorities became unnecessary and thus dissolved the public authorities in 1982 as administration reform. All container terminals constructed and operated by the public authorities were transferred to public corporations owned by local public authorities for operation.

Phase	Port Policy	National Movement
1950–1982 (LDP) a. Development of basic facilities		a. Port and Harbor Act b. Foreign trade port authority act
1982–1993 (LDP) a. Development of facilities other than basic facilities b. Creation of comprehensive port space	a. Port for 21st Century b. Port Follow-up for 21st Century	a. Dissolved foreign trade port authority/foundation of public corporation b. Structural Impediments Initiative c. Basic Plan for Public Investment
1993–1994 (Non-LDP)		a. Finance System Council rank C (investment control) b. The Great Hanshin-Awaji Earthquake
1994–1998 (LDP) a. Selection and concentration, development of hub port	Port to Support the Era of Internationalization (central core port policy)	a. Amount increase for the Basic Plan for the Public Investment b. Fundamental Principles of General Logistics
1998–2009 (LDP) a. Selection and concentration, development of hub port b. Port operation by vertical separation	Super-hub port policy (privatization of public corporations)	a. Advance comprehensive approval system for public facilities b. Private Finance Initiative law c. Act on Special Zones for Structural Reform
2009–2012 (Non-LDP) a. Selection and concentration, development of hub port b. Port operation by vertical separation	International Strategic Port Policy (operating company system)	a. The Great East Japan Earthquake
2012–present (LDP)		

(Note) LDP: The Liberal Democratic Party-based Administration
Non-LDP: Non-Liberal Democratic Party-based Administration

Fig. 3: Transition of Japanese Port System

The Ministry of Transport established the first Port and Harbor Act when the public authorities were dissolved. The Port and Harbor Act indicates the necessity of developing port facilities other than the basic ones. However, the act mainly considered development, and port operation was not mentioned.

The port policy presented by the Non-Liberal Democratic Party regime announced that the Fiscal System Council, the consultative body of the government, concluded that port investments should be inhibited (rank C among ranks A/B/C that imply investment control). Consequently, the budget allocated to port development was less than to public works in other fields. Although ports worldwide were in the course of construction and operation of large-scale container terminals because of predicted size growth of container ships, the Japanese government announced that they would decline this investment.

Realizing the necessity of constructing a large-scale container terminal to accommodate for large container ships, in 2005, the Japanese government introduced the super-hub port system by amending the Port and Harbor Act and by enabling a single private business operator to integrally operate a number of successive container terminals at three ports (Keihin, Hanshin, Ise Bay). Thus, operators could pursue the managerial advantage of scale. This led to the establishment of the current system of wide-area port management/operation by the private sector.

A comprehensive logistics policy that included a combination of roads and other infrastructure was announced.

In 2011, the country amended the Port and Harbor Act to establish a two-tiered (separating infrastructure and operation) system, and while leaving the port/management to the private sector, an environment to enable wide-area management/operations was developed. Sixty years after 1950, the wide-area operation system was realized

3.2 Characteristics of Japanese government's leadership

As seen in Figure 4 by the allocation of roles between the country and port managers under the Port and Harbor Act, the country was not directly involved with the operation of ports, and its role was limited to provision of instruction by basic policies of port construction/management and technical standards for facilities. It abandoned the operation of ports to port managers, who are the local public authorities.

Japanese local public authorities were established under the Local Autonomy Act. As indicated by the roles of local public authorities and country shown in Figure 5, the Local Autonomy Act defines that local public authorities "undertakes the wide range of roles to independently and comprehensively implement the administration for the community on the basis of promoting the welfare of residents" and specifies that the role of the country is to implement measures from a national point of view.

National government	Port Management Bodies (Local Governments)
a. Policy formulation for the development and administration of nationwide ports b. Establishment of necessary laws and regulations c. Providing advice and guidance on port administration and operation to port management bodies d. Financial assistance for port management bodies in relation to port construction projects e. Implementation of port construction projects (Limited to projects under the direct control of the national government) f. Improvement and maintenance of shipping channels outside the port area g. Establishment of technological standards h. Surveys and research concerning port technology	a. Formulation of port development/management plan b. Construction and maintenance of port facilities c. Permission for and restrictions on facility use in port management districts (marine districts, land districts) d. Leasing and management of port facilities e. Setting and collection fees for use of port facilities f. Marketing and promotion of ports g. Establishing conditions for providing port services

Fig. 4: Allocation of Roles between the Country and Port Managers under the Port and Harbor Act

Local/National	Role according to the Local Autonomy Law
Local Governments	The task of a local government shall be to promote the welfare of its residents, for which purpose it shall carry out a wide range of tasks in the autonomous and comprehensive performance of local public administration.
National Government	In order to accomplish the purpose of the preceding paragraph, the role of the National Government shall in the main be to attend to: matters relating to its position as a nation in the international community; matters concerning basic rules on national activities or local autonomy that should be standardized nationally; or matters concerning policies and programs to be implemented on a national level or from a national viewpoint.

Fig. 5: Role of Local Government and National Government according to the Local Autonomy Law

Since the operation system by local public authorities was introduced in 1950, the Japanese port operation system has been concentrated to constructing port facilities, but there has been no change in the basic system. Because a local public authority must maximize the public welfare of residents in the area under its jurisdiction, it implements the measures optimal to its respective locality, including those against competition between neighboring ports. However, those measures may not be optimal in Japan as a whole.

As a result, port management/operation functions were paralyzed when the functions of local public authorities were affected by the Great East Japan Earthquake in 2011.

Figure 6 shows the focal region of the Nankai Trough Earthquake, whose occurrence in the waters surrounding Japan is anticipated. If the Nankai Trough Earthquake occurs, the damage is expected to be more severe than that in the Great East Japan Earthquake in 2011. Particularly, because the assumed disaster-stricken region includes a number of ports, such as the Ports of Nagoya, Osaka, and Kobe (major ports for international trade), according to Takahashi et al. (2014), ports serving as transportation routes of 7.4 million TEU of marine container cargo, that is, 42% of the entire marine container cargo in Japan (17.51 million TEU; 2011), would be paralyzed. The damage is expected to expand far beyond the administrative district of each local public authority, and thus, the damage level would be beyond that local public authorities could handle and recover.

In addition, because horizontal/vertical division of work has been advanced, this type of paralysis of Japanese logistics would cause significant damage to the global economy. It is the mission of the national government to prevent such damage from spreading.

In summary, the characteristic of Japanese government's leadership is that the Japanese Government lays emphasis on decentralization/privatization of the port management/operation too much and lowers the leadership of the government. When a large-scale natural disaster occurs, this characteristic becomes remarkable.

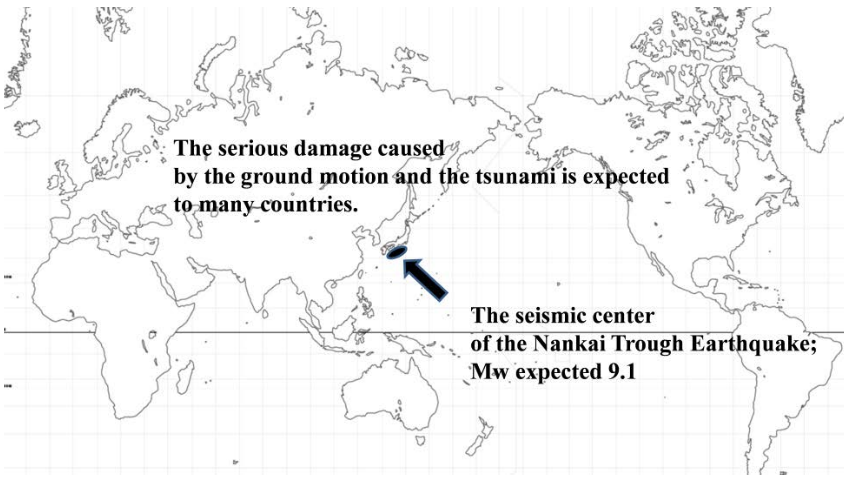

Fig. 6: Assumed Seismic center of Nankai Trough Earthquake (Mw 9.1)

4. Management/operation Integration Cases of the Ports of Denmark/Sweden

4.1 Formation of Transnational Economic/Living Area

Öresund Link, the bridge and underwater tunnel used for both road and railway, was opened in 2000. It connects Copenhagen and Malmö and reduces the travel time to approximately 45 minutes by car and 30 minutes by train. There are many people commuting across the border from Malmö and the neighboring area to Denmark, and an economic/living area termed the Öresund Region reaching the outskirts of both cities has been formed.

In the Öresund area, integrated economic growth was achieved regardless of the border: for instance, a major industrial cluster of biological research called Medicon Valley was formed that crosses the border. The Port of Copenhagen and Port of Malmö were located across each other over the border at the Strait of Öresund, but the opening of the Öresund Link led the two countries to agree to integrate the management/operation of ports, and integrated port operations began in 2001.

4.2 Structure of Port Operations

Figure 7 shows the operational structure of the Copenhagen Malmö Port. The cities of Copenhagen and Malmö were originally the managers of the Port of Copenhagen and Port of Malmö, respectively, and the city mayors agreed to integrate the management/operation of those ports in 1998. The Port of Copenhagen was initially owned by the city of Copenhagen, but the ownership was transferred to a port corporation 100% owned by the Danish government in 2000. The port ownership was split among Copenhagen city and the port development company CPH City & Port Development: 45% was owned by the Danish government, and 55% was owned by the city of Copenhagen; furthermore, the Port of Malmö was owned by the city of Malmö.

Copenhagen Malmö Port (CMP) is integrally operating both ports. CMP is 50% owned by Copenhagen city and the port development company and 50% owned by the Malmö port corporation. Separating the owners and operators of both ports, the owners are participating in port operations via a financing relationship. Currently, the ownership ratio in the port operation is as follows: the Danish government, 22.5%; the city of Copenhagen, 27.5%; the city of Malmö, 27%; and private corporations, 23%. CMP is managing/operating the port while borrowing port assets from CPH City & Port Development and the city of Malmö.

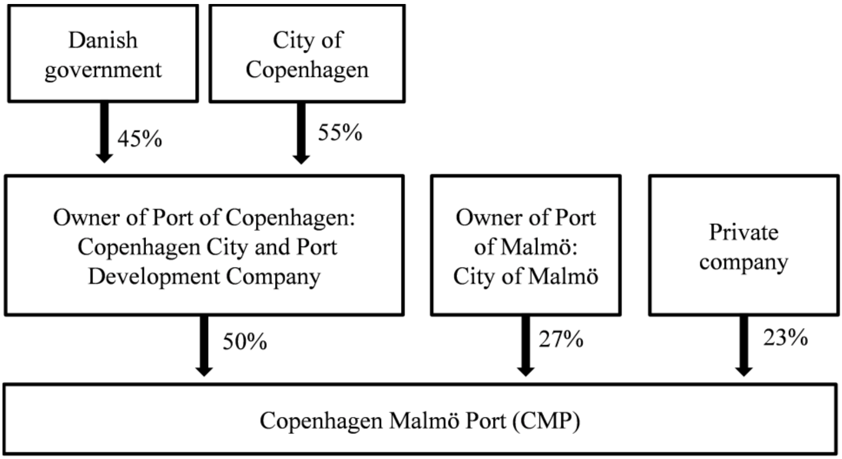

Fig. 7: Owners of Port of Copenhagen and Port of Malmö, and Ownership of CMP (The homepage of CMP, Hirano, 2009)

4.3 Involvement of National Government in CMP

Ports in Denmark used to be managed and operated by the country, but operations of all ports were transferred to local public authorities. Furthermore, aiming at management/operation by private companies, the port act was revised in 1999 to systematically enable management/operation by private bodies. This movement adheres to the line of privatization taken by England in the 1980s. However, in 2000, the policy was changed to enable the national government to manage/operate the company, and the government is now involved by making investment to CMP, the company owning the Port of Copenhagen and operating the Port of Copenhagen and Port of Malmö.

5. Comparison of the participation of the national government on the port management/operation

The authors introduced the three forms in this paper which the national government participates in in the port management/operation body. The first is a participation form by the government representative such as the Canadian port authority. The second is a participation form by the capital investment of the government such as CMP. The third is the form the national government does not participate in the port management/operation and entrusts it to the local government or the port management/operation body financed by the local government.

By the comparison of three forms, the difference in participation forms of the national government becomes clear.

The power of the participation in the port management/operation is decided according to the capital investment ratio. Generally, capital investment ratio more than 50% which can hold the right of management/operation completely is the strongest. The power of the participation by the government representative is decided according to the cooperation with other members of board. If other members go along, the government can show powerful leadership, but unless other members go along, intention of the government may not be necessarily reflected.

On the other hand, each port management/operation bodies in Japan completely becomes independent each other, which is under perfect competition in economics. It is the method that is most suitable when it is necessary for this form to raise ability to the uniformity standard that there is in a delayed part. However, when economics surpass a constant standard, and the perfect competition produces the problem of the overinvestment, which is a worldwide economic problem. The port management/operation affects national interest directly and the government must prevent the mutual destruction by the overinvestment legally, but the system as of one of Japan cannot reflect intention of the government legally.

For reinforcement of the international competitiveness between national nations as well as reinforcement against the large-scale natural disaster, the powerful leadership of the government is important. This problem is common throughout the world.

6. Conclusion

The authors identified the following facts in this paper.

The case of Canada presented an example of a foreign port in which the federal government developed policies to establish the system, realize the integration of three neighboring ports, and engage in realizing integrated, effective port management/operations and enhanced transportation capability of logistics infrastructure as Port Metro Vancouver. Canadian port policy was on track to decentralization of authority/privatization, but they changed this approach as they realized the importance of the federal government's leadership. This was conducted in the context of an economic mission and powerful leadership exercised by the federal government who chose to spark the domestic economy by focusing on the tremendous trade growth between North America and China.

In the case of port management/operation integration at the cross-border CMP, the Danish government became involved with the ownership and operation of port assets because it was a port operation matter concerning two countries.

On the other hand, the Japanese case indicated that port operation has been left to local public authorities since 1950 and that the national government is involved only with budget allocation. As a result, Japanese port policy is capable of providing partial optimization for residents within each administrative district through local public authority operations; however, this is not optimal for Japan as a whole. Furthermore, assuming a large-scale natural disaster, it became apparent that port operations by local public authorities may have considerable negative effects on the global economy as the functions of local public authorities are paralyzed.

Accordingly, the authors conclude that the following three points are important to strengthen the international competitiveness and disaster-handling capabilities in port operation and to implement policies aimed at overall optimization Instead of partial optimization.

a. The national government should develop and implement a comprehensive logistics policy of ports, railways, and roads with international competitiveness and strong resistance against large-scale natural disasters.
b. The logistics policy can be established through items such as implementing public works, promoting port integration and so on.
c. The national government should participate in the port management/operation by the capital investment to the port management/operation body.

But there will not be the effect of c. if the government does not perform a. and b. at the same time. The authors appeal to port-related people globally through the case of Japan in that from the aspect of enhancing international competitiveness and disaster-handling capabilities, port operation requires policies developed by the national government, the establishment of an operation system in which the national government is involved, and powerful leadership of the national government.

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A New Research Protocol to Develop Multiple Case Studies on Illicit Activities in Trade, Logistics, Processing and Disposal of WEEE - Waste in Electrical and Electronic Equipment

Juha Hintsa and Melanie Wieting

Abstract

The illegal trade and disposal of electronic waste – known as e-waste or waste electrical and electronic equipment (WEEE) – is increasingly becoming a threat to global environmental health and security. To enhance the capabilities of governments in the EU and beyond to combat this growing crime, INTERPOL, Cross-border Research Association (CBRA) and five other partners launched the 2-year Countering WEEE Illegal Trade (CWIT) project in September 2013, funded by the EU's 7th Framework Program. The purpose of this paper is to present a new case study protocol for harmonized collection of detailed data on several dozen illicit WEEE cases across the globe. The CWIT case study protocol aims to capture multiple aspects of WEEE violations: (i) What was done wrongfully in e-waste trade and how; (ii) Which WEEE products and fractions, geographies, and transport modes were involved; (iii) Who was involved in illicit acts; (iv) What were / would have been the illicit economic benefits, and negative socio-economic impacts; (v) How was detection and inspection carried out; and (vi) What is the up-to-date situation with investigations, prosecutions and punishments? The outcomes of three preliminary illicit WEEE cases - with non-sensitive, anonymized data - are included in the paper. It is anticipated that the illicit WEEE case studies will play a central role in the development of policy, enforcement, technology, training and other recommendations to combat more

effectively and efficiently the wide spectrum of regulatory violations in trade, logistics and disposal of WEEE in the future.

Keywords: environmental crime, WEEE, supply chain security, FP7-CWIT

1. Introduction

The need to identify a consistent and effective approach to the handling of waste electric and electrical equipment (WEEE) is increasingly important as the illicit handling and trade becomes move evident in the global supply chain. The negative environmental, safety and health impacts means it cannot be relegated as an industry problem or regulatory problem to be addressed, it needs broader engagement across sectors. The illegal handling and cross-border movement of electronic waste is proving to be one of the more complex crime types facing both law enforcement and regulatory bodies. Apart from the clandestine nature of any crime, the nature of the legitimate waste trade is already complex - add to it the illicit activity and the issues for enforcement are vast.

The definition of WEEE poses a problem in itself: there are variations of the definition. The European Union Directive on WEEE 2012/19/EU is the most frequently used and lists WEEE as ´electrical or electronic equipment which is waste including all components, subassemblies and consumables which are part of the product at the time of discarding´. Work done by the Solving the E-Waste Problem (Step) Initiative defines WEEE as 'a term used to cover items of all types of electrical and electronic equipment (EEE) and its parts that have been discarded by the owner as waste without the intention of re-use'.

The WEEE identified in illicit cross-border movements likely covers the entire spectrum of waste electrical equipment and is not necessarily limited to articles that have the highest potential resale or reuse value. For the purpose of this research paper practical categories in use at collection points have been chosen - Large Household Appliances; Cooling and Freezing Equipment; Small House Household Appliances; Screens; Lamps; Professional Equipment and IT

Equipment - those vary from the ten categories as defined by the EU WEEE Directive.

The purpose of this paper is to begin to highlight the modus operandi, actors and geographies that have been identified in exploitation of the WEEE supply chain. The specific intention by the authors is to develop and test a consistent method of gathering such information from a wide cross section of government bodies that operate in different countries, with different resources, methods of training, legislative frameworks, and so forth.

The paper will follow the structure of providing first a brief overview of other research that has been done in the field of illicit WEEE trade and logistics activities. The content of the case study questionnaire will be detailed followed by examples of three preliminary cases collected through this method. The analysis of these cases studies will begin to identify trends which will be further expanded on during the CWIT Project. The last section of the paper covers discussions and conclusions, as well as suggestions for future research.

2. Literature review on illegal activities in WEEE

As with most non-ideological crime types, financial gain is the major driver for the illegal e-waste trade. Academics have described the negative value of waste as being a key element in why this otherwise legitimate trade and industry incentivizes stakeholders to seek illegal avenues to deal with their waste (Bisschop 2012, p.235). Rather than a commodity being exchanged for money like in any traditional transaction, in the case of waste, a waste producer provides the waste to the recycler, together with the money. Beyond this, some electronic waste contains elements that are valuable enough to warrant recycling and treatment, leading ultimately to ´double profit motivation' – in the context of violations in trade, import/export and disposal regulations.

In developed countries, the practical cost of e-waste disposal has increased due to stricter law enforcement, making exports cheaper than domestic disposal (Ni and Zeng 2009, p. 3993). For instance, in the United States, it costs as much as

18 USD to safely remove lead from a CRT monitor (UNEP n.d., p.105). According to recent estimates, the improper disposal of CRTs generates an economic saving between 50-75%, compared to the cost of lawful recycling. Profitability of illicit electronic waste is increased by exploitation of existing, legitimate, shipping and international transport modes. As an example, after delivering goods to the United States from China, the empty shipping containers would normally be returned. However they have been used to transport electronic waste back to China rather than being returned empty (Schluep 2012, p.105). At the same time, brokers get doubly paid for moving e-waste across borders - for acquiring the e-waste and for further shipping it to the destination place. Further, poor migrants provide cheap labor and line the pockets of greedy entrepreneurs. Inadequate law enforcement in developing countries considerably adds to this problem (Ni and Zeng 2009, p.3993 & Bisschop 2012, p.235).

As an example, in Germany collection points are important sites for the illicit export trade where the waste equipment suitable for export is packed into sea containers and vehicles. The operator may act as an agent from whom the exporters purchase. In other cases the operator has no hand in the trade. A notable example is Hamburg which has a large cluster of such sites, where around 20 companies are involved in trading electrical equipment and some of those dealing exclusively in used equipment. Apart from Asia and Africa, Eastern European countries like Russia, Ukraine and Poland are common destination points. Experts estimate Germany to be hosting a few hundred or even a thousand such collection points. The exporters are often of foreign origin who come to Germany, procure a considerable amount of material for shipping, and then receive the same shipments in the country of destination in order to sell them off with lucrative profits (Sander and Schilling 2010, pp.62-65). Other players involved in this illicit trade include agents, forwarding agents, other service providers for logistics and formalities as well as shipping lines (Sander and Schilling 2010, pp. 61- 65). All the federal states of Germany have control and monitoring functions in place, with the export ports of Hamburg and Bremen being extended by a central control function

(Sander and Schilling 2010, p.85).

In the USA, supposedly legitimate recycling firms appear to be common culprits, who charge a recycling fee for safe disposal in accordance with the national law, but actually export it to developing countries. Moreover, a commonplace activity for buyers from developing countries- particularly from Africa- is to travel to OECD countries to secure consignments of e-waste and arrange for shipments. After successful importation, brokers sell the scrap to informal recycling centers as Guiyi. Once the dismantling process is over, the valuable components are resold to manufacturing companies or metal refineries by waste brokers operating in strong trade networks. Not much is known about the payment methods of e-waste buyers but there is evidence of the use of telex transfer or popular money transfer systems, such as Western Union. (UNEP n.d., pp. 108-109).

While the push factors for the illegal electronic waste trade are evident, destination countries and the pull factors are also considerable drivers in the illegal electronic waste trade. The need for metals to be used in manufacturing in Asia, China specifically, has contributed to China being one of the primary destination countries for electronic waste despite the year 2000 ban on import of used electronic and electrical equipment. Most of the waste is reportedly destined for informal recycling sectors e.g. in the province of Guangdong. The demand in this sector exists particularly for Cathode Ray Tube monitors and printed circuit boards (Schluep 2012, p.106). United Nations Office for Drugs and Crime, UNODC, estimates that 80% of e-waste generated globally is shipped to Asia – with 90% of that amount destined for China. The main sources of e-waste reaching China are the European Union, Japan and the United States. Such shipments are in breach of the law in the countries of export as well as in China (Schluep 2012, p.105).

Next to China, other leading recipient countries of e- waste appear to be India, Pakistan and Nigeria. All four countries are signatories to the Basel Convention and have national regulations in place to address the importation of hazardous waste, but the actors involved in this trade manage to circumvent the law and export them as ‘used goods’ (Sthiannopkao and Wong 2012, p.4). In recent years, China and India have been making efforts in switching to more sophisticated systems for e-waste management. Both countries have established national registry records to keep track of domestically produced electronics, with the ultimate purpose of introducing producer take-back schemes. India has created an inventory system and has run several trials but is yet to reach a satisfactory level. China is at an early stage of designing an e-waste inventory. No visible signs of progress have been made in Pakistan in terms of government cataloging of domestically manufactured electronic goods. Collection points remain largely restricted to informal recycling centers in all developing countries. Some technological advancements have been made for the disposal of e-waste in China and India and to a lesser extent, in Pakistan. China possesses fairly large capacities of smelting furnaces for recycling non-ferrous substances and displays good potential of developing well-equipped and modern facilities. Notwithstanding these developments, the current state of play clearly indicates that the vast majority of e-waste will continue being recycled in informal sectors for many years to come (Sthiannopkao and Wong 2012, p. 6).

The legitimate market of used electronic equipment also acts as a pull factor and complicates enforcement against the illegal trade where the “digital divide” is bridged between developed and developing countries (Schluep 2012, p.107). West Africa is becoming an increasingly popular destination among illegal exporters from the EU and Japan, and legal exports from the USA (Bastiaan et al. 2009, p.422) and the reported figure of 80% of electronic waste going to Asia (UNEP n.d, p. 105) may need to be revised to account for this trend. The shortage of accurate data on used electronic and electrical equipment entering Africa is made more difficult as the distinction between used electronic and electrical equipment and waste electrical equipment is not made until after the goods arrive in the country and are dispersed. A 2009 study of the e-waste problem in Ghana estimated that around 30% of the used electrical and electronic equipment imported was determined to be non-functioning and should have been classified as electronic waste - half of this amount was repaired locally and sold to consumers and the other half was unrepairable (G8 2013, p.8). The estimate of 30% being determined as non-functioning could be considered a conservative one.

Previous research has identified the most common method of concealment of illicit waste shipments was via mislabeling to avoid the necessary inspections or permits for the products to be transported internationally. A study by the G8 Roma/Lyon Group in 2013 analyzed the nature of the threat of global hazardous waste trafficking. This group sought information from member countries via questionnaires. The results identified some examples of the mislabeling modi operandi being used such as a case in France in which hazardous waste was labelled as raw material to avoid the application of the waste regulation, despite the fact that it never went through any recovery process. These materials contained dangerous components such as lead that were being sent to developing countries which are ill-equipped to deal with the associated hazards (G8 2013, p.7). The interplay between legislations that cover electronic and hazardous waste also complicate enforcement activities. For example, if a used computer is in working condition, it is not classified as hazardous waste and thus not covered by the Basel Convention. Mixing used working equipment with end of life electronic equipment is one way smugglers exploit this legislative ambiguity (Schluep 2012, p.107).

Identifying the actors involved in the illegal electronic waste trade, and their relationships to the legal waste trade as well as each other, is impeded by the confusion created by legitimate traders involved in illicit activity. The G8 assessment reported that some member countries identified organized crime groups (OCGs) as being active in waste trafficking. Using the Palermo convention as their framework for identifying organized crime, Italy, Japan and the United Kingdom cited organized crime as being at least part of their illegal waste trade problems. According to the report, quite often OCGs have a facilitating role in the trafficking of e-waste. They tend to make use of seemingly legitimate companies to mask their identities in this criminal activity. These companies are able to offer much lower prices to the consumers due to their non-compliance with safety and environmental regulations. Falsification of documents is a common method employed to conceal the origin and actual composition of the material. E-waste is often shipped to Africa and Asia under the guise of second-hand computer or other mechanical parts. Illegal e-waste traders frequently exploit the services of specialists and experts with seasoned experience and technical knowledge of regulatory loopholes and disposal of trafficked e-waste. They are typically based in the countries of origin with strong networks in the destination countries. However, in some cases, criminal groups established in destination countries are the key drivers of trafficking activities in the source countries. According to a EUROPOL report OCGs are normally well-equipped to control the entire chain of waste processing activities, starting from pick up to transportation and the final disposal of waste (EUROPOL 2013, pp.6-10).

In addition to organized crime, opportunistic crime or crime that is committed out of ignorance of the controls was also reported (G8 2013, p.11). Previous work by INTERPOL has identified that electronic waste tends to be less formal or structured than the traditional hierarchical organized crime structure. Small groups of traders and brokers are those often identified in the illicit activity. This may be because their activities are less sophisticated than large-scale commercial traders and therefore more likely to be detected by enforcement or the professional traders do not want the reputational risk associated with the illicit activity. As also concluded in the e-waste to non OECD countries report, only companies that are responsible for import and export are recorded to law enforcement agencies. They might only facilitate transport and will not be the origin and final destination.

The detrimental environmental and human health impacts of illegal handling and dumping of electronic and hazardous waste would have reputational risks for companies involved in illicit dealings. The water, soil and/or air pollution that results from electronic waste being diverted from legitimate recycler centers and into illegal disposal such as incineration or burying has long term consequences (G8 2013, p.34). In a case identified by the G8 study, a waste shipment destined for the Netherlands arrived in Rotterdam and it was identified that the contents was far more toxic than originally thought. The cost of proper treatment was high and as a result the owner of the goods identified a company in Abidjan who would ‘treat’ the waste at a price twenty times less than that quoted in the Netherlands. The waste was subsequently dumped in the area surrounding Abidjan poisoning the local population (G8 2013, p.6).

Finally, identifying points in the electronic waste supply chain which are vulnerable to criminal exploitation requires a thorough understanding of the actors, their relationships and the systems and methods in place for waste transport across all the countries involved in the supply chain. Only then can relevant opportunities for law enforcement intervention be identified in the supply chain to interdict the actors involved in the illicit activities. Understanding the criminality associated with the electronic waste stream requires an empirical approach however, the limited information available on this crime type from official sources makes this increasingly more difficult and identifies significant information gaps. The research that has been undertaken so far however can provide a basis for identifying trends and modus operandi that can be further supported through law enforcement data on the illicit cases. In order to reach next levels of knowledge and understanding of WEEE-illicit activities, the next section of this paper presents our new research protocol to collect information and data on illicit cases across the globe.

3. A new case study protocol

Building on the literature review of "universe of illicit WEEE activities" in the previous section of this paper, as well as previous and parallel related work at INTERPOL and at CBRA (see e.g. Männistö et al. 2014, Hintsa et al. 2012, Hintsa 2011, Hintsa et al. 2011), we present next the new case study protocol for exploring and understanding the various factors and angles of the discipline in hand. Due to the dynamic real-world phenomenon with illicit WEEE, and the strive for a deep contextual understanding, the case study was selected as the core research approach for our paper. This choice is consistent with Yin (2009, p. 18) who suggests that a case study is an appropriated strategy when investigating “contemporary phenomenon in depth and with its real-life context, especially when the boundaries between phenomenon and context are not clearly evident." The pragmatic case study approach helps to build rich, insightful case descriptions that underpin convincing interpretations, conclusions, and recommendations (Yin 2009).

The case study protocol has been developed as an iterative process within the CWIT-project consortium (Work package 5 team), during January - May 2014. Below is a visual overview of the protocol (Figure 1), followed by a table with all individual questions, 26 in total (Table 1).

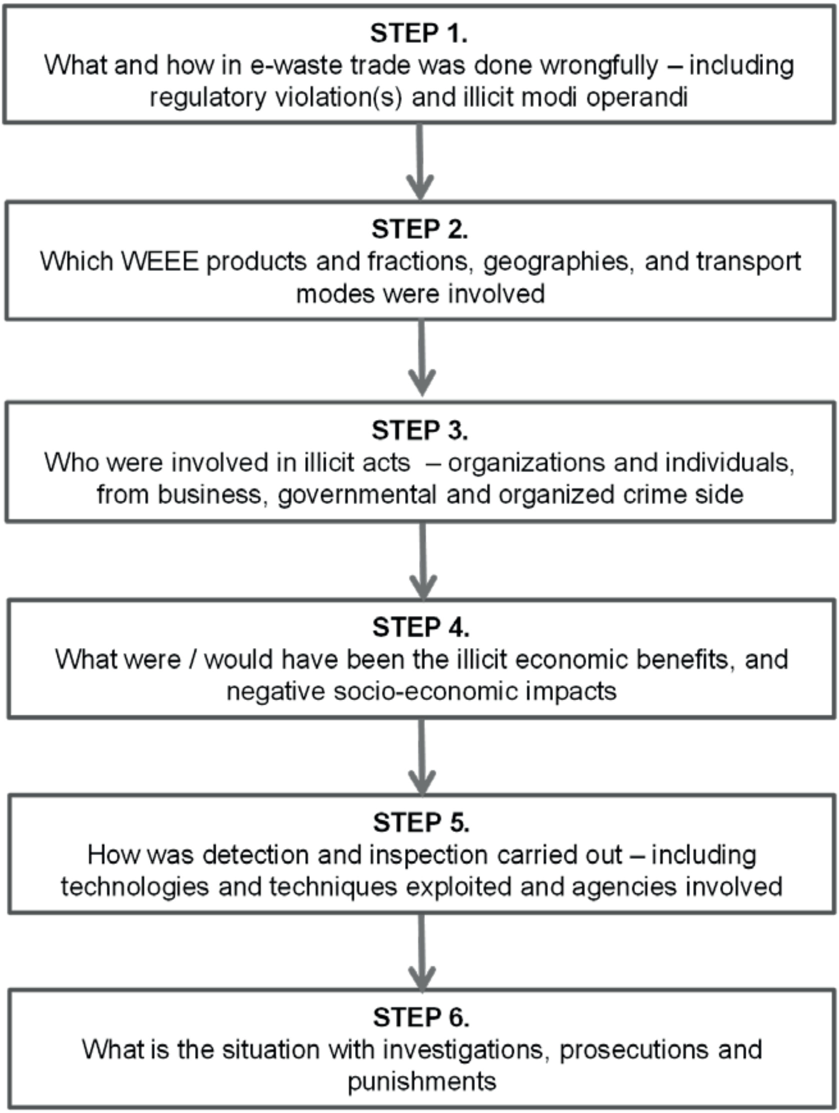

Fig. 1: Overview of the six-step case study protocol.

Next follows the table with all individual questions, grouped per research protocol steps.

Nr.	Specific questions per case study step
1	a) Which violations were identified? (6 options given + other) b) What was the shipment declared as? c) Were there violations regarding permits/licenses provided with the shipment of e-waste, including false documents and false declarations? d) Was the e-waste concealed? e) Was the shipment of e-waste combined with other illegal goods, such as narcotics, counterfeit goods, arms/weapons, etc.?
2	f) What types of WEEE products were parts of this case? (7 options given + other; asking further details) g) What types of WEEE fractions were parts of this case? (5 options given + other; asking further details) h) How was the e-waste transported? (5 options given + other) i) Were there companies involved in the movement of the e-waste - including the import, export and in-country transport/dumping? j) Did this shipment contain both used electrical and electronic equipment and waste electrical and electronic equipment?
3	k) Which parties were identified as being involved in the illegal transshipment of WEEE? (8 options given + other; asking further details) l) Were any governmental agencies involved in the illicit acts of this case? m) Primary person/s involved; Has the person/s previously been convicted for other crime(s) and/or other illegal trade? Is the person known to be linked to a criminal group? Did the persons involved make use of falsified identification documents (e.g. passports)? // Answers excluded from this conference paper, due to sensitivity reasons //
4	n) Did the investigation reveal the motivation for the offence? o) Please estimate criminal proceeds/illicit economic benefits of this offence. p) What would have been the socio-economic damages in this case if it had not been intercepted? For example, loss of governmental revenues, environmental damages, human suffering, etc.

Nr.	Specific questions per case study step
5	q) Date of detection? r) How was the illegal shipment discovered? (3 options given, and asking for details) s) Were any of the following detection and inspection techniques and technologies used? (4 options given, and asking for details) t) At what stage was the shipment detected? (3 options given, and asking for details) u) If governmental actors were involved in detection of this case, please identify which sectors and provide details of the activity. (6 options given + other) v) Was there international collaboration linked to this e-waste case, including police, customs, environmental agency networks, judicial cooperation etc.
6	w) If government actors were involved in investigation or prosecution of this case, please identify which sectors and provide details of the activity. (6 options given + other) x) During the investigation, did you identify links between the e-waste offences and other crime(s)? (21 options + other; asking further details) y) If this violation led to one or more court cases, please advise the categories and the official charges (3 options + other) z) Which penalties were imposed as a result of this offence? (7 options + other)

Tab. 1: Specific questions per case study step

The collection efforts were extended to Law Enforcement Authorities - in WEEE context that is Police, Customs and Environmental inspection authorities - across 89 countries, covering regions of Asia, Europe, North and South America, Africa, the Middle East and Oceania. INTERPOL National Contact Bureaus, NCBs, were the primary recipient of the study questionnaire.

4. Preliminary information on three cases

In this section preliminary information on three illicit cases - Case A, B and C - are presented, first one table per case (Tables 2, 3 and 4), followed by a brief cross-case analysis and summary.

4.1 ILLICIT CASE A. Export from Finland to Ghana and Cameroon by maritime transport

Nr.	Case study findings
1	• Violations were identified as follows: Customs procedures; reporting requirements; labelling and record keeping; and payment issues. • Tax evasion and false accounting were part of the scheme. • Goods were declared as used items. • Charity was used as a frame / cover for the illicit activity
2	• WEEE-products were: Cooling and freezing; Small household appliance (SHAs); IT equipment; Screens (CRT TVs) • WEEE-fractions were: Compressors, Batteries, Waste tires • Various portions in different containers: one mostly WEEE, others about half WEEE.
3	• Companies involved in the illicit acts: WEEE/dealers/brokers (import & transit); same people arranging the export and import • Wholesale trading company, situated in Finland.
4	• Negative socio-economic impacts: Loss of governmental revenues, environmental effects in the receiving countries
5	• Three containers were intercepted in export on 1.12.2011, 12.12.2011 and 2.4.2012 • This was a targeted operation: • Both non-intrusive inspection (NII) technologies and manual inspection were exploited.

Nr.	Case study findings
6	• Governmental agencies involved in investigation: Environmental Inspection (export) – expert opinion; Customs Administration (export) - investigation • Criminal court hearing starts in May 2014.

Tab. 2: Illicit case A

4.2 ILLICIT CASE B. Import to Hong Kong from Spain

Nr.	Case study findings
1	• Regulatory violations with permit requirements. • Shipment declared as metal scrap.
2	• Import case, coming from Spain to Hong Kong, on 10 Sept 2012. • WEEE-products were: Screens (LCD panels)
3	• Companies involved: Trading company on waste materials in Hong Kong.
4	• Motivation for the illicit act: Done for trading purposes. • Negative socio-economic impacts: The environmental problems associated with improper disposal.
5	• Date of detection was 14 Sept 2012 • It was an intelligence led operation. • Customs administration (import) took care of the detection. • Both non-intrusive inspection (NII) technologies and manual inspection were exploited.
6	• Criminal case: Maximum fine for first conviction is $200,000 & to imprisonment for 6 months. Maximum fine for second and subsequent offence is $500,000 and 2 years' imprisonment. • Environmental Inspection (import) took care of the investigation and prosecution • Court outcome: HKD 15,000 fine to company.

Tab. 3: Illicit case B

4.3 ILLICIT CASE C. Transit by road from Serbia through Hungary to Germany

Nr.	Case study findings
1	• Permit requirements - The waste was amber listed according to the 1013/2006/EC Regulation and the exporter did not have permission for the transboundary shipment of this waste. • Shipment was declared as green listed waste according to the 1013/2006/EC Regulation. The Inspectorate determined that the shipment was amber listed.
2	• WEEE-products were: IT (printed circuit boards) • WEEE-fractions were: printed circuit boards • Total of 14,264 tons of electronic waste, EWC code 16 02 16
3	• Companies involved in the illicit act were: Transport companies (transit); e-waste collection organizations (transit); and e-waste treatment facilities (transit)
4	• na
5	• Date of detection at the border crossing in Hungary, was 14 March 2012. • Customs Administration (Transit) - The Customs stopped the shipment on the border crossing, inspected the documents and sent them to the Environmental Inspectorate. • Manual inspection of the shipment, as well as inspection of documents, were carried out. • Detection was part of systematic approach, namely an operation in conjunction with an International Organization.
6	• Environmental inspection (Transit) inspected the documents and the shipment and determined that the shipment is illegal. • Customs Administration (Transit) participated in the investigation process. • Criminal code was violated: The Environmental Inspectorate imposed a fine of 14.264.000 HUF to the exporter.

Tab. 4: Illicit case C

4.4 Cross-case analysis and summary

Lastly, a brief analysis and summary is provided, covering all the three cases from the previous sub-sections.

4.4.1 STEP 1. What was done wrongfully in e-waste trade and how – including regulatory violation(s) and illicit modi operandi?

Regarding regulatory violations in these three cases, customs procedures as well as permit requirements were violated twice - the former in cases A and B, mis-declaration as ´used items´ (A) and ´metal scrap´(B), and the latter in cases B and C. Next to those, case A contained following additional illicit acts: violations in reporting requirements; in labelling and record keeping; and in payment issues. Lastly, false accounting and tax evasion were also reported to have taken place in case A.

4.4.2 STEP 2. Which WEEE products and fractions, geographies, and transport modes were involved?

WEEE-products and -fractions were reported as follows:

- Case A: WEEE-products were: Cooling and freezing; Small household appliance (SHAs); IT equipment; Screens (CRT TVs). WEEE-fractions were: Compressors, Batteries, Waste tires
- Case B: WEEE-products were: Screens (LCD panels)
- Case C: IT (printed circuit boards). WEEE-fractions were: printed circuit boards. Total of 14,264 tons of electronic waste

Transport modes were maritime for cases A and B, and road for case C.
Case A also reported: Various portions in different containers: one mostly WEEE, others about half WEEE.

4.4.3 STEP 3. Who were involved in illicit acts – organizations and individuals, from business, governmental and organized crime side?

Company participation in the illegal activities was identified and articulated in all three cases; while no references were made to participation of governmental agencies or organized crime groups in the illicit acts. Below is the summary of company participation, in each of the three cases:

- Case A: WEEE/dealers/brokers (import & transit; same people arranging the export and import); wholesale trading company in Finland.
- Case B: Trading company on waste materials in Hong Kong.
- Case C: Transport companies (transit); e-waste collection organizations (transit); and e-waste treatment facilities (transit)

(note: all nominal data regarding companies, people etc. has been removed here)

4.4.4 STEP 4. What were / would have been the illicit economic benefits, and negative socio-economic impacts?

When it comes to the negative socio-economic impacts of the three illicit cases - or, what would have been the negative impacts in case no governmental intervention took place - no quantified values were given. Instead, following qualitative remarks were provided in cases A and B:

- Case A: Loss of governmental revenues, and environmental effects in the receiving countries
- Case B: the environmental problems associated with improper disposal.

Regarding estimations on illicit economic benefits, no information was provided in any of the three cases.

4.4.5 STEP 5. How was detection and inspection carried out – including technologies and techniques exploited and agencies involved?

Firstly, all three cases included some sort of "target-oriented approach", versus being "purely random", as detailed below:

- Case A: Environmental authority and Customs conducted a joint operation
- Case B: An intelligence led operation.
- Case C: Detection was part of systematic approach an operation in conjunction with an International Organization.

Secondly, Customs administrations played a key role in shipment detection in all three cases. Intra-agency co-operation was highlighted in case C, where Customs agency was reported to have stopped the shipment on the border crossing, inspected the documents and sent them to the Environmental Inspectorate for the purpose of further evaluation.

Thirdly, two of the cases, A and B, included usage of Non-intrusive inspection (NII) technologies, which would normally be x-ray machines. Manual inspection was eventually used in all three cases. In addition, document inspection was reported in case C.

4.4.6 STEP 6. What is the situation with investigations, prosecutions and punishments?

All three cases include violations of the national criminal code, i.e. that of Finland (A), Hong Kong (B) and Hungary (C). Cases B and C have been finalized, each with a financial sanction, while case A is currently under court hearing (situation May 2014). Case B fine to the violator was around 1.400 euros (HKD 15.000) and case C fine to the exporter was around 47.000 euros (HUF 14.254.000)

Following governmental agency participation in investigation and in prosecution was reported:

- Case A: Environmental Inspection (export) – expert opinion; Customs Administration (export) - investigation

- Case B: Environmental Inspection (import) took care of the investigation and prosecution (B)
- Case C: Environmental inspection (Transit) inspected the documents and the shipment and determined that the shipment is illegal; Customs Administration (Transit) participated in the investigation process.

5. Discussions and conclusions

The purpose of this paper has been to present a consistent method for collecting information on illicit WEEE trade, logistics and treatment activities across jurisdictions and agencies. The research conducted through this method can be considered a starting point for gaining a comprehensive picture of the actors, the methods and drivers for the illegal exploitation of the WEEE supply chain - all this with the ultimate agenda to enhance capabilities to fight more effectively and efficiently against illicit WEEE activities in the future.

A case study protocol, in the form of a questionnaire was presented, and the outcomes of three preliminary case studies were shared and briefly analyzed. The analysis identified some commonality across the cases in particular with how the shipments were detected and identified as illicit and the categories of WEEE detected. Some of the preliminary case study findings presented in this paper correspond with previous literature, in particular findings on the use of mislabeling and mis-declaration as a method of concealment to avoid detection by border official intervention. At the same time, findings regarding the involvement of organized crime in these cases did not indicate so far the involvement of a known organized criminal network. The commonly held belief that organized crime is the principle actor involved in this illicit supply chain requires far more extensive research to fully substantiate this assertion. This research activity identified some trends and also identified the information gaps that are consistent across reporting countries. Information being returned commonly excluded data on the actors involved in the previous steps in the supply chain, suggesting that once the goods was detected and dealt with via seizure and application of penalty, there was limited analysis on the broader network involved in the activity. This may be due to a lack of resources by the respective agencies, the knowledge of the respondent or the penalty being too minor to warrant further investigation.

A comprehensive analysis of all steps in the supply chain is not possible with the three cases reported in this paper in particular as the details of the locations and actors involved have been retained within the law enforcement sector due to their sensitivities. The analysis however was intended to provide a snapshot of the information known and unknown by authorities charged with detecting and enforcement of breaches. The information gaps identified, and held within the law enforcement sector, provide opportunities for improved information collection for example to identify targeting opportunities for enforcement authorities in the future.

Regarding future research topics, the authors make following two recommendations: (i) the current case study protocol should be expanded from written questionnaire to follow-up interviews, where additional in-depth information may be captured; and (ii) detailed understanding of the illicit economic gains linked to WEEE trade, logistics and disposal, in forms of illicit revenues, illicit cost savings etc. is crucial to target future policy, enforcement and other actions to "where it hurts the most", i.e. where the illicit actors have the biggest economic gains.

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A Literature-Based Qualitative Framework for Assessment of Socio-Economic Negative Impacts of Common Illicit Cross-border Freight Logistics Flows

Juha Hintsa and Sangeeta Mohanty

Abstract

Global supply chains and freight logistics systems are commonly exploited in trafficking activities: for example cocaine may be shipped from Colombia to the Netherlands concealed in ocean liner structures while stolen cultural products may be hidden inside an air container, shipped for example by express courier from Egypt to Italy. In order to design effective and efficient governmental policies and corresponding regulations, enforcement priorities, inspection schemes and other countermeasures, one needs a clear picture of such common illicit flows - such an integrated research paper does not exist today.

The objective of this paper is to capture and summarize some of the key characteristics, in particular socio-economic negative impacts, of following six common trafficking flows: trafficking in cocaine and heroin; counterfeit products; ozone depleting substances; firearms; stolen cultural products; and endangered species. The negative socio-economic impacts in this paper fall ultimately into following six categories: Increasing health care and social security costs; Increasing environmental damages; Increasing human suffering; Increasing market place distortions and/or unfair competition; Losses in tax revenues regarding indirect border taxes; and Losses in cultural heritage. The main outcome of this paper is an integrated matrix derived from both practitioner and academic literature to map the socio-economic negative impact –categories per

each illicit flow-type. Finally, this qualitative paper suggests several quantitative research (sub-)topics for the future.

Keywords: trafficking, illicit trade, socio-economic impacts, FP7-CASSANDRA

1. Introduction

Freight logistics systems, a crucial layer of global trade and supply chains, are exploited for a variety of illicit activities, in particular for trafficking of prohibited and restricted goods. These imply heavy costs to several public institutions, including but not limited to the law enforcement bodies such as customs and police. In general terms, the socio-economic impacts of these illicit trade streams are many, while crucial information on them is dispersed across extant literature. This fragmented knowledge risks producing disjointed responses to the aforementioned crime category. A systematic compiling of this vital information would enhance a holistic understanding of the vicious acts, their linkages and societal implications. Thus the intent of our paper is to present a high level assessment of the various negative socio-impacts of the select cross-border illicit flows for the benefit of regulatory bodies, law enforcement agencies, supply chain practitioners, and academics alike.

We focus on six commonly occurring illegal trade flows, derived from the literature (see e.g. Männistö et al. 2014, Hintsa et al. 2012, Hintsa 2011, Hintsa et al. 2011). These flows are: Trafficking in cocaine and heroin; counterfeit products; ozone depleting substances; firearms; stolen cultural products; and endangered species.

2. Socio-economic impact assessment in the context of illicit activities

Socio-economic impact assessment (SEIA) is commonly considered as a yardstick for measuring the direct and indirect potential impacts of a proposed development activity on social, economic and environmental welfare (Mackenzie 2007, pp. 6-7). It aims for a qualitative and quantitative analysis of the proposed development project or policy initiative, helping to optimize social and economic welfare, address social equity concerns and devise mitigation strategies against negative impacts (Tamborra 2002). However, in the context of illegal activities such as organized crime, SEIAs have been conducted to facilitate an evidence-based understanding of the related issues and to develop appropriate mitigation strategies (EP 2013, pp. 8- 11). In other words, SEIAs are used first to understand the situation as-is, with all the current negative socio-economic impacts of specific illicit activities; and afterwards the SEIA-outcomes may be used e.g. to facilitate work to enhance the criminal code.

On global scale, there have been a few socio-economic assessment reports on the illicit narcotics industry, paying particular attention to consequences on employment and productivity, inflation, income distribution, trade and balance of payments, finance and investment, family and community, poverty, public health, education, environment, corruption and other threats to civil society (UPDCP 1995 & UNDCP 1995b).

On European scale, an exploratory study has been carried out by the European Parliament in the year 2013. It focuses on the dynamics of the distribution and existence of various forms of organized crime, and provides a structured, analytical framework of the costs of organized crime as well as baseline estimates of the social and economic costs associated with these criminal rackets. The existing discrepancies across the EU in data collection approaches and data matching in the private and the public sectors, the priorities in practice by enforcement and other relevant agencies, the nature of the exposure of each Member State (MS) to different crime risks (with some MSs as points of origin and some as points of destination), varying legal systems and practices etc., made cross- comparisons and policy guidance quite difficult. Nevertheless broad estimates of the damage costs of several categories of organized crime in the EU have been provided in this report. These include human trafficking, cigarette smuggling, VAT fraud, fraud with agricultural and structural funds, fraud against

EU individuals, motor vehicle theft, payment card fraud and insurance fraud (EP 2013, pp. 8- 11). The study draws important distinctions between the direct harm caused by the activities themselves and the "criminal economies of scale", where perpetrators exploit existing crime and social networks and existing technology. It deepens our understanding of the social and economic impacts of the crimes that are linked to the victim's resources, and the nature and patterns of various forms of organized crime (EP 2013).

On national level, the UK undertook an extensive study aimed at an increased understanding of the scale and social and economic costs of some organized crime types. Illegal activities like theft, organized child sexual exploitation, counterfeit currency, drugs supply, organized environmental crime, firearms supply, organized fraud, organized immigration crime, organized intellectual property (IP) crime and organized wildlife crime, fall within its scope. The costs estimated are based on damages done within the UK only (Mills et al. 2013).

Regarding our paper, we consider the socio-economic impact assessment (SEIA) literature - in particular when in "illicit context" - as important reference information for us. In the next section of this paper, our intention is to identify a maximum number of instances of negative socio-economic impacts, in our research context of "six common illicit cross-border freight logistics flows".

3. Literature-based analysis of six common illicit cross-border freight logistics flows

The purpose of this section is to review key literature - both practitioner and academic - in problem characteristics, market volumes and values, logistics routes etc.; and eventually the negative impacts of six common illicit cross-border freight logistics flows. The six illicit flows have been chosen by the study authors, based on previous work conducted by them (note: this list of six flows is not meant to be exhaustive, and it can and should be expanded in future research). In each of the sub-section below, the socio-economic impacts per illicit flow - paragraph comes as the last one.

3.1 Trafficking in illicit narcotics: cocaine and heroin

Heroin and cocaine represent the largest share in the global illicit narcotics markets. According to experts, global drug use in terms of the number of drug dependent users or drug use disorders, has remained more or less stable during the past years (UNODC 2013, p. ix). Global estimates on the total amounts of cocaine manufactured range from 776 to 1,051 tons in 2011, expressed in quantities of 100% pure cocaine (UNODC 2013, p.x). The Andean region, including Colombia, Peru and Bolivia are the main suppliers. The annual market volume consumed in Europe is around 124 tons worth a value of 34 billion USD (UNODC 2010, p. 95). The chief entry points into Europe are Spain and Portugal, while the Balkan routes are increasingly being used for trafficking into South-East Europe (Europol 2011, p. 9). Trafficking mostly occurs via maritime routes and to a lesser extent by air traffic and postal services (UNODC 2010, p.96, Frontex 2012, p. 29). Heroin consumption in Western and Central Europe has been showing a declining trend but its use has been growing in parts of Asia and Africa (UNODC 2013, p.x & p.32). The annual flows into the global market are assessed to be between 430-450 tons. Afghanistan is the chief source followed by Myanmar and Laos (UNODC 2010, p.9). Europe appears to be the main market for Afghan heroin (UNODC 2010, p. 111). Around 87 tons are consumed on an annual basis mostly in Western and central Europe (UNODC 2010, p. 120). The annual consumption in Western Europe alone is worth approximately 20 billion USD (UNODC 2010, p. 110). Heroin is mostly trafficked into the EU via the Eastern Mediterranean route, at the Turkish borders (Frontex 2012, p. 28). However recent years have witnessed a remarkable proliferation of new, emerging routes such as the Black Sea and the Balkan routes (Europol 2011, p. 8). The bulk of the heroin flow enters Europe by sea and air, while the Balkan routes rely primarily on road transportation (UNODC 2010, p.120).

Socio-economic impacts: Drug addiction has consequences for public health and safety, employment and productivity, environment, criminal activities and other dangers for civil society. Cocaine, heroin and other opiates are strongly associated with drug-related deaths and the spread of blood-borne and sexually transmitted diseases like AIDS and Hepatitis C, through needle sharing (less in cocaine) and prostitution, increasing healthcare costs (UNDCP 1995, pp. 31-33 & UNODC 2010, p. 109). Driving under the influence of drugs is a common cause of road accidents and resultant injuries and deaths. Drug abuse is linked to unemployment, destroying human capital and creating economic burdens to society. Drug addicts in the workforce have low rates of productivity and create significant costs to the business sectors, reducing the competitiveness (UNDCP 1995, pp. 16-17). School children will often have impaired psychological and social development which decreases their potential and future employment opportunities (UNDCP 1995, p. 35). Narcotics production has been known to cause inflation in countries like Afghanistan and Bolivia, where the cost of food articles rose due to increased narcotic cultivation (UNDCP 1995, p.25). It has profound effects on ecosystems: coca and opium poppy plantations are associated with massive deforestation, disappearance of rainforests (applies mainly for cocaine), soil erosion, improper disposal of toxic wastes, overuse of chemicals, overuse of land and so forth (UNDCP 1995, pp. 36-37). Moreover, drug users raise their likelihood of engaging in criminal activities like petty theft or burglary, in order to finance their addiction. A report on heroin addicts revealed some 90 percent to have resorted to shoplifting or burglary to finance their drug purchases (UNDCP 1995, p. 37). Further, the illicit drug industry frequently incites serious violence. A notable example is Colombia, where narcotics trade has been associated with a vast number of killings (UNDCP 1995, p. 38). Finally, drug trafficking has destabilizing effects on the economy. The “drugs-for-arms” trade, refers to the vicious circle where drug businesses financially support warlords and militants, who in turn are directly involved in drug trafficking. These activities have deleterious consequences on governance, security and the authority of the state (Ward and Byrd 2004, p.36).

3.2 Trafficking in counterfeit products

Counterfeit products constitute a breach of Intellectual Property Rights (IPR). It refers to “contraband activities which are a form of theft and involve the illegal production and sale of goods which are intended to pass for the real product" (FIA 2001, p.10). The problem of counterfeiting has escalated with the development of a free global market and the recent trend of outsourcing manufacturing activities to developing countries offering cheaper labor force but with weaker regulatory regimes, thus creating opportunities for unwarranted production (UNODC 2010, p. 173). Electronic products are one of the most common classes of counterfeited goods, while apparel - clothing, accessories and shoes - remains the most dominant category of counterfeits (UNODC 2010, pp. 173). Recent years have witnessed a surge in counterfeit pharmaceutical medicines and lifestyle drugs (Europol 2011, pp. 27-28). The International Chamber of Commerce (ICC) frequently cites counterfeiting to account for 5-7% of world trade that translates into 600 billion USD per year, whereas the Organization for Economic Cooperation and Development (OECD) estimated the value of counterfeit and pirated goods at 176 billion USD in 2007, accounting for 2% of the world trade in goods (UNODC 2010, p. 173). China is the main country of provenance for counterfeit products finding their way into the EU, particularly in the context of cigarettes, clothes, shoes, toys and pharmaceuticals. While sea is the main conveyance for larger volumes of imports, smaller consignments are being sent via air and by post (UNODC 2010, 179). The annual market volume entering the EU from East Asia has been roughly estimated as two billion articles per year, worth about 8.2 billion USD at destination (SANGEEETA16, p.175).

Socio-economic impacts: The negative impacts of counterfeiting are many. Counterfeit manufacturing directly hurts licit businesses as they suffer from IPR infringements. For example, the WHO estimates the annual losses to the pharmaceutical sector at 45 million EUR (UNICRI 2012, p. 34). Legitimate companies also tend to accrue losses through reputational damage as consumers unsuspectingly buy duplicate low quality products assuming them to be the bona fides (OECD 2007, p.18). As lawful businesses lose competitiveness, they cut down on retail and manufacturing jobs, ultimately leading to loss of innovation and reducing employment (Europol 2013, p.1). Counterfeit products put public health in jeopardy. Spurious drugs have reduced therapeutic value, cause patients to develop microbial resistance, or even lead to deaths through a complete therapeutic failure (UNICRI 2010, pp. 27-28 &.184). Other fake commodities like cigarettes, cigarette lighters, mobile phones, batteries, toys, and clothing may contain toxic substances and other elements endangering human health. Counterfeit alcoholic drinks are known to have caused several deaths in Europe and beyond. (UNODC 2010, p. 173 & Europol 2013, p.2). Counterfeit production has been associated with serious labor rights violations, negligence of workplace safety, environmentally unsound practices, illegal labor and underpayment (UNODC 2010, p.174 & UNODC 2010, p. 176). This unscrupulous practice implies fiscal losses to the state as legitimate companies experience a reduction in sales, and fake commodities undermine the tax base by evading customs duties and sales tax / VAT through smuggling and informal retailing (UNODC 2010, p.176, UNICRI 2012, p.35). Other indirect losses to the states and governments may arise from this illegitimate activity. The presence of counterfeits can be a deterrent to foreign investors. Further, legitimate companies may raise the price of drugs to offset their losses, implying additional economic burden to national health services (UNICRI 2012, pp. 34-35). Law enforcement authorities face logistical challenges from the increasing volumes of seized counterfeit goods, in terms of storage capacities and disposal which can be a technically complex and costly operation. Finally, counterfeit businesses can contribute to political unrest as the illicit profits fuel other criminal networks like terrorist organizations (OECD 2007, p. 15).

3.3 Trafficking in ozone depleting substances

Ozone depleting substances (ODS) primarily include chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs) and halons, which are used for various purposes like refrigeration, air-conditioning, fire-fighting and crop protection (UNODC 2012, p.115). They are one of the worst pollutants linked to soil, water and air contamination, the most worrying possibly being the thinning of the ozone layer. The public concern over this alarming phenomenon led to the establishment of the Montreal Protocol on substances that deplete the ozone layer, in 1987. Several controls were put in place in the EU and the USA on the production and trade of these harmful chemicals (UNEP 2011, p. 3). Despite all efforts the controlling mechanisms appear to be easily circumvented and the illicit trade of ODS continues to thrive (UNEP 2011, p.3).

Socio-economic impacts: Illicit imports and use of ODS lead to a series of problems. The thinning of the ozone layer results in increased ultra-violet (UV) radiation reaching the earth surface. Stronger UV rays harm human health by attacking the immune, respiratory and digestive systems. They cause significant damage to eyes and raise the risk of skin cancer. Marine ecosystems are destroyed when increased UV radiation reduces the productivity of small organisms like plankton that form the basis of the marine food chain. Strong solar UV radiation impacts agriculture and forest ecosystems. It destroys crops leading to a reduction in plant yield and also damages trees. Thus, illegal imports of ODS pose multiple challenges and problems to public health, environment, agriculture and food security (UNODC 2012, pp. 114- 115).

3.4 Trafficking in small arms and light weapons

Small arms and light weapons (SALW) refer to the category of weapons that can be operated and transferred by single persons, as opposed to “heavy weapons”. Small arms include revolvers, self-loading pistols, rifles and carbines, sub-machine guns, assault rifles, and light machine-guns. Light weapons consist of heavy machine-guns, grenade launchers, small mortars, mobile anti-aircraft and anti-tank guns, mobile rocket launchers, shoulder-fired anti-aircraft missile launchers, and mortars of calibers under 100 mm (Council of the EU 2006, p.4).The illicit SALW circulation exploits mainly the maritime and land freight modes rather than the air freight, most likely since surface transport is marked by fewer detection mechanisms and is less costly. Experts estimate around 639 million SALW to be in circulation around the globe, produced in 90 countries with 1500 companies involved in the SALW trade. The illicit SALW market is estimated at 1 billion USD (Council of the EU 2006, p. 4).

Socio-economic impacts: It is estimated that SALW are exploited in 500,000 killings each year, including 300, 000 in armed conflicts. Since 1990 SALW has cost the lives of approximately 4 million people globally, and have forced over 18 million people to leave their homes and countries (Council of the EU 2006, pp.2-3). SALW related violence keeps robbing communities of scarce public health and natural resources, and impedes opportunities for investment and rebuilding after conflict (Council of the EU 2006, p. 4 & p.10). In conflict ridden areas access to education for children is limited and other economic opportunities are reduced, exacerbating poverty for millions of families. Children are often abducted to serve as child soldiers (Council of the EU 2006 2006, p. 4). Many rebel groups in possession of illegally obtained SALW are frequently involved in other illicit trade to fund their operations (Council of the EU 2006, p. 10). Violent conflicts cause internal displacement contributing to the spread of diseases like malaria, tuberculosis, AIDS etc., putting pressure on medical resources (Council of the EU 2006, p. 14). The proliferation of illicit SALW is undeniably an immense threat to global security, peace, stability, global health and economic development.

3.5 Trafficking in stolen cultural property

This criminal activity is fuelled by the demand from the art market, the opening of borders, the improvement in transport infrastructures and the existing political instability in certain countries. The regions particularly affected by this criminal activity are Europe, Latin America, Middle East, North and Sub-Saharan Africa and South-East Asia. The most common targets are private homes, museums and places of worship. The types of objects stolen greatly vary from country to country but generally speaking, paintings, sculptures, statues and religious items are some of the most coveted artefacts. Quantifying the value of trafficking in cultural property is not an easy matter due to the clandestine nature of this activity and where illegal items are often mixed with legal ones, making it difficult to distinguish between legitimate and illegitimate trade.

Socio-economic impacts: Apart from economic damage, the most obvious impact of stealing and trafficking cultural property is a loss of cultural heritage, stripping a country of its memory, history and identity. Looting and pillaging become rampant in times of war and crises, such as recently in Iraq, Egypt, Mali and Syria. Private owners can experience a great sense of sorrow and loss of cultural identities and values. Illegal excavations pose a threat to future archaeological research of the sites by ruining the scientific and historical context of the single finds. Lastly, criminals rackets engaged in this illicit trade are frequently connected to other forms of organized crime, backing other illegal operations.

3.6 Trafficking in endangered species: wildlife and timber

Trafficking in endangered species- particularly in wildlife and timber- ranks among the most profitable illicit businesses across the globe. Weak regulatory capacity, political conflicts, corruption and extensive poverty in source countries along with lucrative foreign markets and the abnormally high profit margins are large contributors to the overall problem (UNODC 2010, p. 152). The low risk of detection and weak penalties for perpetrators do not successfully thwart these criminal operators (IFAW 2013, p. 5).

The scale of poaching activities has reached unprecedented heights and three large wildlife species - elephants, rhinos and tigers - face the most immediate threat of extinction. These mammal species are mainly hunted for their skins, bones, horns and other body parts for medicinal, decor, household use and other purposes. (UNODC 2010, p. 153). Sub-Saharan Africa and South-East Asia are the principal source regions of illicit wildlife products, including elephant ivory, rhino horn and tiger parts, whereas China, the USA and the EU are the largest consumers (Haken 2011, p. 12). The annual value of ivory entering the global market is estimated at 100 million USD. A kilogram of raw ivory could fetch about 850 USD. The price of one kilogram of powdered rhino horn can reach almost 30,000 USD. Tiger parts also carry exorbitant prices with skins selling for as much as 20,000 USD and a kilogram of bones fetching up to 1,200 USD.

For timber, trafficking from South-East Asia to the EU and other parts of Asia represents one of the largest illicit flows (UNODC n.d., p.2). The annual value of the illegally felled timber passing through this route was estimated at 3.5 billion

USD, with an annual market volume of 10 million cubic meters. The primary source is Indonesia and the government claims to be losing 4 billion USD annually due to this unlawful activity. The use of fraudulent documents – either forged or bought from corrupt officials in source countries - is the most common means to facilitate smuggling timber across borders.

Socio-economic impacts - wildlife: Apart from causing undue suffering to animals, wildlife trafficking is associated with a multitude of problems. The most visible impact is the potential threat of extinction. There are now an estimated 3,200 tigers, 50,000 elephants and 16,000 rhinos surviving in the wild (UNODC 2010, p.55 & Haken J. 2011, p. 11). The annihilation of animal species causes major losses to the global ecosystem and biodiversity. The loss of exotic wildlife hurts the tourism industry of source regions, including hotel, restaurant and rental businesses. A smaller inflow of tourists also means less air traffic implying losses to the airline industry. National parks incur significant economic losses through poaching activities in their premises as in the case of Namibia. For destination countries cross-border wildlife trade poses threats to public health where illicit flows prevent national health authorities from investigating the health risks posed by some animal species (Haken J. 2011, pp. 13-14). Profits accrued from wildlife trafficking are used to fund militant operations, fuelling civil conflicts in politically unstable states. (Lawson and Vines 2014, pp. 8-9 & Haken J. 2011, p. 14). This has serious implications for national and global security. Illicit wildlife trade puts human lives at stake and presents perils to communities surrounding wildlife habitats. Criminals terrorize and exploit people in rural communities, lure poachers and exacerbate corruption in enforcement offices and are responsible for killing many park rangers (IFAW 2013, p.10). Further, illegal wildlife trade has linkages with other forms of organized crime, including drug trafficking and money laundering. Drugs get smuggled within wildlife consignments and wildlife products are bartered for drugs or weapons. Highly sophisticated money-laundering tools are used by wildlife traffickers to camouflage their activities (IFAW 2013, pp. 14-16).

Socio-economic impacts - illicit timber. Similarly, the illegal trade of timber has deleterious consequences. First and foremost, it is linked to massive deforestation. The most heavily impacted region is South-East Asia that provides habitat for rare animal species. Lost forest cover can wipe out animal species in incredibly short time spans, destroying entire ecosystems (UNODC 2010, p. 163). Soil erosion, increased risk of landslides and floods, accelerated global warming caused by higher carbon stock, are other environmental repercussions. Extensive timber operations by powerful interest groups have been largely responsible for displacing communities from their ancestral lands, leading to loss of livelihood and aggravating poverty (UNODC 2010, p.166). Moreover, local inhabitants are plainly exploited by Illegal logging companies who make massive profits from the timber acquired from them at throwaway prices. Like many other organized crime types, illicit revenues from timber trafficking contribute to funding insurgent groups, aggravating political instability (Haken J. 2011, p.42). Finally, the practice of Illegal logging and trade in timber without the payment of duties and taxes drives down world market prices of timber. As market prices fall, other loggers are tempted to follow the same practice. The global market losses are estimated to be around 10 billion USD and governments losses 5 billion USD in revenues, per annum.

4. Summarizing the socio-economic negative impacts of the various illicit flows

Building on the findings from the previous section, the purpose of this section is to summarize the negative socio-economic impacts of the various illicit flows, starting with following two perspectives:

- 1. Negative impacts at the destination country / region (Table 1)
- 2. Negative impacts at the source country / region (Table 2)

Both of these tables have now seven illicit flows, instead of the original six, as endangered species has been split to wildlife and timber, due to the differences in the socio-economic impacts between the two.

After these two tables, as the last step of summarizing our findings in previous section of this paper, an integrated matrix is presented to map the negative socio-economic impact categories per illicit flow type.

Below in Figure 1 is the mapping between the socio-economic negative (SEN) impact -categories against each illicit flow type, combining the findings from origin and destination countries / regions, as presented separately in tables 1 and 2 above.

Illicit flow	Negative socio-economic impacts at the destination
Trafficking in cocaine and heroin	Impacts public health, employment, productivity, drives up social welfare costs, triggers criminal activities and violence, fuels other organized crime types.
Trafficking in counterfeit products	Hurts licit businesses, loss of tax revenue, impacts public health, deters foreign investment, puts pressure on healthcare services, puts pressure on law enforcement authorities (storage and disposal).
Trafficking in ozone depleting substances	Environmental damage, climate change, impact on human health, impact on agriculture and food security.
Trafficking in firearms	Widespread killing, robbing of natural resources, impedes investment and rebuilding, deters education, worsens poverty, impacts public health through spread of diseases.
Trafficking in stolen cultural products	na
Trafficking in wildlife	Threats to public health through spread of animal-borne diseases, fuels other organized crime types and fraud.
Trafficking in timber	Losses in tax revenues, environmental damage

Tab. 1: Negative socio-economic impacts at the destination country / region

Illicit flow	Negative socio-economic impacts at the origin
Trafficking in cocaine and heroin	Human suffering, environmental damage, causes inflation (some cases), incites violence, fuels other organized crime types and political stability.
Trafficking in counterfeit products	Hurts licit businesses, violates labor rights, causes environmental damage.
Trafficking in ozone depleting substances	Environmental damage, climate change, impact on human health, impact on agriculture and food security.
Trafficking in firearms	na
Trafficking in stolen cultural products	Loss of national cultural heritage, economic loss to state, damage and destruction through looting and pillaging, sorrow and economic loss to private owners, threatens archaeological research.
Trafficking in wildlife	Animal cruelty, ecosystem and biodiversity loss, feeds corruption, impedes economic growth (losses to tourism and aviation sector), creates unemployment, losses to national parks, fuels other crime types and fraud, causes exploitation of local communities and triggers violence (e.g. killing park rangers).

Illicit flow	Negative socio-economic impacts at the origin
Trafficking in timber	Environmental damage (landslides, floods, soil erosion, global warming), threatens survival of animal species, exploitation of local communities, loss of livelihood, fuels other organized crime types, contributes to political instability.

Tab. 2: Negative socio-economic impacts at the origin country / region

In total there are six categories of SEN, presented as columns in the matrix, first explained in the list below:

- SEN1: Losses in tax revenues regarding indirect border taxes
- SEN2: Increasing health care and social security costs
- SEN3: Increasing market place distortions and/or unfair competition
- SEN4: Increasing environmental damages
- SEN5: Increasing human suffering
- SEN6: Losses in cultural heritage

Type of illicit cross-border flow	SEN1	SEN2	SEN3	SEN4	SEN5	SEN6	Notes
Trafficking in cocaine and heroin		*YES*		*YES*	*YES*		*na*
Trafficking in counterfeit products	*YES*	*YES**	*YES*	*YES**	*YES**		**Note1*
Trafficking in ozone depleting substances		*YES*		*YES**	*YES*		**Note2*
Trafficking in firearms		*YES*			*YES*		*na*
Trafficking in stolen cultural products						*YES**	**Note3*
Trafficking in wildlife		*YES**	*YES**	*YES*			**Note4*
Trafficking in timber	*YES*		*YES*	*YES*			*na*

Fig. 1: Integrated matrix mapping the socio-economic negative (SEN) impact - categories against each illicit flow type

The four pieces of notes, as indicated on the rightmost column of the matrix above, are explained next:

- Note1: With counterfeit products one may face five of the six categories of negative socio-economic impacts (excluding SEN6, losses in cultural heritage), depending on the product type; counterfeit pharmaceutical products being an extreme example.
- Note2: Trafficking in ozone depleting substances may have negative impacts for the future agriculture and food production.
- Note3: Next to the loss of actual cultural products, this illicit flow may disturb / threaten archeological research activities.
- Note4: May lead to increasing unemployment rates in the tourism sector at the origin countries, as less tourists travel there to see the wildlife.

Lastly, following four aspects were excluded purposefully from this summary matrix:

- 1. One could consider that each illicit flow may lead to losses in tax revenues regarding indirect border taxes, while consumers ultimately purchasing these illicit products have then less money to buy licit products.
- 2. One could consider increased regulatory, law enforcement, judicial and penitentiary costs for each of the illicit flows.
- 3. One could consider increased organized crime activities as a "side cost" for each of the illicit flows, e.g. when illicit economic gains are reinvested into parallel criminal activities.
- 4. One could consider increased petty / opportunistic crime activities as a "side cost" in particular for illicit narcotics trafficking, as drug users commonly fund their purchases via petty theft etc.

5. Conclusions and topics for future research

The objective of this paper has been to provide a clear, robust picture of common illicit cross-border flows of goods, including their socio-economic negative impacts both at destination and at source; particularly in order to facilitate enhancements in governmental policies and corresponding regulations, enforcement priorities, inspection schemes and other countermeasures in fight against illicit, in the context of global supply chains and freight logistics systems. The main outcome of this paper has been the integrated matrix to map the socio-economic negative impact –categories (in total six) per each illicit flow type (in total seven, following splitting endangered species into two). The most common impact categories were following two, both with five “illicit flow matches”: Increasing health care and social security costs; and Increasing environmental damages. On third position is increasing human suffering (four matches); followed by Increasing market place distortions and/or unfair competition (three matches). The last ones were Losses in tax revenues regarding indirect border taxes (two matches) and Losses in cultural heritage (one match). Ultimately, it is left for politicians on both national levels as well as on international agreement levels to set weights and priorities within the various illicit flows, in terms of future policy and regulatory development, enforcement priorities and actions and so forth.

Finally, several sub-topics call for future research, including the following five:

- With all flows: Quantification of both the illicit market sizes (value, volume etc.) and the socio-economic negative impacts (monetary and non-monetary, whenever feasible).
- With all flows: Distinguishing between import “freight logistics flows versus other modalities (e.g. passenger luggage and inside body)”.
- With some flows, e.g. counterfeit products: Distinguishing between “domestic production versus 3rd country imports”, while assessing the problem size etc.
- With some flows, e.g. firearms: Distinguishing between “legally versus illegally imported” products, while assessing the problem size etc.
- Beyond the illicit flows presented in this paper: Expanding the analysis to cover various forms of fiscal fraud, quota violations, trafficking in human beings, currency export / import violations etc.

Acknowledgements

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Product Recalls in the Meat and Poultry Industry: Key Drivers of Supply Chain Efficiency and Effectiveness

Vijaya Chebolu-Subramanian and Gary Gaukler

Abstract

There has been a significant increase in the number, size, and severity of food product recalls in the United States in the past decade. Additionally, the pressure to reduce costs has caused many food supply chains to off-shore production activities, making the logistics of recall events more challenging and costly for these supply chains. Thus, there is a strong need for research that can help identify the determinants and key drivers of supply chain efficiency and effectiveness with respect to food recall events. We focus our investigation on meat and poultry supply chains in the United States. Through an empirical analysis of over 500 recall events recorded in the government tracking database during the 2005-2013 period, we identify and test key factors that impact the product recall process in contemporary food supply chains. We conduct a statistical regression analysis to examine the impact of recall strategy, hazard type and the supply chain entity detecting the hazard on the time to recall and the amount of product recovered at closure. Future work also aims to investigate the impact of supply chain structure, reverse logistics and the potential impact of traceability (e.g., RFID) and condition monitoring (e.g., temperature sensors) on recall outcomes.

Keywords: supply chain management, food recalls, meat and poultry industry, safety hazards

1. Introduction

Over the past decade the size, severity and number of food products recalled in the United States has increased significantly. Additionally, in the year 2003 most recall cases were categorized as class I recalls, i.e., for foods that pose the greatest risk of illness or death (Dyckman and Lansburgh, 2004). The increasing complexity of food supply chains and off-shore production activities is making the logistics of recall events more challenging and costly for these supply chains (Roth et al., 2008). There is also no specification or emphasis on product safety for products thus sourced which makes them more vulnerable to the risk of recalls (Lyles et al., 2008).

Recalls are often costly and have a damaging impact on the entities involved. For example, in January 1999 samples from a meat and poultry processing plant in Arkansas of the Thorn Apple Valley Inc Company tested positive for listeria. The plant operations were shut down and products worth $30 million were recalled. As a result the Thorn Company faced $ 5.1 million in losses of production and sales and reported $184 million as debt and filed for bankruptcy (Skees et al. 2001).

Raw foods of animal origin such as meat and poultry are found to be the most likely to be contaminated and susceptible to foodborne illness carrying pathogens such as listeria as compared to other food groups. Also foods that mingle the products of many individual animals, such as ground beef, are particularly hazardous because a pathogen present in any one of the animals may contaminate the whole batch. For example a single hamburger may contain meat from hundreds of animals or a broiler chicken carcass can be exposed to the drippings and juices of many other birds that went through the same cold water tank after slaughter (Centers for Disease Control and Prevention Food safety, 2011). According to Kramer et al. (2005), most major meat processors in the U.S. have been involved in a recall at some point in time. Consequently, we focus our investigation on meat and poultry supply chains that sell products to end customers in the United States.

The initiation of a product recall primarily occurs as a result of periodic quality control inspections carried out by regulatory agencies or firms themselves in the supply chain. Other less frequent modes of detection are through customer complaints or foodborne illness outbreaks (Teratanavat et al., 2005), (Dyckman and Lansburgh, 2004). The product recall is then communicated to the public through a recall announcement issued by the Food and Safety Inspection Services (FSIS) or the United States Department of Agriculture (USDA). This is followed by efforts by the firm to recover the entire recalled product spread along the supply chain. The closure of the case is recorded on satisfactory completion of the recall process as evaluated by the firms themselves and the regulatory agencies (FSIS-USDA recalls and public health alerts, 2014).

The increase in product recalls has led to an increasing acceptance by companies, consumers, regulators and investors that recalls are an inevitable part of conducting business and the focus has now shifted to the timing and timeliness of a recall (Berman, 1999) (Hora, et al, 2011).

The time it takes to recall a product and the amount of product recovered has a direct impact on the cost and severity of a recall event. As the time to recall increases the amount and spread of the recalled products increases as more products make their way into the hands of the consumers (Smith et al. 1996), (Berman, 1999), (Hora et. al, 2011). This in turn may have lead to an increase in investigation costs, reimbursement costs, medical costs etc. Consumers also expect a more efficient and effective recall from a brand of high reputation (Dawar and Pillutla, 2000). Therefore an increase in the time to recall and amount of product recovered may have an effect on liability costs and brand value.

However, the “time to recall” has been given different connotations in research reflecting in its various operational definitions. Johnson-Hall (2012) measure it as the time between the beginning of the shelf life of the last produced product and the issue of the recall announcement and Hora et al. (2011) measure it as the time between the first sales of the recalled product and the time of the recall announcement. Tertanavat et.al (2005) denotes it as the “completion time” and quantifies it as the time between the announcement of the recall and the completion of the recall case.

In our work unlike in previous research we define the “time to recall” as the difference between the initial time of production of the product and the time of the recall announcement. A hazard in a product can be detected anytime starting from the first production of the product in the supply chain. A lower time to recall indicates an efficient upstream detection of the hazard close to the time of its production and this in turn will minimize the impact of the recall as the possibility of the product spreading through the downstream supply chain and reaching the customer will be preempted (Hora et al, 2011), (Johnson-Hall, 2012). Therefore through our definition of the “time to recall” we aim to analyze key factors which influence the detection efficiency of a recall.

Once a product has been recalled it is the responsibility of the firm recalling the product to trace, track and effectively recover the entire recalled product from the supply chain and also inform all the other affected entities of the recall. The FSIS and USDA also determine the effectiveness of a recall by conducting "effectiveness checks" to ensure that all entities in the supply chain are aware of the recall and that the recalled product has been completely recovered (FSIS-USDA recalls and public health alerts, 2014).

A lower time to recall implies a quicker detection of the hazard which in turn may lead to a more effective recovery of the product in the supply chain as the spread of the product through the downstream supply chain, specifically to the consumer will be minimized. This is especially true of perishable products with shorter shelf lives as compared to durable products as the consumption or disposal of the product near the end of its shelf life will impact recovery rates (Johnson-Hall, 2012). We also analyze whether factors impacting the “time to recall” have a similar impact on “amount of product recovered”. Through this we aim to gain insights into the supply chain visibility and tracking capabilities of the recalling entity and its partners.

Figure 1 illustrates the various stages in the recall timeline. It also depicts the specific period of the recall timeline, the products and the time span of the data under scrutiny in various studies in literature and the focus of our research.
In line with recent work we aim to test the efficiency and effectiveness of meat by measuring the “total time to recall” and the “recovered product” of an event according to our definition through an empirical study of meat and poultry recalls during the period 2005-2013.

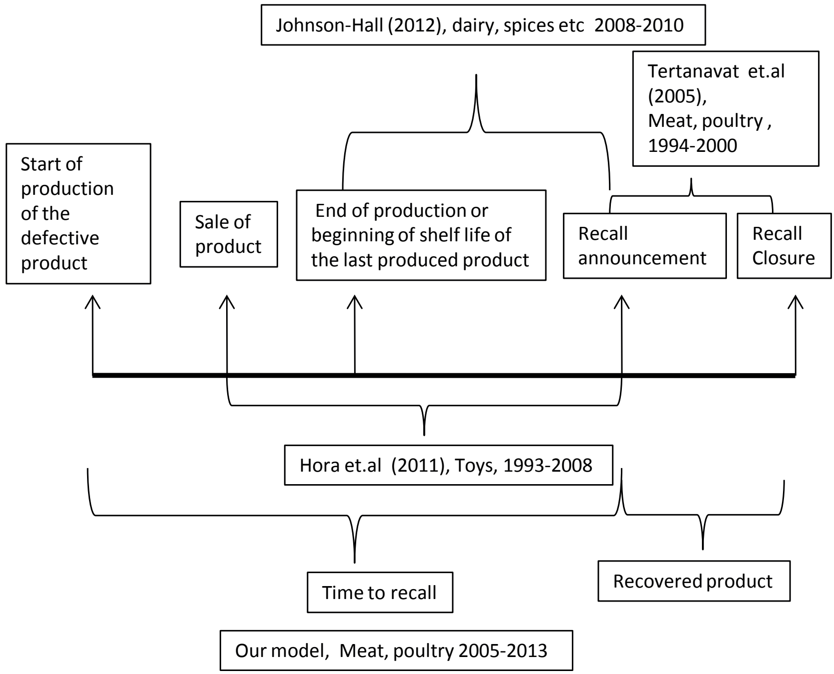

Fig. 1: Focus of literature and our model

2. Related Literature

Research in the area of food contamination has dealt with a range of issues from investigations on the effectiveness of recall operations as well as predictive models for bioterror attacks and implementation of traceability systems. Here, we provide a broad overview of related research and the narrow down the scope of our work.

There are several papers in literature which attempt to arrive at a better understanding of a food contamination event by using an “event study” approach to analyze consumer perceptions, stock market reactions and loss of brand equity post product recall. For example, Jonge et al. (2007) attempt to understand the determinants influencing consumer perceptions of food safety incidents. Marsh et al. (2004) empirically test the shift in consumption patterns and change in consumer demands in the face of a food contamination event.

There are other papers which analyze the fallout of a food contamination event on shareholders, stock markets and company valuations (Salin and Hooker, 2001).

The use of mathematical modeling and simulation for a specific case of food contamination has also been the theme of other work in this area. For example, Weiser et al. (2013) utilize network graphs to trace back an e.coli outbreak in Germany along the supply chain and Tromp et al. (2010) use specific historic data to model the transmission of salmonella through a broiler supply chain.

However, in a recent survey Akkerman et al. (2010) review quantitative operations management approaches to food safety and quality and stress the need for more research in this area.

Johnson- Hall (2012) also states that although the USDA and the FDA (Food and Drug Administration) recommend that recalls should be issued promptly and completed there are no regulations in place to enforce this and in most cases the authorities are unaware of how companies carry out the recalls. Therefore recent studies stress the need for extensive work in this area that can help identify key drivers of supply chain efficiency and effectiveness with respect to food recall events.

From an empirical and statistical data analysis perspective Hora et al. (2011) investigate the major factors influencing the time to recall in the toy industry and attempt to address the question of why it takes so long to recall a defective product.

Meat and poultry recalls are regulated by the USDA and FSIS while the FDA regulates other food products such as vegetable, fruits and dairy products. A testimony to a senate subcommittee states that though both agencies engage in inspection activities their authorities, responsibilities, policies, procedures, training and enforcement strategies are quite different (FSIS testimony, 2005).

Johnson-Hall (2012) analyzes the influence of supply chain factors on recalls administered by the FDA through an econometric analysis of recall data. However this study does not analyze the amount of recovered product at closure. In our work by investigating meat and poultry recalls administered by the USDA we also hope to compare and contrast the impact of agency level differences on recalls.

Teratanavat et al. (2005) analyze meat and poultry prior to the year 2000. They use statistical regression to analyze impact of size of firm, stock market reaction, and difference between firms which implemented food quality safety process and firms which have not on the recall process. In our work we study the influence of recall strategy, detection entity and hazard type on the efficiency and effectiveness of a recall.

Mainly, as depicted in Figure 1 through our analysis of the time to recall and amount of product recovered we aim to gain insights into pre as well as post contamination capabilities (detection and tracking) of supply chain entities. Therefore we hope that this work will contribute to the current body of literature on recalls.

3. Methodology

In the following sections we present our data for this study and describe the variables and the modeling methodology.

3.1 Data

Data is recorded for meat and poultry recalls from the USDA-FSIS recall tracking database for the years 2005 -2013 for all completed recall cases, i.e., cases closed and moved to the archive (FSIS-USDA recalls and public health alerts, 2014).Therefore recent years such as 2013 may still have open ongoing recalls. The cases prior to 2005 do not contain complete data and are not considered.

Our initial sample consisted of 570 cases (Figure 2). It should also be noted that the USDA-FSIS online database is a dynamic list, as cases get closed the FSIS moves records from "current" list to the "archives" adding to the number of completed cases.

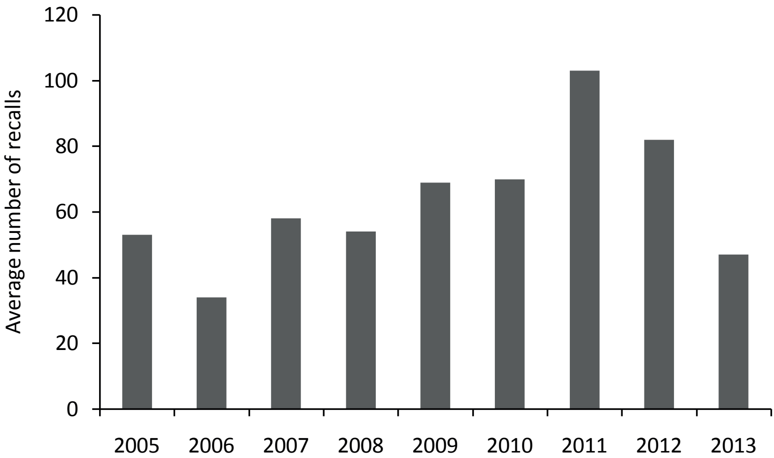

Fig. 2: Annual number of meat and poultry recalls

A recall announcement is issued by the recalling firm independently or on the recommendation of the FSIS. The recall announcement on completion contains the following information:

1. Date of the recall

2. Name of the recalling company (e.g. National beef packing, Taylor farms)
3. Product type (e.g. Beef sausage, Pork pie, Chicken dip)
4. Position (in some cases) and location of the recalling entity (e.g. processing center from Washington, supplier from Pennsylvania)
5. Scope of recall: List of states across which the recall was initiated
6. Hazard type: The hazards described in the data can be classified as:
   a. Mislabeling: This hazard occurs when the company mislabels the ingredients in the product, interchanges labels between products, changes product content but does not change the corresponding label etc. These errors may in turn lead to omission of the list of allergens in the product which the customer needs to be cautioned against, e.g.: milk, eggs and peanuts.
   b. Contamination: Contamination in the product may occur due to pathogens (e.coli, listeria), presence of foreign matter (plastic pieces, metal) or when certain required production practices are not followed (undercooking of meat, temperature not maintained).
   c. Violation of regulations by firms: e.g. an uninspected facility in production, lack of food safety processes.
   d. Others: A small number of announcements do not have any specified hazard type.
7. Injuries/illnesses (if any)
8. First and last date of production: The recall announcement consists of a series of products; therefore we record the first and last production date over all the products listed.
9. Best before date for the product (earliest and latest): We record the earliest and the latest best before dates over all products listed in the announcement.
10. Mode of discovery of the hazard and entity discovering it:
    a. Inspection or investigations conducted by supply chain entities or the FSIS

   b. Reports of injury/illness to consumers tracked by FSIS or other regulatory authorities and linked to a certain product
   c. Customer complaints: The customer in this case may be a third party customer such as a food service provider and not necessarily a retail consumer.
11. Hazard level classification: The recalls are classified into the following levels according to severity:
   a. Class I: For products that predictably could cause serious health problems or death.
   b. Class II: For products that might cause a temporary health problem, or pose only a slight threat of a serious nature.
   c. Class III: For products that are unlikely to cause any adverse health reaction, but that violate FDA labeling or manufacturing regulations.
12. Number of units of the product recalled (in lbs)
13. Number of units of the product recovered on recall closure (in lbs)

We conduct an initial scenario analysis of the recall process and correlate it to the data above as depicted in Figure 3.

3.2 Model

We now describe the variables in our model.

Dependent variables

The dependent variables in our model are the time to recall and amount of product recovered.

1. Time to recall

The time to recall is the difference between the time the product is first produced and the time of the recall announcement. The recall announcements may include several product varieties, for e.g.: the September 2013 product recall by Siberoni in Oregon involved beef pelmeni (ravioli) and chicken pelmeni. In the case of several production dates for products in a given announcement we record the earliest production date in the given product list. The date of recall is recorded directly from the case record.

The detection time ranged from 1 to 1096 days for the cases considered from 2005-2013. A natural log transformation of the number of days for the time to recall was utilized to eliminate any skewness.

Time to recall = Time of recall announcement - Time of initial production of the product

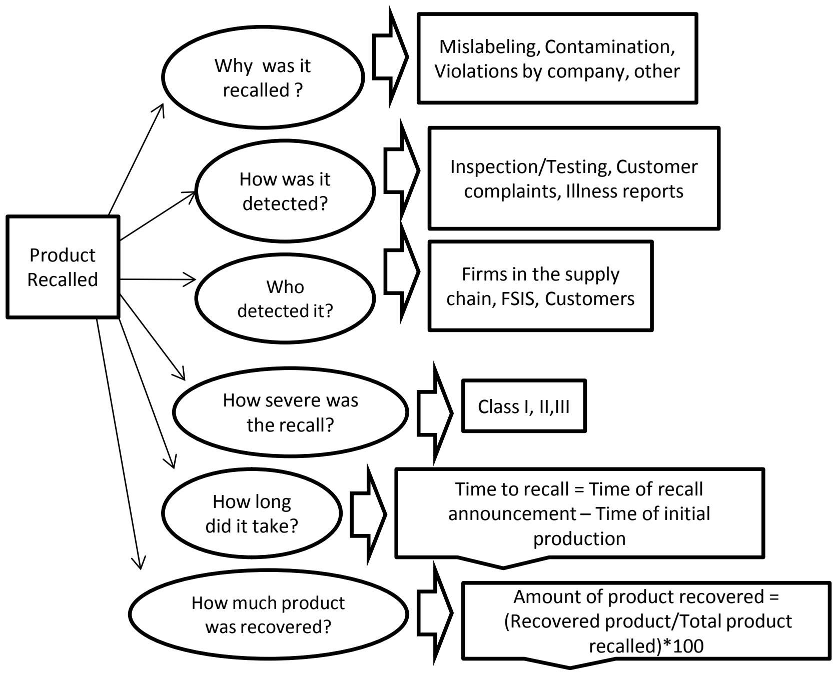

Fig. 3: Scenario analysis

2. Amount of product recovered

The amount of product recovered at the closure of the recall is recorded in the case details issued by the regulatory agencies. However, the probability of a larger amount of product being recovered is more when the amount of product initially recalled is larger. Therefore as in Tertanavat et al. (2005) we record the amount of product recovered relative to the total product recalled as a percentage.

Amount of product recovered (%) = (Amount of product recovered/ Total product recalled)*100

Independent variables

The independent variables in our model are the recall strategy, supply chain entity detecting the hazard and hazard type.

1. Recall strategy

Recall strategies have been characterized relative to whether or not illness or injury has been associated with the defective product at the time of the recall (Chen et al., 2009), (Hora et al., 2011). Johnson -Hall (2012) state that preventitive recall strategies are indicated when no injuries or illnesses related to the defective product have been confirmed prior to the recall. In contrast, reactive recall strategies are indicated when injury or illnesses have been confirmed and are linked to the defective product prior to the recall.

Preventive recall strategies have been associated with delays in recalls in prior studies as companies may have a tendency to delay recalls to prevent repercussions on their stock value, brand etc (Chen et al., 2009), (Hora et al., 2011). However, Johnson-Hall (2012) find that these results do not hold for food products primarily because recalls associated with an illness are largely underreported.

We test a similar hypothesis as in literature for our data to confirm whether it holds for meat and poultry recalls. We also hypothesize that a preventive recall strategy will be associated with a larger amount of product recovered as the occurrence of illnesses indicates downstream spread and consumption of the product thus hampering recovery efforts which is absent in this scenario. As in other studies we code 0 for reactive and 1 for a preventive strategy.

- *Hypothesis 1: Product recalls with preventive recall strategies are associated with a longer time to recall as compared to those with reactive recall strategies.*
- *Hypothesis 2: Product recalls with preventive recall strategies are associated with a larger amount of recovered product as compared to those with reactive recall strategies.*

2. Detection entity

As seen in the data description in section 1.3.1 the detection entity which detects the hazard in the product can be the firm or its supply chain partners, regulatory agencies (FSIS, USDA, CDC etc) or a customer. It has been hypothesized in previous studies that recalls detected by external entities (customers and regulatory agencies) indicate a lower recall detection competence of the supply chain entities and will have a longer time to recall, on average, than recalls detected by internal entities (firms and their supply chain partners) which indicates higher recall detection competence (Johnson-Hall, 2012).

We further propose that a supply chains detection competencies can also be an indicator of their supply chain visibility and tracking capabilities and will in turn impact the amount of affected product recovered post- recall. We code 0 for detection by an external agency and 1 for detection by an internal agency.

- *Hypothesis 3: Product recalls with recall detection by external entities are associated with a longer time to recall as compared to those detected by internal entities in the supply chain.*
- *Hypothesis 4: Product recalls with recall detection by external entities are associated with a smaller amount of recovered product as compared to those detected by internal entities in the supply chain.*

3. Hazard type

From the description of the hazard in the recall notice, we classified the hazard type as “mislabeling”, “contamination”, “violation of regulations” and “others”. The hazard type “violation of regulations” and “others” constituted a very small percentage of recalls and therefore were not considered for further analysis.

The detection of hazard type can occur through testing or sampling or the occurrence of an illness. Mislabeling generally occurs when the internal composition of the product is changed (due to change of suppliers, ingredients etc) but the label is not changed accordingly. This is tougher to detect through testing or sampling as compared to testing for a common foodborne illness causing pathogen. Also mislabeling can be considered to be an external hazard wherein the product by itself is not hazardous to the population as a whole but the packaging fails to mention the presence of ingredients which may be hazardous or unacceptable to a certain section of the population. In the case of contamination the product is internally hazardous in its composition and harmful to anyone consuming the product.

We thereby hypothesize that mislabeling may take longer to detect and hence recall and also lead to a lower amount of recovered product. We code 0 for contamination and 1 for mislabeling.

- *Hypothesis 5: Product recalls with a hazard type of mislabeling are associated with a longer time to recall as compared to those with hazard type of contamination.*
- *Hypothesis 6: Product recalls with hazard type of mislabeling are associated with a smaller amount of recovered product as compared to those with hazard type of contamination.*

Control variables

We control for the year of recall with 2013 as the base year.

4. Method

Our final sample consisted of 397 recalls after eliminating cases with incomplete information for any of the variables in our model. Tables 1 and 2 show the means, standard deviations and correlations for all the variables.

We show the bivariate relationship between the dependent and independent variables in Figures 4-6. It can be seen that 90% of the recall strategies were preventive in nature, internal detections resulted in 23% of the total product recalls and 63% of the recalls were due to a contamination hazard.

To investigate the multivariate relationships with all the independent and control variables, we analyze the data using ordinary least squares (OLS) regression analysis. In order to employ OLS regression, we first check that the data did not violate underlying assumptions related to normality, homoscedasticity, and multicollinearity.

To verify the assumption that error terms in the models are normally distributed, we performed the Shaprio-Francia-W test for normality. We could not reject the null hypothesis that there is no difference between the cumulative distribution of the error terms against the theoretical normal distribution ($p < 0.38$), confirming the normality of the data. The presence of heteroscedasticity in residual errors violates a critical assumption of OLS regression (homoscedasticity). Thus, to confirm that the variance of residual error is constant for all values of an independent variable, we ran White's test and we could not reject the null hypothesis of no heteroscedasticity in both tests ($p<0.04$) In order to test for multicollinearity, we checked the bivariate correlations and found that the variables did not demonstrate high correlations among them. Therefore, our data does not appear to be affected by multicollinearity.

The results of the OLS regression with time dummies and 2013 as the reference, for the time to recall and the amount of product recovered are presented in Table 3 and Table 4.

Variables	Mean	Standard deviation
1.Time to recall (days)	3.74	1.74
2.Amount of product recovered (%)	42.7	36.2
3.Recall strategy:Preventive	0.90	0.28
4.Recall strategy: Reactive	0.10	0.28
5.Detection entity:Internal	0.23	0.42
6.Detection entity:External	0.77	0.42
7.Hazard type: Mislabeling	0.37	0.49
8.Hazard type: Contamination	0.63	0.49

Tab. 1: Means and standard deviations of the variables

Variabl es	1	2	3	4	5	6	7	8
1	1.00							
2	-0.32	1.00						
3	-0.06	0.17	1.00					
4	0.06	-0.17	-1.00	1.00				
5	-0.11	0.15	0.17	-0.17	1.00			
6	0.11	-0.15	-0.17	0.17	-1.00	1.00		
7	-0.38	-0.05	-0.24	0.24	-0.10	0.10	1.00	
8	0.38	0.05	0.24	-0.24	0.10	-0.10	-1.00	1.00

Tab. 2: Correlations for the variables

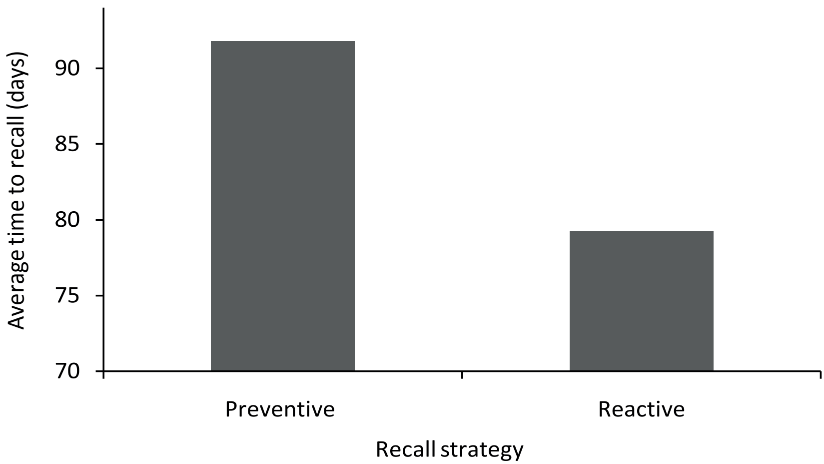

Fig. 4a: Bivariate relation between average time to recall and recall strategy

5. Discussion

We now interpret the results of the OLS regression. At the 5% significance level our coefficient's estimates are significant whenever the t-statistic is greater than 1.96 or lesser than -1.96 or the p-value is less than 0.05. Similar to the findings of Johnson-Hall (2012) our results also do not support hypothesis H1 that a preventive recall strategy in the supply chain will result in a longer time to recall in contrast to a reactive recall strategy at a 0.01 significance level. However, hypothesis H2 is supported as we find that a preventive recall strategy in the supply chain will result in a larger amount of recovered product than a reactive recall strategy. The coefficient of this variable is positive and significant.

We also find that hypothesis 3 is supported and detection by an external entity will result in a longer time to recall as compared to detection by an internal entity at a 0.01 significance level. Hypothesis 4 which states that detection by an external entity is associated with a smaller amount of recovered product in contrast to detection by an internal entity such as supply chain firms and their partners is also supported.

The high t-statistic and very low p-value for mislabeling confirms that it is the most significant coefficient. The results also support Hypothesis 5 that mislabeling is associated with a longer time to recall in contrast to the hazard type of contamination. It can also be seen that Hypothesis 6 is supported and a hazard type of mislabeling results in a smaller amount of product recovered as compared to a hazard type of contamination.

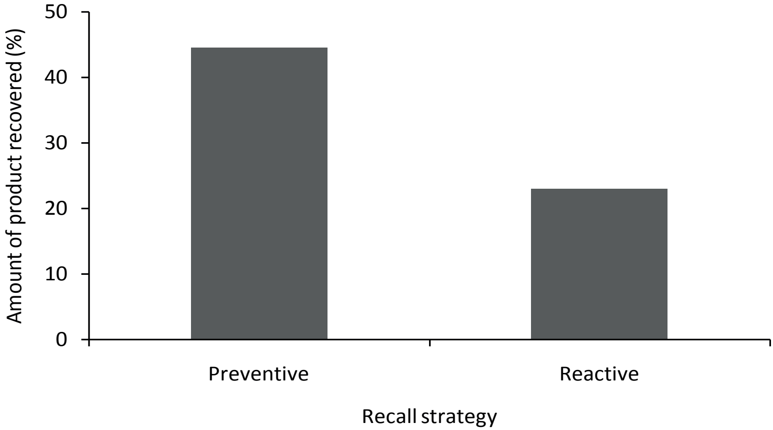

Fig. 4b: Bivariate relation between amount of product recovered and recall strategy

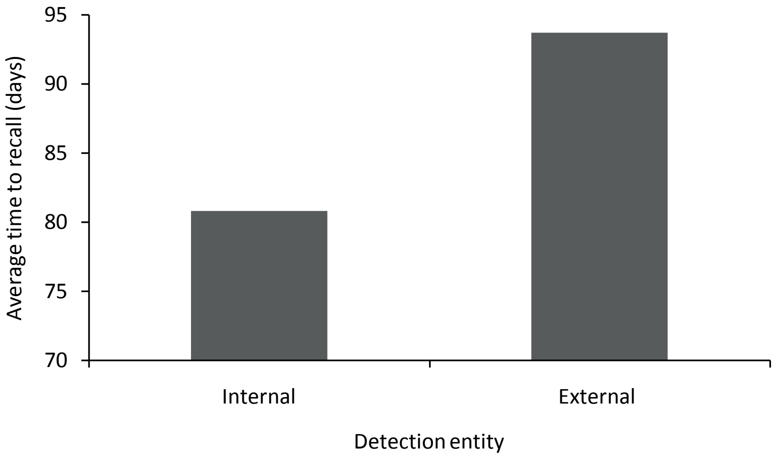

Fig. 5a: Bivariate relation between time to recall and detection entity

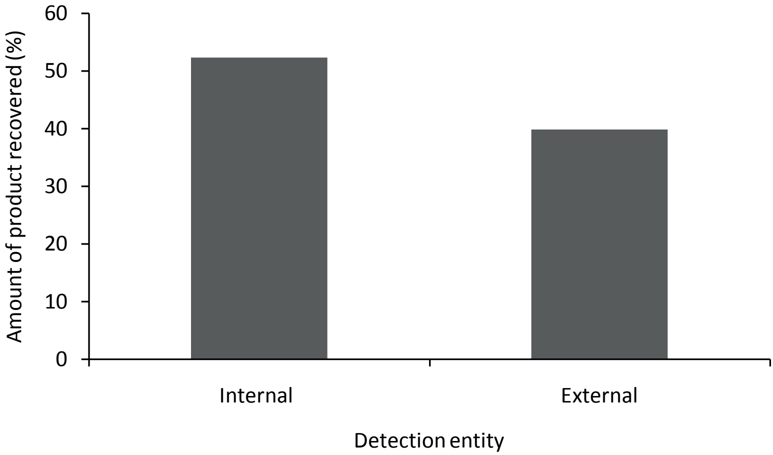

Fig. 5b: Bivariate relation between amount of product recovered and detection entity

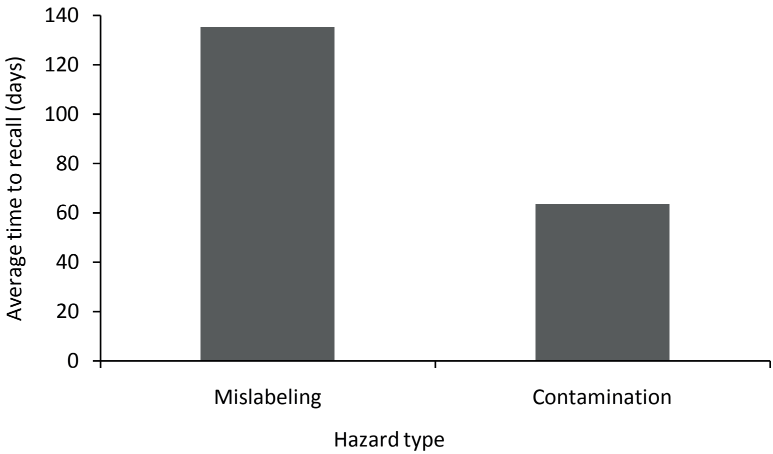

Fig. 6a: Bivariate relation between time to recall and hazard type

For time dummies in table 3, it is found that only year 2010 is significant and the results also suggest that as time progresses the time taken to recall products decreases. For time dummies in table 3, year 2005 is significant and results suggests that as time progresses the amount of product recovered increases.

Our results show that recall strategy, detection entity and hazard type have a significant impact on the time to recall and the amount of product recovered which in turn will affect the efficiency and the effectiveness of a recall process. Preventive recall strategies have been associated with delays in recalls in prior studies as companies may have a tendency to delay recalls to prevent repercussions on their stock value, brand etc however we find that these results do not hold for meat and poultry recalls primarily because recalls associated with an illness are largely underreported (Johnson-Hall, 2012). However we find that a preventive recall strategy will be associated with a larger amount of product recovered as the occurrence of illnesses in the reactive recall scenario indicates downstream spread and consumption of the product thus hampering recovery efforts which is absent in this case.

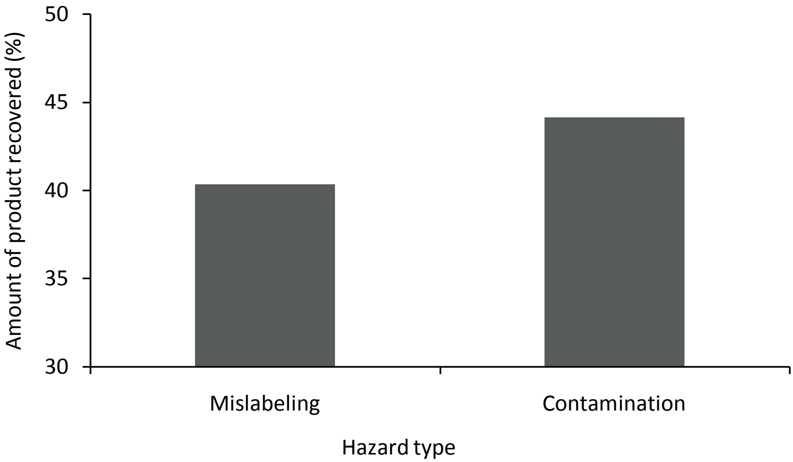

Fig. 6b: Bivariate relation between amount of product recovered and hazard type

It has been posited in literature that recalls detected by external entities (customers and regulatory agencies) indicate a lower recall detection competence of the supply chain entities and have a longer time to recall, on average, than recalls detected by internal entities (firms and their supply chain partners) which indicate a higher recall detection competence. Our results support this hypothesis and we further find that a supply chain's detection competency is an indicator of its visibility and tracking capabilities as detection by internal entities results in a larger amount of recovered product in contrast to detection by external supply chain entities.

Mislabeling is found to have a significant impact on the time to recall and the amount of product recovered. A hazard caused due to mislabeling is associated with a longer time to recall as well as smaller amount of recovered product. This may be primarily because of the inherent difficulties in detecting mislabeling through a testing or a foodborne illness.

As a part of ongoing work we hope to incorporate more independent variables such as shelf life, hazard class and position of the recalling entity in the supply chain (manufacturer, supplier etc) and incorporate control variables such as product type (poultry, pork, beef etc). Future research will also focus on the impact of supply chain structure and reverse logistics on the recall outcomes.

We also aim to comment on the potential impact of traceability (e.g., RFID) and condition monitoring (e.g., temperature sensors) on recall outcomes.

Further work will also include investigation of policy level differences between the functioning of different regulatory agencies such as the FDA and the USDA/FSIS to gain insights into the recall processes conducted by the respective agencies.

From a methodology perspective we hope to analyze the data utilizing duration (survival) models.

	Estimate	Standard error	t-value	$\Pr(>\|t\|)$
Preventive strategy	-0.6757	0.2302	-2.935	0.00353**
Internal detection	-0.4249	0.1487	-2.857	0.00451**
Mislabeling	1.2296	0.1343	9.154	<2e-16***
2005	0.6492	0.3411	1.903	0.05779
2006	0.4431	0.3125	1.418	0.15709
2007	0.3311	0.2938	1.127	0.26048
2008	0.5159	0.2929	1.761	0.7900
2009	0.3552	0.2880	1.233	0.21828
2010	0.6533	0.2876	2.272	0.02366*
2011	-0.0771	0.2838	-0.272	0.78603
2012	0.2646	0.2809	0.942	0.34678

Significance codes: *** 0.001 **0.01*0.05.0.1

Multiple R-squared: 0.2145

Adjusted R-squared: 0.1918

p-value: 4.684e-15

Tab. 3: OLS regression for time to recall

	Estimate	Standard error	t-value	$\Pr(> \lvert t \rvert)$
Preventive strategy	23.124	6.7432	3.430	0.00067^***
Internal detection	12.1470	4.3562	2.788	0.00556**
Mislabeling	-8.4330	3.9347	-2.143	0.03273*
2005	-21.3065	9.9919	-2.132	0.03362*
2006	-11.1395	9.1549	-1.217	0.22445
2007	0.4075	8.6063	0.047	0.96226
2008	-12.3778	8.5804	-1.443	0.14996
2009	-6.0482	8.4373	-0.717	0.47392
2010	-9.3172	8.4236	-1.112	0.26663
2011	-2.0570	8.3136	-0.247	0.80471
2012	-4.7964	8.2273	0.583	0.56025

Significance codes: *** 0.001 **0.01*0.05.0.1

Multiple R-squared: 0.07591

Adjusted R-squared: 0.04916

p-value: 0.001395

Tab 4: OLS regression for amount of product recovered

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Control and Monitoring in International Logistics Chains

Albert Veenstra, Joris Hulstijn and Paul Griffioen

Abstract

In this paper, we introduce an approach to monitoring and control in the international movement of goods that builds on value chain modeling. The approach is taken from the accounting domain and adapted to application in supply chains and logistics chains. This approach is based on identifying equations that can be used to verify the accuracy and integrity of data in the supply or logistics chain. This enhances visibility, and will contribute to compliance in the international movement of goods.

We introduce a case study of a retail company in the UK that ships containers from China to its warehouses in the UK. We obtained unique data from this chain, in which independent measurements were taken of the cargo volume in the containers. Based on the analysis of this data, we show that there is a considerable chance that recorded volumes on shipment documentation by manufacturers may be wrong. We show that the incorrect data follows patterns that can be detected, which provides a starting point for the development of analytical detection models.

Keywords: containers, supervision, risk management, supply chain

1. Introduction

Annually, there are 177 mln ocean container movements (Drewry, estimated 2012 data). Given the global imbalances in trade, 40-45% of these containers move empty. Therefore, there are about 80 mln full containers moving around the World. A container has obvious advantages: it keeps goods safe and dry, enables the loading of large volumes of goods in relatively limited time.
Since 9/11 a significant question has become: what is stored in these containers? As a result, customs agencies have strengthened existing and developed new mechanisms to supervise this flow of goods. At the same time, many companies are also struggling with the lack of information due to shipment in containers. In many cases, shipping lines provide little visibility as to where the container is at any time during transportation, and documentation such as the ship manifest and bills of lading are not very accurate. The result of this lack of visibility is that companies are not able to make a crucial match between what was ordered, what was shipped, and what was received, and consequently, which invoices need to be released for payment, see e.g. (Steinfield et al. 2011, Klievink et al. 2012).
We observe that this lack of supply chain visibility leads to two potential problems:

1. Products that are expected to arrive may not arrive, or arrive later than expected, and, with the current lack of visibility, this is often only discovered upon arrival of the goods.
2. Critical information on the goods, such as number of boxes, weight and volume, on documents is often not correct, which means that errors occur in inventory management systems if the documents are used for data input, instead of observed information from the containers. Moreover, container capacity is not used in an optimal way, when volume and weight information are incorrect. Finally, customs declarations may also be incorrect, which can result in additional checks, scanning and physical inspection and corresponding delays in the arrival of the goods.

This paper will develop an approach that offers new opportunities for verification of trade information in international logistics chains. We will concentrate on the second problem mentioned above. We will therefore develop an approach for the verification of volume and weight data at different stages in the logistics chain. To do so, we adapt principles from accounting and apply these principles to the supply chain management context. To demonstrate the usefulness of this approach, we report on a case study that provides a unique insight in an international container transport chain, with data on volume and weight on several thousands of containerized shipments. This case study is part of the EU FP7 project CASSANDRA (SEC-2010.3.2-1, GA nr 261795) that aims to develop new technical solutions for international logistics visibility.

The remainder of this paper is structured as follows. First, we provide a brief overview of the state of the art in international logistics visibility. In the next section, we will introduce the container logistics chain, as well as the shipments data. The section after that, we will describe the technical visibility solution developed in the CASSANDRA project. We continue to develop a model that supports the continuous analysis of data in our container logistics chain with the aim to identify matching problems in an earlier stage.

2. State of the art international logistics visibility

Before we start with a discussion on logistics visibility, we first introduce a simple data model that will help to structure our discussion. In principle, in international container logistics chains, there are three categories of data:

1. Data on product
2. Data on consignment
3. Data on container

The first class contains information on the product such as the product description, formal product classifications, composition of the product, individual weight and volume of the boxed product, value of the product and so on. The second class contains information on the grouping of products in so-called consignment. These consignments are the batches of product that are sent from manufacturer to receiver, or in legal terms, from consignor to consignee. Usually, consignments are determined by the purchase order, or some standard order quantity determined by inventory optimization. The consignment is also the basis for declarations to customs. Information on the consignment is in principle similar to the information on the product, but it also contains information about the number of products, the number of boxes, total weight and total volume of the consignment. The third class is the container in which consignments can be moved. A container can contain one or multiple consignments, but a single consignment can also be moved in multiple containers.

In principle, businesses require visibility at the product level. Organizations such as GS1 cater for this with product level tagging solutions, and worldwide standardized product description data structures. Government agencies usually require information on consignments, since these are the basis for declaration processes.

The business case for visibility was recognized around the end of the 1980s, when international data exchange became a reality. The development of Electronic Data Interchange for Administration, Commerce and Transport (EDIFACT) was published for the first time in 1987. Not long after that, international trade portals, such as GT Nexus and SmartCargo saw the light. Another well-known platform in ocean shipping, INTTRA, followed about a decade later. The business case for these platforms is to be a one-stop shop for shippers and transport operators, for the exchange of all data related to the international commercial transaction and related transport operations.

The type of visibility that is provided by these platforms is, in first instance, based on the data that shipping lines can provide. In a shippers’ survey in a EU FP7 project INTEGRITY, we identified 11 crucial milestones in an international container logistics chain INTEGRITY 2009, pg. 34-35). These are reported in table 1.

nr	Milestone	Original source	Commonly provided by
1	Container stuffed at origin	manufacturer	Often not reported
2	Container closed and locked	manufacturer	Often not reported
3	Container gate in at terminal	Terminal at origin	Shipping line
4	Container loaded on ship	Terminal at origin	Shipping line
5	Ship departed	Terminal at origin	Shipping line
6	Ship arrived	Terminal at destination	Shipping line
7	Container unloading from ship	Terminal at destination	Shipping line
8	Container released by customs	Customs	Port community system
9	Container released by carrier	Shipping line	Shipping line
10	Container gate out from terminal	Terminal	Shipping line
11	Container arrived at warehouse	Logistics service provider	Warehouse operator

Tab. 1: International container logistics milestones

It is clear from this table, that the ocean transport community has a role to play in providing international logistics visibility: they can provide 6 out of 11 desired milestones.

There are several problems with these ocean transport milestones, however. First of all, they are at the level of the container. This means that a translation to the consignment level (which is relevant for both customs and the cargo owner) has to be done on the basis documentation that is put together by the manufacturer, or his local representative. Second, the milestones' original source is not the shipping lines, but the ocean terminal. They provide their data to the operational departments of shipping lines, who then process this data for their visibility services. This processing is not faultless (see for instance Schilt 2012).

Many of these platforms, and several of their competitors, such as the Global Logistics Services platform of Descartes, and in-house platforms of global logistics service providers, such as the Korean Pantos Logistics, also provide services to upload and exchange other documentation, such as purchase orders, packing lists for consignments, transport orders, customs declarations, and so on. The data in these documents then provide an extra layer of visibility on top of the ship- and container-level milestones. The integrity of these visibility solutions depends crucially on three kinds of registrations, to provide linkages:

- Purchase Order: links products to consignments
- Container Manifest, or Packing List: links consignments to container(s)
- Loading List: links containers to a ship

Capturing these links is not easy. Purchase orders are often annual contract, where manufacturers can ship periodically whatever they have produced. Instead of a purchase order, they then issue a Shipping Order, which is the actual description of the consignments to be shipped. Packing lists of containers are sometimes reconstructed based on warehouse management systems after containers have been loaded and closed. This holds especially for large consignments that are distributed over several containers.

There is a specific reason why the container level visibility that the ocean shipping community can provide does not offer a complete solution to many companies. This reason is related to the structure of the commercial transaction for many container chains leading to Europe and the US. Many importers in Europe and the US buy their goods based on the standard Incoterm Free on

Board (FOB). This term specifies that the importers become owner of the goods when they are loaded onboard the ship in the port of origin. What happens before that time is the responsibility of the manufacturer/seller of the goods: the exact information on stuffing of the container, the customs declaration for export and the information provision to the ocean carrier that goes into the ocean transport document (called the bill of lading, or the seaway bill), the ship's manifest and any customs declaration the ocean carrier will make. This crucial information is all compiled outside the control of the buyer.

The ocean carrier is only interested in a general description of the goods, and the weight and some special requirements (dangerous cargo, refrigeration, oversized). As a result of this, the importer does not control the information quality at the beginning of the chain, and is often informed about shipment of the goods based on the documentation the ocean carrier provides, i.c. the bill of lading or seaway bill. In other words, the importer will have great problems capturing one of the crucial information linkages identified above: the container manifest that links information on exactly which consignments went into which container. To solve this problem, the only thing an importer can do is to require additional effort from the manufacturer, for which the manufacturer will often ask additional financial compensation. Against these immediate additional costs stand unclear benefits for the importer of having this additional visibility in an early stage in the chain.

This paper will attempt to clarify these "unclear" benefits, by offering an approach to verify data at the consignment level, and based on the insights this provides, calculate benefits for the consignee. For this purpose, we first introduce some methods from the accounting domain, and adapt these for application on container logistics chains.

3. Model-based Auditing

Business reality can be modeled as a value cycle: an interrelated system of flows of money and goods (Starreveld et al. 1994). The value cycle of a trading company for example contains two types of transactions: purchasing and selling goods. The flow of money exactly mirrors the flow of goods, but in reverse. The point of an accounting information system is to accurately and completely capture these flows using accounts. Figure 1 shows an example of the value cycle for two trading companies, connected by trade documents (quittance, invoice, purchase order). We use the following notation. Decisions (authorizations) are shown as an oval: an event or change of state. Rectangles are the recordings of a state of a certain value to the company, such as inventory or accounts payable. Records of states, i.e. accounts, are related through *reconciliation relationships*, indicated by dashed lines, which come together in the general ledger. The direction of the arrow indicates the influence of events. Arrows generally indicate an increment, while the sign '–/–' indicates a decrement of the corresponding account. Thus, a purchase leads to an increment of the accounts payable, while the purchased goods are added to the inventory. A sale leads to an increment of the accounts receivable and a decrement of the inventory, and so on.

Depending on the type of business, the accounting relationship between the flow of money and the flow of goods is stronger or weaker. For manufacturing, the relationship is strong, because the resources needed to manufacture a product can be counted. In the services industry the relationship is much weaker. The stronger the relationship, the more the auditor can rely on expected proportions. In particular, to measure the completeness of revenue, the auditor can verify revenue against the number of goods sold and the sales price. Starreveld (Starreveld et al. 1994) developed a typology based on the type of business, to determine the expected internal controls. The typology also provides a model of what kinds of information are expected to be recorded for different types of businesses.

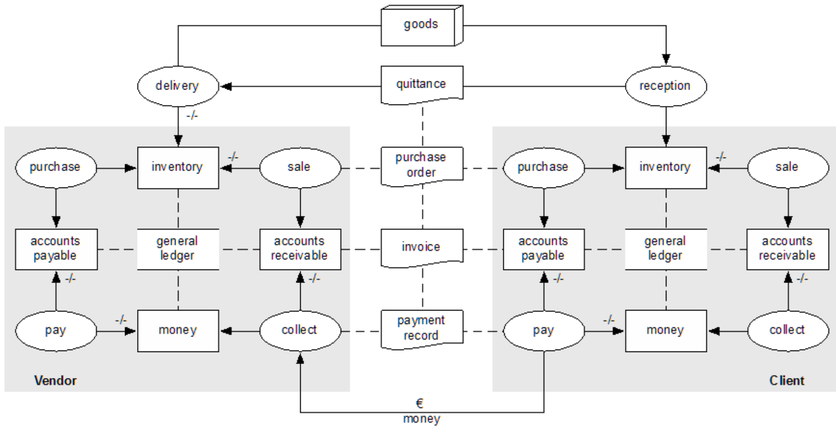

Fig. 1: Value cycle models of two trading companies, linked by trade documents

Auditing is the systematic, objective and documented process to obtain and evaluate evidence about some object of investigation, to ascertain the degree of correspondence with established criteria (Knechel et al. 2007). In assessing the risk of possible misstatements, auditors typically make use of the guarantees and internal controls inherent to the type of business. The purpose of model-based auditing is to develop and use a normative meta-model of the relationships between the flow of money and the flow of goods, for monitoring and auditing purposes (Weigand and Elsas 2012). The term 'model-based auditing' is chosen by analogy with model-based diagnosis (de Kleer and Williams 1987), and other model-based approaches to knowledge systems, see (Stefik 1995). Model-based approaches are opposed to more practical approaches that do not start from a mathematical model, but instead try to automate existing practices and heuristics.

The relationship between flows of money and goods can be expressed in two prescriptive 'laws', meaning that they express how the flows of money and goods should ideally be related, given the type of business (Starreveld et al 1994). The first law is concerned with *transformation.* It is called the law of the rational relationship between sacrificed and acquired goods, and states that, for all events e that affect the incoming and outgoing states or accounts S, T according to the arrows in Figure 2, S → (e) → T, we have:

input(T, e) = f • output(S, e), for some normative ratio f (1)

For example, if we look at a sales event, we have*: increase in accounts receivable = sales price • decrease in inventory*. Similarly, if we look at a purchase event, we get: *increase in inventory = increase in accounts payable * purchase price*.

The second law is about *preservation*. For all states S, the value at the end of a period should equal the value at the beginning, with increments added and decrements subtracted. Also losses are accounted for. We assume there are standards and norms for normally expected losses, given the type of goods.

S[t1] = S[t0] + input(S, [t0, t1]) – output(S, [t0, t1]) – losses(S, [t0, t1]) (2)

Note that some accounts are counted in monetary value, while others, like inventory, are counted in other units: kilos, hours, boxes, or containers. Griffioen (2013) argues how important units of measurement are in expressing accounting equations.

A special instance of the first law therefore deals with *conversion* or *aggregation*.

T in unit u = f • T in unit v, for f a normative conversion ratio (1')

For example, suppose that we are looking at a shipment of shoes. Because of the size of a shoebox and the way shoes are stacked on pallets, suppose that on average a 20-foot container will contain 5600 pairs of shoes. So we get *Shoes* in unit *20-ft-container-load = 5600 • Shoes* in unit *pair*. Another example is the conversion of weight to volume, or vice versa, for a box or some other unit of cargo.

The general idea of model-based auditing is to use such equations to define a normative meta-model of the flow of money and goods, made specific for each type of business, and use it to verify actual data against. Discrepancies can be either exceptions or violations, and will therefore have to be explained. If such verifications are automated, they can used to monitor a process continuously (Alles et al. 2006).

APPLYING THE VALUE CYCLE MODEL TO LOGISTICS CHAINS

To use the value cycle model approach in logistics chains, we have to make a number of adaptations.

First of all, the value-cycle model uses variables related to the commercial transaction (inventory, purchase, sales, credit and debt). In practice, however, there are many other transactions and pseudo-transactions, that could be the source of verification relationships. A very relevant transaction in this respect is the hiring of transport, where the seller requires proof that goods are taken into custody by the transport operator, and the buyer needs a document that proves to the transport operator that he is the rightful owner of the goods.

Another observation is that financial auditing, until now, has mostly dealt with individual firms. In international logistic, we are looking at a web of firms, collaborating in a chain or network. Therefore we need to be able to provide assurance over inter-organizational links. We argue that the model-based auditing technique is quite capable to do so, since, in principle, the kinds of reconciliation relations that we want to use also apply across inter-organizational links. In fact, the application of these relations for verification purposes may be stronger, since in the supply chain we can often use data derived from actors having opposed interests. An example is comparing import value of the goods and export value.

Finally, the value cycle model itself does not specify any physical relationship between resources and finished product. For each application domain, these ‘laws’ have to be found and tested in practice. Now clearly, if this value cycle approach is to be applied to international container chains, the set of financial equations needs to be extended with physical goods equations.

Summarizing, we need to adjust the value cycle model in three respects: (1) adding variables and components related to transport and handling, (2) verifying across inter-organizational links, and (3) finding the individual 'laws' that govern the international trade domain, in particular, capturing equations related to the flow of physical goods. The next step is to develop reconciliation relations that are useful for our case study.

DEVELOPING RECONCILIATION RELATIONS FOR LOGISTICS CHAINS

When applying the value-cycle approach to logistics chains, we focus on the relationship between containers and consignments. Based on the value cycle approach discussed above, type-(1) relationships can then be developed as follows (brackets contain alternate variable dimensions), ignoring, for the moment, values:

$$\text{total consignment volume (weight)} = \text{box count} * \text{volume (weight) per box} \quad (3)$$

and

$$\text{total container volume(weight)} = \Sigma\ \text{volume(weight) per consignment} \quad (4)$$

where the summation is over the total number of consignments.

In these relationships the number of boxes is the normative ratio. In a logistics chain with many different products or product types, however, there may be as many consignments as normative ratios. This makes this type of reconciliation relationship relatively useless for verification purposes.

We can also formulate type-(2) preservation equations. Again, we focus on physical variables, and ignore value. The basic preservation equation, expressed in total volume, is:

$$\text{goods underway} = \text{goods ordered} - \text{goods delivered} -$$

goods ready for shipment – goods in manufacturing (5)

In all these equations, the term 'goods' is short for 'consignments of goods'. The same variable can be expressed as:

goods underway = goods in pre-carriage + goods in terminal at origin + goods at sea + goods in terminal at destination + goods in on-carriage (6)

For each component, one can write:

- goods in pre-carriage = goods arrived at terminal of origin – goods ready for shipment
- goods in terminal at origin = goods in pre-carriage – goods at sea
- goods at sea = total goods underway – goods at terminal in origin – goods at terminal at destination – goods in pre-carriage – goods in on-carriage
- goods in terminal at destination = goods at sea – goods in on-carriage
- goods in on-carriage = goods delivered – goods arrived at terminal at destination

Note that the easiest way to fill all these equations is with data at the container level. This is also the level the parties in the logistics chain are implicitly verifying these equations. A shipping line will eventually carry all the containers that were booked for transport, and a terminal will load or unload all containers it was supposed to handle. Eventually all containers will leave a terminal for transport to the end destination. All these parties have an interest not to lose containers during their operations. For a party interested in the cargo, the visibility it is interested in as in the timely movement of containers. This is an important operational interest, that requires adding a time dimension to each of these equations, as well as finding norm durations for each step in the logistics chain. Given that in this paper, we aim to focus on the verification of weight and volume, and not timeliness, we leave this for further research.

The purpose of this paper is work with consignment level data (i.e. data on what is in the container), and to verify the correctness of the description of the goods, especially their volume and weight. In this case, all the equations above should clearly indicate the types of goods and the corresponding unit they are expressed in. This may result in a lot of equations, but it will provide a new opportunity to identify mismatches between cargo descriptions and actual goods movements.

Seen in this context, equation (3) and (4) contain variables that can be independently verified, by using data from different sources: the weight or volume of the container can be measured in the container terminal at origin or destination through weighing, and the box count can be derived from an independent tally at stuffing or stripping of the container, or from the stuffing/stripping company's invoice. Often, such companies are paid based on the number of boxes being handled, so the invoice provides a reliable independent source of evidence. The weight and volume of the boxes of goods can be recorded in the standard product data, or can be measures with a scale or volume scanner at the beginning or end of the chain. The weight and volume of the boxes as well as the box count are recorded on the packing list or container manifest.

With the help of these normative, or prescriptive, equations that describe the situation as it should be, deviations in the actual flows can be identified based on actual measurements of the variables during operations. Depending on the quality of the underlying information system, these deviations can point at more or less serious risks in the flow of goods. By mining transactions (see for instance, Rozinat and van der Aalst, 2008 or Khan et al., 2010), different recordings of, for instance, weight or item numbers, for the same shipment will emerge. These differences can indicate that things went wrong with the shipment.

4. Case study

The case study concerns a specific trade lane between China and the United Kingdom set up by a number of cooperating freight forwarding companies, for the benefit of a British retail company, here called ABC. The freight forwarding companies involved are a forwarder based in Hong Kong, a forwarder based in the UK and a container handling company in the port of Felixstowe in the UK. The container handling company's role is to bring containers from the container terminal and unpack the containers for storage in a warehouse in the port area. From there, the forwarder brings the goods to the distribution warehouses of ABC. ABC's shop replenishment operation is based on just in time logistics, in which different timing and routing applies to different groups of products. It is crucial for the accurate replenishment of shops to know what goods will be arriving, when and in which container, preferably before the container arrives. Figure 2 shows a schematic representation of the container logistics chain, with the main parties involved.

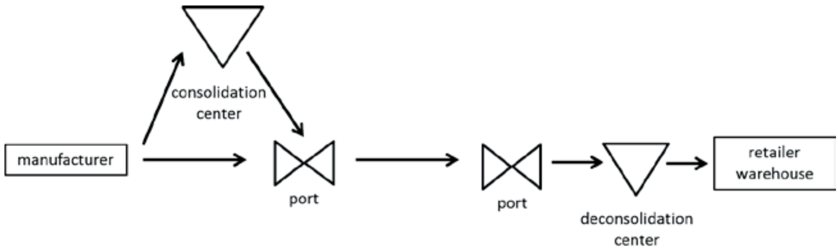

Fig. 2: Container logistics chain

The manufacturers are mostly located in China. The freight forwarder at origin operates two consolidation centers in Hong Kong and Shenzhen. The ports used are either Hong Kong or Yantian in China. The port at destination is Felixstowe, while the consolidation center is run by a logistics service provider that is based in the port, located next to the container terminal. The UK based part of the same freight forwarder that consolidates at origin, takes care of transportation from the deconsolidation center into the retailer's warehouse.

This case study has been part of two European R&D projects: INTEGRITY (2008-2011) and CASSANDRA (2011-2014). In this period, the level of control in the chain underwent significant changes. We will describe three main stages of developments here.

Stage one

Initially, 80% of containers were stuffed at manufacturers' premises. Documentation was also provided by tmanufacturers. This documentation, together with original orders and shipping line documentation (bill of lading) was collected in a so-called purchase order registration system. This system keeps track of the fulfillment on individual purchase orders. It is updated only after the ship sails, because ocean shipping companies usually deliver their documentation several days after ship sailing. In this stage, about 20-30% of the containers' content was a complete surprise. As a result, the retailer did not use this system to fill its inventory systems, but relied on the container handling company to supply accurate counts of boxes and products. The container handling company had to count the boxes anyway, since they were paying employees by the box.

Stage two

As part of the EU FP7 project INTEGRITY, two improvements were made:

1. The retailer introduced a rule that an accurate container manifest had to be attached to the inside of the container door, and that any discrepancy with the count of the container handling company in Felixstowe would result in a penalty for the manufacturer.
2. The INTEGRITY project provided access to accurate container terminal milestones from the ports at origin as well as tracking data from CSDs, providing advance information on containers, as well as information on the link between container and ship. This facilitated mitigating actions for containers that were delayed (due to unannounced rerouting of

ocean vessels, or unexpected transshipment of containers in Singapore to another ship).

The penalty rule led to a 99% accuracy on container manifest documentation.

Stage three

A remaining problem was consistent underutilization of container space, particularly in terms of volume. Around one-third (!) of the containers were found to have a volume discrepancy. A standard 40ft container has a capacity of about 67,5m3. The retailer ships about 6000 40ft containers annually. Therefore, a 10% underutilization of 33% of the containers results in the loss of space that is equal to about 200 containers. At an average shipment cost of about €3.000 per container, this amounts to savings on the total freight bill of €600.000. This amounts to about 3,3% of the total freight bill.

One mitigating measure was to move more of the container stuffing process to the retailer's freight forwarder controlled consolidation centers in the two main loading ports Hong Kong and Shenzhen/Yantian in China. About 25% of ABC's shipments now go through these warehouses in Yantian and Hong Kong. Many full container load (FCL) shipments are still sent directly by manufacturers. In fact there is a rule from the retailer that shipments above a certain volume (55m3) can be shipped directly, while shipments below that threshold need to be consolidated in the consolidation centers.

At the moment, however, the underutilization of container space persists. As part of the EU FP7 CASSANDRA project, the freight forwarder and the logistics services provider initiated a joint project to reconcile weight and volume data at both ends of the chain, in order to find early signals of underutilization of containers. In the next section, we will analyze the volume data, in order to gain some insight in the reasons for the persistence of the underutilization of container volume.

5. Data analysis

We have obtained data on container shipments for the period from 11th of April 2013 to 28th of June 2013. In this period, 1250 containers were shipped, with a total of 2515 consignments. On average, a container contains two shipments. The maximum number of shipments in a container we found in the data was 8.

For this period we have descriptions of containerized shipments, consisting of: date of shipment, supplier identifier, container number, product description, container type (20ft, 40ft, 40ft high cube), loading pattern (full container loaded by manufacturer, or consolidated container), quantity of product, number of boxes, volume of boxes, total volume of cargo in the container. All this data originates from the shipment orders submitted by manufacturers, from which the shipment documentation is derived. During this period, volume measurements were performed at the logistics service provider in Felixstowe, by means of a cube scanner. This is a device that scans boxes in 3D, and determines the exact volume, as well as measures for height, width and depth. For about 16% of the containers, discrepancies were observed between the volume of the boxes listed on the documentation and the measurements. This section provides an analysis of these discrepancies. We will refer to the two different sources of the volume data as the document data and the measurement data.

First we analyze some histograms, based on the documentation data, for the three main container types (20ft, 40ft and 40ft high cube). We display the histogram for the 40ft container data below.

A standard 40ft container has a cargo capacity of 67,7 m3. Observe that virtually none of the shipped standard 40ft containers achieves this maximum. In fact, the average utilization rate of the 20ft, 40ft and 40ft high cube containers is 82,3%, 80,8% and 86,4% respectively. If instead of high cube containers, normal 40ft containers would have been used, the utilization rate of these containers would have been 98,8%. On average, we find an 18% underutilization of container space.

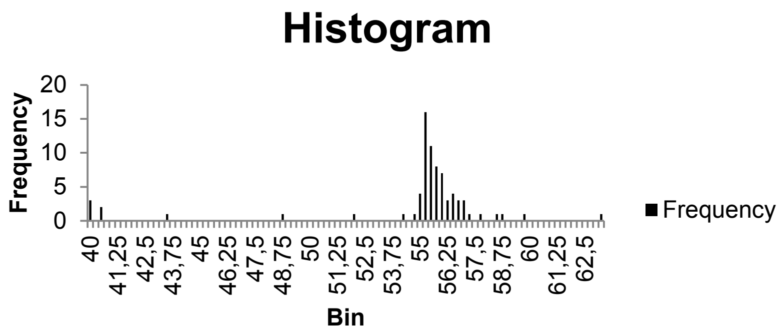

Fig 3: histogram container volumes, 40ft containers

The histogram of the 40ft containers also shows another interesting feature: it peaks around 55 m3. This is the threshold that was introduced as a business rule by the retailer for container loading by manufacturers.

Now we confront these document data with the measurement data. We deduct our measurement from the document data. This means that a positive difference refers to overstating the volume in the container by the manufacturer. The results are listed in Table 2 below.

	20ft	**40ft**	**40ft high cube**
Maximum negative	-2,14	-12,03	-10,07
Maximum positive	8,93	19,78	6,82
Average	1,50	1,82	-0,703

Tab. 2: Overview of discrepancies in container shipments

Observe that the differences between documented volumes and measurements are substantial. On average, for 20ft and 40ft containers, there is more than 1,5 m3 more volume on the documentation than actually in the containers. Notice also the large spread: differences can be both negative and positive, and the spread is substantial. The largest spread is found for 40ft containers, and it is more than 30m3.

One might expect the differences to follow a normal distribution. We performed an analysis based on a normal probability plot of the discrepancy data, which shows that the distribution deviates from the normal distribution in the area close to the mean, but not in the extreme tails.

If we compare the discrepancies against the documented data, we can see that most of the discrepancies are clustered around three volumes that we can associate with an almost full 20ft container, the 55m3 threshold and the 65,7m3 maximum volume of a 40ft container.

From this analysis, we conclude that manufacturers are not very accurate about the stuffing of containers, and they tend to label a volume with a specific number (55m3, of 67,5m3), without providing an accurate measurement of the volume.

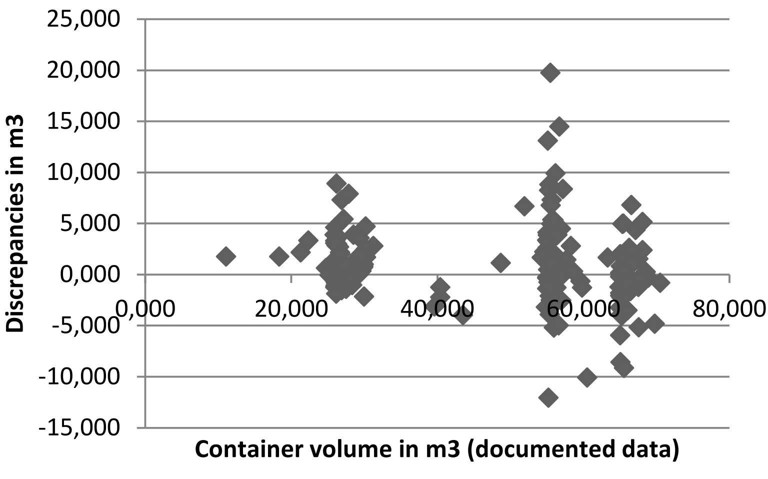

Fig. 4: Scatter of discrepancies against documented volume data

The retailer in our case has two solutions available. One is to route even more volume through the consolidation centers of its logistics services providers. The second is to develop some early detection mechanism that allows them to identify containers with unreliable volume data on the documents in an early stage, so that some mitigating action can still take place. We leave the development of such a model for further research.

6. Conclusions

Container shipping has lead to enormous efficiency gains in international transport, but has also produced a lack of supply chain visibility. The poor quality of data about the flow of goods, may lead to several problems in supply chain management, including wrong deliveries, inventory problems, and delays due to additional customs inspections.

In this paper, we introduce a verification approach to enhance supply chain visibility. We use accounting principles to identify relationships between the flows of goods and money, and use these so called reconciliation relations to verify the accuracy and completeness of data. The relations are used for cross-verification of data sources taken from across the supply chain. When parties have opposed interests, cross-verification of data from those parties is a strong measure to identify errors and improve data quality.

We first adapted the approach to supply chain and logistics domain. We managed to identify sensible reconciliation relations, which capture the essential linkage of products to consignments, and consignments to containers.

Next, we introduce a case study of a trade lane between China and the UK. Under pressure of a retail company in the UK, containers are shipped, via two additional logistic service providers, one in China and one in Felixstowe. By sharing data, these service providers were able to implement a number of additional control measures, and improve data quality and reliability of delivery. We obtained unique data from this chain. Independent measurements were taken of the cargo volume in the containers, both at stuffing and unloading. Based on analysis of this data, we show that the volumes recorded on the shipment documentation issued by manufacturers may be wrong. We also show that the errors in the data follow patterns that can be detected. This suggests that it is feasible to develop analytical error detection models. We leave the development of such models for further research.

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III.
Performance and Collaboration

Insight Into Current Supply Chain Management Approaches

Dynamic Capabilities and Firm Effectiveness: The Mediating Role of Supply Chain Performance

Alica Grilec Kaurić, Dario Miočević and Josip Mikulić

Abstract

Dynamic capabilities (DCs) have been in the recent focus of mainstream strategy research. Recent theoretical advances have seen the advent of DCs in supply chain management research, where DCs have been identified as enhancers of supply chain performance and firm's effectiveness. However, the literature predominantly lacks studies that empirically integrate the DCs, supply chain performance and firm's effectiveness in single theoretical framework. Building on this gap in the literature, this paper investigates the interplay between DCs, supply chain performance and firm effectiveness. The study was carried out on a sample of 85 medium and large manufacturing firms in Croatia. This study contributes to the literature by offering empirical evidence that the DCs (agility, adaptability and alignment) higher value-added impact on firm's effectiveness in the presence of supply chain performance as a mediator. In the end, this study offers valuable theoretical and practical implications as well as suggestions for further research.

Keywords: dynamic capabilities, supply chain performance, companies' effectiveness, manufacturing industry

1. Introduction

In recent years, the field of business research has seen supply chains as a source of sustainable competitive advantage (Motedel, Toloie-Eshlaghy and Halvachi-Zadeh, 2011, Wu and Barnes, 2011) and thus identified it as a driver that improves financial performance of the focal compay (Oh et al, 2013). The most recent studies in the field have confirmed the positive relationship between supply chain management and firm performance (Kim, 2006, Ou et al, 2009). However, the open question remains: What are the key factors that contribute to the performance of the firm engaged in the supply chain?

One of the fields that has shown a great interest in researching the sources of competitiveness is resource-based view (RBV). In the tradition of RBV, above average performance of a firm is achieved by utilizing various resources in forms of assets, organizational processes, intangibles, information, knowledge, etc. (Barney, 1991). Though, due to imitability, some authors argued that physical resources are not deemed to become a source of sustainable competitive advantage. Hence, theoretical advances in the field of strategy have started to stress the importance of dynamic capabilities (DC) in building the firm's competitive position (Teece et al, 1997). DCs represent higher level organizational and strategic competences, by which managers create, integrate and recombine lower level internal and external resources and capabilities with a goal of implementing value-creating strategies in rapidly changing business environments (Eisenhardt and Martin, 2000, Teece et al, 1997). Although the DCs have shown predominant focus in the context of focal firm, many authors have studied DCs in the context of supply chains (Wu et al, 2006, Chmielewski and Paladino, 2007, Wilden et al, 2013). However, despite the growing interest of supply chain researchers for DCs, the literature is still scarce on these issues (Beske, 2012).

Some authors indicate that the DCs are the key factor that distinguishes the typical from the excellent supply chain (Mehrjrdi, 2009). In excellent supply chains, firms employ DCs that enable them to achieve efficiency through achieving exceptional results in the speed, quality and cost (Ketchen et al, 2008, Mehrjrdi 2009th). In his seminal work, Lee (2004) proposed that all effective supply chains need to have three distinctive DCs: agility, adaptability and alignment. These DCs have been integrated in the framework known as 3A supply chains (Lee, 2004). Each of the defined DCs has a direct impact on a particular area of business performance. Yet, most of the previous work in the field has inspected these DCs separately. For instance: agility (Christopher, 2000, Alastair, 2003, Ismail and Sharifi, 2006, Motadel Toloie-Eshlaghy and Halvachi-Zadeh, 2011, Wu and Barnes, 2011), adaptability (Duclos et al, 2003, Stevenson and Spring, 2007, Wang, 2008, Oh et al, 2011) and alignment (Ryu et al, 2009).

Therefore, the main goal of this study is to determine the influence of 3A dynamic capabilities (agility, adaptability and alignment) on supply chain performance and focal firm's effectiveness. By contextualizing our study within the supply chain management field, we seek to contribute to the theory in several ways. First, the study aims to theoretically and empirically validate the importance of 3A DCs for performance outcomes of supply chain as a whole. Second, this study provides empirical evidence that higher supply chain performance is an important precedent to higher firm effectiveness. Third, the value-added of this study is the empirical assessment of indirect effects in the model in which the supply chain performance is seen as a mediator in the link between 3A DCs and focal firm's effectiveness. Fourth, most studies in the field of supply chain management are still being conducted in the context of developed markets; therefore, in this study we show that the philosophy of supply chain management is equally important for the firms originating from emerging and developing economies.

The rest of the paper is structured as follows. First, the theoretical framework along with the research hypotheses is presented. This is followed by a detailed description of the methodology and main study findings. Finally, this paper concludes with a discussion of research findings, managerial implications, limitations and suggestions for further research.

2. Literature review

2.1 Dynamic capabilities in the supply chain context

Firm capabilities (dynamic and static) along with the assets, organizational processes, attributes of the company, informations, knowledge etc. comprise the firm's resources (Barney, 1991). Resources are controled by the firm and they allow the firm to design and implement a strategy that will help them achieve business efficiency and effectiveness (Barney, 1991). On the other side, capabilities represent firm's immaterial (intangible) assets. According to Barney (2001), firms that build their strategies on intangible assets are more superior than firms that build their strategy on the platform of tangible assets (Barney, 2001).

Dynamic capabilities (DCs) are defined as capabilities that integrate, build and reconfigure both internal and external resources in a changing business environment. DCs represent the firm's ability to achieve new and innovative forms of sustainable competitive advantage (Teece et al, 1997). In academia, DCs became popular in 1997 after Teece and colleagues published their seminal paper in which they set out the theoretical framework for DCs applicability in the firm context (Cepeda and Vera, 2007). As an important determinant of firm's competitiveness, DCs are related with the firm's business performance (Wu et al, 2006, Chmielewski and Paladino, 2007, Wilden et al, 2013).

In the supply chain context, however, DCs are defined as *“the ability of the companies to identify, use and adapt to internal and external resources/information in order to facilitate all activities in the SC"* (Wu et al, 2006). In the available literature, only three DCs were highlighted as the drivers of supply chain excellence, namely the 3A DCs. According to Lee (2004), all supply chains should have three key dynamic capabilities in order to be successful: **agility**, **adaptability** and **alignment**. Each of these DCs has an impact on a particular area of supply chain performance. Agility has a goal to accelerate the supply chain response to changes in supply and demand (Christopher, 2000, Alastair, 2003, Ismail and Sharifi, 2006, Thomas et al, 2009, Motadel, Toloie-

Eshlaghy and Halvachi-Zadeh, 2011, Wu and Barnes, 2011); adaptability has a goal to adapt the supply chain to current market conditions (Duclos et al, 2003, Stevenson and Spring, 2007, Wang, 2008, Oh et al, 2013), while alignment has a goal to align the interests of all firms present in a supply chain with the interests of their own firms (Ryu et al, 2009). In accordance with the opinion of Tang and Tomlin (2008), strategy based on 3A DCs (Lee, 2004) reduces all potential supply chain risks and possible negative consequences. For example, the risk of economic and political factors can be reduced by supply chain adaptability and the risk of demand or supply can be reduced by supply chain agility.

Agility represents the ability of the SC that brings growth and survival in the market (Lin, 2006, Motadel, Toloie-Eshlaghy and Halvachi-Zadeh, 2011), and has a goal to *„quickly respond to short-term changes in supply or demand"* using the following methods (Lee, 2004): 1) continuously providing information about the changes in supply or demand to the supply chain partners so they could react quickly; 2) collaborate with suppliers and customers in order to redesign processes, parts and products in a way which would provide them with a better starting position. **Adaptability** is defined as ability to reduce total costs and also resolves the weaknesses of the make-to-order strategy (Chan and Chan, 2010). In other words, it is the ability with the goal to *"modify design/shape of the supply chain in order to adapt to the market changes"* using the following methods (Lee, 2004): 1) monitoring changes in the economic environment; 2) using intermediaries to achieve growth in the market; 3) providing that different products use the same parts and manufacturing processes; 4) creating different supply chains for different product lines in order to optimize all market opportunities (for example, small products series are produced close the domicile market, while large in countries with low production costs). **Alignment** includes the interests of supply chain members and without it, superior supply chain performance is not possible (Lee, 2004). It is the ability with the goal to *"to encourage the initiative of the supply chain partners to increase supply chain performance of the entire supply chain"* using the following methods (Lee, 2004): 1) to ensure equal access to forecasts, sales data and plans to all partners; 2) clarify the roles and responsibilities of all partners in order to avoid conflicts; 3) redefine the terms of the partnership in order to share the risks, costs and rewards for improving supply chain performance; 4) to align the initiatives so "players" could maximize overall supply chain performance and at the same time maximize the return from the partnership. In the next chapter, we discuss the research model and hypotheses.

2.2 Research hypotheses

The utilization of DCs should lead to a more responsive, adaptive and efficient supply chain (Defee and Fugate, 2010). The role of DCs in the supply chain is to identify, use and adapt internal and external resources in order to improve all activities in the supply chain (Wu et al, 2006). Put differently, supply chain excellence depends on the utilization of 3A DCs, as suggested by Lee (2004). In previous studies, 3A DCs were related to various organizational outcomes in supply chain management, namely: with indicators of business performance (Cagliano et al, 2004, Yusuf, 2004, Swafford, 2008, Qrunfleh and Tarafdar, 2014), with indicators of supply chain performance (Sukati et al, 2012, Qrunfleh and Tarafdar, 2014), with structural properties of logistics and supply chain networks (Busquets et al, 2009, Chan et al, 2009, Ivanov et al, 2010), and with core management processes (Sussland, 2003). Yet, in recent literature only one empirical study linked the integrated concept of 3A DCs with supply chain and firm performance (Whitten et al, 2012). Following their conceptual properties, 3A DCs directly enhance supply chain performance indicators: higher **quality** (the supply chain will be able to precisely deliver products to the final customer); better **visibility** (the supply chain will have continuous and effective communication flow – from the product idea to the customer), better **flexibility** (the supply chain will be able to quickly produce and deliver non-standard orders), better **innovativeness** (the supply chain will be able to introduce new products more quickly), lower **costs** (due to lower inventory costs, the supply chain will minimize total costs of the final product). Departing from the previously discussed theoretical and empirical background, we propose the following hypothesis:

> H1: 3A dynamic capabilities are directly and positively related to supply chain performance.

By integrating to supply chain, firms expect to enhance their business result through various outcomes such as: improved price/cost ratio, enhanced product quality, increased reliability of delivery, improved product innovation, and the shorter time required for placing the products on the market (Li et al, 2006). According to previous studies, the most common goals of supply chains are: customer satisfaction (Martinez-Olvera, 2008), profit maximization for all supply chain members (Samanovic, 2009), provision of value-added services to final customers (Chan, 2003), and simultaneous enhancement of supply chain and single firm performance (Li et al, 2006). Therefore, the ability of supply chains to produce and deliver products that satisfy the needs of final customers will result in greater business success for all firms in the supply chain (Qrunfleh and Tarafdar, 2014). Based on the preceding theoretical arguments, the following hypothesis is proposed:

> H2: Supply chain performance is directly and positively related to firm effectiveness.

In today's business environment, firms are aware that cooperation with other firms in supply chains brings benefits to them only if all firms operate successfully (Lummus and Vokurka, 1999). This theoretical argument supports the notion that overall supply chain success inevitably influences how the focal firm's organizational processes influence its business performance. Therefore, we propose the following hypothesis:

> H3: Supply chain performance significantly mediates the relationship between 3A dynamic capabilities and firm effectiveness.

3. Methodology

3.1 Operationalization

For the purpose of this study we use construct operationalizations from previous studies. The agility scale was adapted from Whitten et al (2012) and Zelbst et al (2010). The adaptability scale was adapted and modified to a lesser extent from Whitten et al (2012), and Swafford et al (2006). The alignment scale was adapted from Whitten et al (2012) and was complemented with some scale items from Ryu et al (2009), and Power et al (2001). To measure supply chain performance, we relied on the ideas suggested by Chan (2003) who provides the most comprehensive measurement framework and classifies supply chain performance indicators at quantitative level (cost, resource utilization) and qualitative level (quality, flexibility, visibility, trust and innovativeness) (Chan, 2003). We complemented this scale with items from other studies (Green et al, 2012, Qrunfleh and Tarafdar, 2014, Swafford et al, 2008).

To measure firm effectiveness we relied on the guidelines of Robbins and Coulter (2005), and Ruekert et al (1985) and defined several indicators of firm effectiveness: i.e. overall business result, customer satisfaction, and time to market. The respective scale items were adapted from previously published studies (Krohmer et al., 2002, Lee and Choi, 2003, Kim, 2006, Zhang et al, 2006, Li et al, 2006).

3.2 Sample and data collection

For the purpose of data collection, we developed an online questionnaire which we e-mailed to 722 managers of manufacturing companies listed in the Business Registry of the Croatian Chamber of Commerce. In developing the sample frame, we applied the following criteria: 1) firms are active, and 2) firms have more than ten employees. E-mail invitations to participate in the survey were sent out over a period of three months. After a third reminder, 85 useful responses were received, which accounts to a response rate of 11.77 percent which is deemed satisfactory. Table 1 presents an overview of the sample according to firm size.

Nr of employees	Frequency	%
51-250	53	62.35
> 251	32	37.65
Total	85	100

Tab. 1: Sample according to company size

3.3 Data analysis

In order to test our hypotheses we applied partial least squares structural equation modelling (PLS-SEM). PLS-SEM is considered advantageous over covariance-based SEM with regard to the robustness of estimations and statistical power when applied to smaller sample sizes, as is the case in our study (Reinartz, Haenlein and Henseler, 2009). Moreover, PLS-SEM deals more efficiently with non-normal data and facilitates model estimations with both reflectively and formatively identified variables (Ringle, Sarstedt and Straub, 2012).

For the purpose of our study, we used the sequential latent variable score method (Wetzels, et al., 2009, Hair, et al., 2013). Accordingly, first, we calculated latent variable scores (LVS) of the first-order reflective constructs (e.g., Agarwal and Karahanna, 2000). The number of factors to be extracted for each first-order construct was fixed to one. Second, the calculated LVSs were then used as manifest formative indicators of the respective second-order construct in the main model (i.e. 3A DCs, Supply chain performance, Effectiveness). An advantage of the sequential LVS method is that it yields a parsimonious model that encompasses only focal higher-order constructs. In our study, all first-order latent variables yielded appropriate levels of internal consistency.

Structural model estimations in this study were conducted with SmartPLS 2.0 software (Ringle, Wende and Will, 2005). We used mean-centered data and the path weighting scheme, missing data were excluded case-wise.

In order to test for possible mediation we assessed two models, i.e. one without the mediator (i.e. Supply chain performance) and a direct relationship between 3A DCs and Effectiveness, only, and the other model with additional links between a) the predictor and the mediator, and b) the mediator and the dependent variable included. If these relationships prove statistically significant, and if inclusion of the mediator results in a decrease of the direct effect size between the predictor and the dependent variable, then this indicates the presence of a mediating effect.

4. Findings

A graphical presentation of the single cause-effect model and the mediator model is provided Figures 1 and 2, respectively.

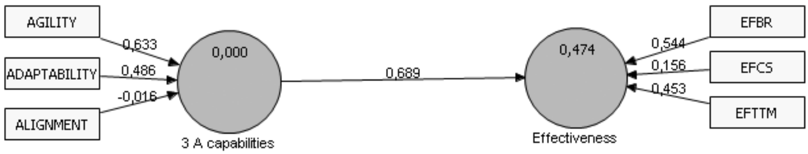

Fig. 1: Simple cause-effect relationship between 3 A capabilities and Effectiveness

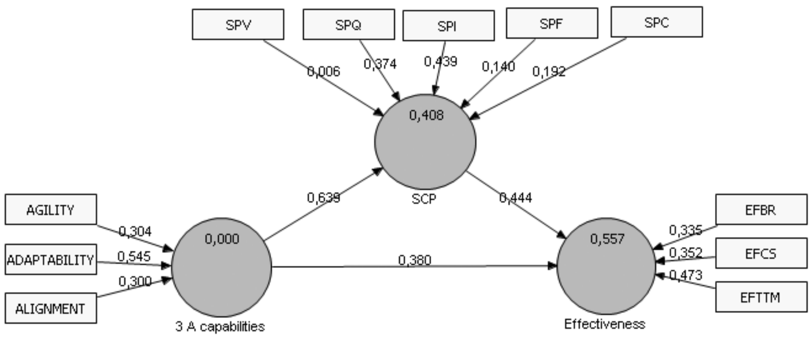

Fig. 2: Mediating role of the supply chain performance

4.1 Assessment of the Measurement Model

The quality of the formative measurement model was assessed by examining the magnitude and significance of indicator weights. To obtain significance-levels we applied bootstrapping to calculate standard errors and respective t-statistics (Tenenhaus, et al, 2005). We set the number of bootstrap samples to 5000 and the number of cases equal to the number of cases in the original sample. The results of this analysis are presented in Table 2.

Table 2 reveals that most of the formative indicator weights are significant at the 0.01 or 0.05 level. Lowest significance levels are reported for SPV and SPF (t-value = 0.039 and 0.817, respectively). Interesting to note, inclusion of the mediator significantly increases the significance level of Alignment as a component of 3A DCs.

	Original Sample	Sample Mean	Standard Deviation	Standard Error	T Value
ADAPTABILITY -> 3A DCs	0,545	0,530	0,148	0,148	3,677
AGILITY -> 3 DCs	0,304	0,323	0,163	0,163	1,864
ALIGNMENT -> 3 DCs	0,300	0,285	0,160	0,160	1,878
EFBR -> Effectiveness	0,335	0,326	0,138	0,138	2,428
EFCS -> Effectiveness	0,352	0,328	0,160	0,160	2,203
EFTTM -> Effectiveness	0,473	0,492	0,144	0,144	3,275
SPC -> SCP	0,192	0,215	0,152	0,152	1,257
SPF -> SCP	0,140	0,120	0,171	0,171	0,817
SPI -> SCP	0,439	0,443	0,163	0,163	2,699
SPQ -> SCP	0,374	0,350	0,161	0,161	2,326
SPV -> SCP	0,006	0,008	0,150	0,150	0,039

Tab. 2: Bootstrap results for the outer model

4.2 Assessment of the Structural Model

The coefficients of determination (R2) of the endogenous variables were assessed to evaluate the model's predictive power. In the simple cause-effect model (without the mediator) the dependent variable (Effectiveness) yields an R2 score of 0.474. In the mediating effect model, the mediator variable (SCP) and the dependent variable (Effectiveness) yield R2 scores of 0.408 and 0.557,

respectively. In both models, thus the R2 scores exceed the cut-off value of 0.4 which indicates substantial path structures in the inner model (Chin, 1998).
We further examined Stone-Geisser's Q2 statistic to evaluate the predictive relevance of the model, i.e. to see how well exogenous variables explain endogenous variables (Chin, 1998; Hair, et al., 2013). This statistic, which is reported as cross-validated redundancy in SmartPLS 2.0, should be above zero. Moreover, scores of cross-validated communality (q2) were examined to assess the model's ability to predict the manifest indicators from the calculated latent variables (Tenenhaus, et al., 2005). q2 scores of 0.02, 0.15 and 0.35 are indicative of a weak, moderate, and strong degree of predictive relevance of each effect, respectively. Scores of cross-validated communality and redundancy were obtained through blindfolding and jackknife re-sampling approaches. The findings in regard to predictive relevance of the model are presented in Table 3.

	CV redundancy (Q2)	CV communality (q2)
3 A DCs	0.741	-
Effectiveness	0.734	0.265
SCP	0.707	0.294

Tab. 3: Analysis of predictive relevance

The Q2 statistic indicates predictive relevance of the inner model variables (Henseler, et al., 2009). The q2 statistic further indicates a medium level of predictive relevance for the mediator (SCP) and the dependent variable (Effectiveness).
Finally, significance-levels of the inner model path coefficients were estimated. The bootstrap procedure described earlier was again applied. The results for the single cause-effect model and the mediator model are provided in Table 4.

	Original Sample	Sample Mean	Standard Deviation	Standard Error	T Value
Single cause-effect model					
3A DCs -> Effectiveness	0.689	0.705	0.067	0.067	10.293
Mediator model					
3A DCs -> Effectiveness	0.380	0.351	0.153	0.153	2.478
3A DCs -> SCP	0.639	0.648	0.080	0.080	7.990
SCP ->.Effectiveness	0.444	0.469	0.183	0.183	2.429

Tab. 4: Bootstrap results for the inner model

The findings reveal that 3A DCs have a statistically significant effect on Effectiveness in both the single cause-effect model and the mediator model. The t-value, however, significantly decreases in the mediator model (t = 10.293 and 2.478, respectively).

Furthermore, 3A capabilities have a significant effect on SCP, and SCP has a significant effect on Effectiveness in the mediator model. Given the increase of explained variance in Effectiveness in the mediator model, and the decrease of the direct effect of 3A capabilities, our results indicate that Supply chain performance partially mediates the relationship between 3A capabilities and Effectiveness.

5. Conclusion and Implications

In today's business environment, supply chains represent a form of integrated inter-firm networks. The transformation into excellent supply chains requires utilization of 3A DCs - agility, adaptability and alignment, which are the basis for sustainable competitive advantage of the whole supply chain. The goal of this study thus was to examine whether 3A DCs exhibit a positive impact on supply chain performance and to see how this potentially reflects on firm effectiveness. According to the study findings, we found strong support for our hypotheses.

The relationship between 3A DCs and supply chain performance was found to be direct and positive which suggests that 3A DCs are an inevitable pillar of supply chain competitiveness. By implementing the 3A DCs in everyday business, each individual supply chain member strengthens the competitive position of the supply chain as a whole. Eventually, such synergistic acts result in higher supply chain performance. Our study provided empirical evidence for this which led to acceptance of H1.

With regard to H2, our results indicate that supply chain performance has a direct and positive impact on firm effectiveness. This finding is not surprising, but it has so far not been reported in greater detail in previous studies. Hence, it is crucial to consider the spill over effect that supply chain performance exhibits on the individual performance outcomes of member firms in the supply chain. Nevertheless, this notion is even more evident in H3, where our data shows that supply chain performance partially mediates the relationship between 3A DCs and firm effectiveness. The DCs are internal intangible and "soft" assets embedded in managerial competencies and certainly yield a positive effect on firm business outcomes. Yet, by inspecting the indirect effects in the model, we can conclude that the relationship between 3A DCs and firm effectiveness is better explained by the intervention of supply chain performance as a mediator variable.

This study brings some implications to managerial attention. In order to create an excellent supply chain, firms must value the importance of the supply chain for their focal business in terms of business performance outcomes. Therefore, the managers need to utilize 3A DCs (agility, adaptability and alignment) to successfully manage flows in the supply chain. From a practical standpoint, firms should apply various initiatives that enhance supply chain excellence such as:

continuous monitoring of the needs of end customers, customization of products according to latest customer preferences, clarifying the roles, tasks and responsibilities for other members of supply chain (suppliers and customers), implementing system that will support equitable risk sharing, costs and benefits with other partners in the supply chain. On the bottom line, cooperation between partners in the supply chain is the most important mechanism for the development and improvement of DCs and should not be hindered.

This study has several limitations. First, we relied only on data provided by single firms in the supply chain. Therefore, future studies could incorporate data from the other sides of the supply chain dyad (e.g., customers and suppliers of the focal firm), and by using a more in-depth, qualitative approach. Second, we relied only on single informants from the companies in our study. Future studies should survey different managerial positions (e.g., financial managers) in regard to supply chain issues. Third, it would be interesting to conduct the same study on the example of other sectors.

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Analyzing Process Capability Indices (PCI) and Cost of Poor Quality (COPQ) to Improve Performance of Supply Chain

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Abstract

Many ports have inefficient and ineffective activities in the entire of Supply Chain. Many methods and tools are used to analyze performance of Supply Chain. This study based on our practical experience in implementation of Six Sigma Methodology in port. The main purpose of our research is to analyze Process Capability Indices (PCI) and Cost of Poor Quality (COPQ) for improving performance of Supply Chain in port. PCI and COPQ is performance indicator of Six Sigma Methodology as one of Quality Improvement Method. Case study has been taken in CDG Port, Indonesia. Three big cargos handling have been selected to be analyzed PCI and COPQ, as follow: fertilizer, slab steels, and iron ore. Data were collected by direct observation and interview with Logistics Service Department of CDG Port. The result of Process Capability Indices in handling of cargo is 0.06 in average. This result shows that process capability in cargo handlings have not capable to meet the customer requirements. Meanwhile, Cost of Poor Quality in cargos handling is about 700,449 USD in average and 39.02 % from the sales in average. This cost is still high if it is compared with the sales. Many potential improvements to increase process capability and decrease cost of poor quality. With Six Sigma Methodology, Process Capability Indices and Cost of Poor Quality can be analyzed for improving performance of Supply Chain in port.

Keywords: capability process indices, cost of poor quality, six sigma, port

1. Introduction

Nowadays, every country tries to improve performance in their ports for getting competitiveness. Each port in a country shows how the quality of the trading health. Most of export and import activity have been done in their ports. So, ports in a country have an important role in trading and development. With complexity problems in port, many efforts have been carried out both of concept and practical. All countries try to reduce ineffective and inefficient activities in ports. The entire of Supply Chain in port has become a target to be analyzed its performance.

Many methods and tools have been used to analyze performance of Supply Chain. In this research, Six Sigma Methodology has been implemented as a method to improve quality dramatically. This method can be implemented not only for manufacture companies but also for service companies, including in ports. Originally, Six Sigma has been developed by Motorola in 1986 as a new breakthrough in quality management. Six Sigma approaches allow 1.5 ng shift so it's only 3.4 Defect per Million Opportunities (DPMO) is allowed for product or services. Six Sigma is not only using tools of statistics for quality improvement but also using this value as a standard of industry performance and business strategy.

Supply Chain has become a key business strategy to achieve competitive advantages. Therefore, Supply Chain processes must be arranged and well organized so Supply Chain Management (SCM) concept has developed. Bases on the Global Supply Chain Forum (GSCF), SCM is the integration of key business processes from end user through original suppliers that provides products, services, and information that adds value for customers and other stakeholders.

This research based on practical experience in implementation of Six Sigma methodology in ports, especially in Supply Chain flow of cargos handling. In this research, focus to analyze step of Six Sigma methodology with analyzing the Process Capability Indices (PCI) and the Cost of Poor Quality (COPQ). In the research before, Define and Measure step of Six Sigma methodology, Ridwan (2013, p.144) resulted some performance indicators and performance baseline of sigma value is 1.64 in supply chain flow at CDG port. Many researchers have calculated the process capability. Kane (1986) introduced calculation of the beginning of capability process. Somerville and Montgomery (1996) proposed to calculate Cp or Cpk for a non-normal distribution and making inferences about the process fallout or Part Per Million (PPM) non conforming. Huang and Chen (2003) proposed an integrated Process Capability Indices for multiprocess product. Chen et al. (2003) proposed a generalized capability measure for processes with multiple characteristics. Wang (2005) developed a procedure for constructing Multivariate Process Capability Indices (MPCIs) based on Principal Component Analysis (PCA) and Clement’s method for short-run production. Kurekova (2011) showed some deficiencies of three most applicable methods for calculation of the measurement process capability and Cpm represents best the real measurement process capability instead Cp and Cpk.

Also, many researchers have done a research to get the optimum of Cost of Poor Quality(COPQ). Tsai (1998) proposed to integrate Cost of Quality (COQ) and Activity Based Costing (ABC) framework. Ramudhin et al. (2008) integrated the vital concept of Cost of Quality into to the Supply Chain network designs to minimize a series of costs. Salonen and Deleryd (2011) proposed Cost of Poor Maintenance (CoPM) as a new concept to improve maintenance performance.

This research aims to implement an analyzing the Process Capability Indices (PCI) and the Cost of Poor Quality (COPQ) in supply chain flow at port. With this analyzing, process capability of cargos handling in port can be determined. Also, cost that is caused by poor quality in cargos handling at port can be determined. PCI are a measurement that process can fulfill customer requirements or customer specifications. Whereas, COPQ consist of: prevention cost, appraisal cost, and failure cost both of internal and external failure. Analyzing PCI and COPQ in CDG Port are expected become a basic to improve performance of supply chain flow that is focused in material flows from the ship to the warehouse. CDG port is a logistics provider company in Indonesia and provides freight services, both dry bulk and liquid, operational vehicles, operators, machinery required, packaging process the goods until delivery to the warehouse destination (Ridwan et al., 2013).

2. Literature Review

Many methods and tools were used to improve performance of Supply Chain, especially in ports. This research focused to improve Supply Chain performance with Six Sigma approach. Six Sigma Methodology is one of quality improvement method.

2.1 Supply Chain

Many methods and tools are used to improve performance of logistics and Supply Chain. The Council Logistics Management defines Logistics is the part of the Supply Chain that plans, implements, and control the efficient, effective flow and storage of goods, services, and related information from the point of origin to the point of consumption to meet customer requirements. Supply Chain Management is to apply a total systems approach to managing the entire flow of information, materials, and services from raw materials suppliers through factories and warehouse to the end customer (Chase et al., 2004). Logistics and Supply Chain have become a key or strategic function in companies in achieving competitive advantages.

2.2 Six Sigma Methodology

In the beginning, Six Sigma is implemented in manufacturing area, and then it is implemented in service area, including ports. The initial methodology of Six Sigma was focused on process improvement and accordingly DMAIC (Define-Measure-Analyze-Improve-Control) approach was universally adopted, but as time progressed, the need of implementing Six Sigma at design stage of product or process (Ball et al., 2010). Each steps of Six Sigma Methodology contain tools and techniques. Define step determine the objectives of project and organizing the people. Measure step determine a key performance indicators and measure of sigma value. Analyze step determine Process Capability Indices and calculate the cost of poor quality. Improve step use many tools to improve quality like FMEA (Failure Mode Effect Analysis), design of experiment, etc. Control step maintain quality in control with control chart.

Besterfield (2003) states Six Sigma was simply a Total Quality Management (TQM) process that uses process capability analysis as a way of measuring progress. Process capability analysis is very important to know capability when products is made or services is given. Pyzdek (2001) states that Six Sigma involves an intense effort to reduce process variation to a minimum, so that processes consistently meet or exceed customer expectations and requirements. Process control using control chart to control process variation and process mean. Pande and Holpp (2002) states that adopting Six Sigma methodologies are to improve customer satisfaction, work processes, profitability, speed, and efficiencies.

2.3 Process Capability Indices (PCI)

Cp and Cpk are indicators that use to determine process capability. Pearn et.al (2005, pp.513) states "Process Capability Indices are practical and powerful tools for measuring process performance". Kane (1986, pp.44-45) state "Cp index measures potential process performance since only the process spread is related to the specification limits and Cpk index is related to the Cp index but utilizes the process mean and considered a measure of the process performance". Kane (1986, p.41-45) formulated Cp and Cpk as follow:

$$\mathrm{Cp} = \frac{\text{allowable process spread}}{\text{actual process spread}} = \frac{USL - LSL}{6\sigma}$$

$$\mathrm{Cpk} = \min(\mathrm{CPU}, \mathrm{CPL})$$

$$\mathrm{CPU} = \frac{USL - \mu}{3\sigma} \text{ and } \mathrm{CPL} = \frac{\mu - LSL}{3\sigma}$$

with: USL = Upper Specification Limit, σ = Natural Tolerance
LSL = Lower Specification Limit, μ = Process Mean

Cpk index is actual measurement based on shifting of process mean. Whereas, Cp index show potential capability of the process or services.

Based on Gryna on Juran's Quality handbook (1999, p.22.17), there are two types of process studies, as follow:

1. Process capability that estimate the inherent or potential process capability
2. Process performance that measures the present performance of the process.

The formulation for process capability and process performance are shown below:

Process Capability	Process Performance
$Cp = \frac{USL - LSL}{6\sigma}$	$Pp = \overset{\wedge}{Cp} = \frac{USL - LSL}{6\sigma}$
$Cp\text{k} = \min\left(\frac{USL - \mu}{3\sigma}, \frac{\mu - LSL}{3\sigma}\right)$	$Pp = \overset{\wedge}{Cpk} = \min\left(\frac{USL - \mu}{3\sigma}, \frac{\mu - LSL}{3\sigma}\right)$
$Cpm = \frac{USL-LSL}{6\sqrt{\sigma^2+(\mu-T)^2}} = \frac{Cp}{\sqrt{1+\left(\frac{\mu-T}{\sigma}\right)^2}}$	$Pp = \overset{\wedge}{Cpm} = \frac{USL - LSL}{6\sqrt{\sigma^2 + (\mu - T)^2}}$

Tab. 1: Process Capability and Process Performance (Gryna on Juran, 1999, p.22.18)

Senvar and Tozan (2010, p.259) state Cpkm is a third generation that is derived from the second generation Process Capability Indices (PCI): Cpk and Cpm. Formulation of Cpkm as follow:

$$Cpkm = \frac{Cpk}{\sqrt{1 + \left(\frac{\mu - T}{\sigma}\right)^2}}$$

With: T = Target of specification, midpoint from Upper Specification Limit (USL) and Lower Specification Limit (LSL)

Both of Cpm and Cpkm are used to calculate PCI with processes that have a target of specification. Cp and Cpk can be measured if the process condition

under control statistically. If the process is out of control, so it must be controlled statistically.
Comparation of Cp value and total product outside from specification limit can be seen in the table below:

Process Capability Indices, Cp	Total product outside two-sided specification limits*
0.5	13.36 %
0.67	4.55 %
1.00	0.3 %
1.33	64 ppm
1.63	1 ppm
2.00	0

*Assuming the process is centered in midpoint between the specification limits

Tab. 2: Process Capability Indices,Cp and Product outside Specification Limits (Gryna on Juran, 1999, p.22.18)

Six-sigma concept of process capability recognizes 1.5 standard deviation shifts in the process average and so the product or the process must achieve a Cp of at least 2.0 (Gryna in Juran, 1999). Process capability does not meet the specification of customer; it is caused by variability of process and not centralized to target of process. Montgomery (2001, p.331) states there are two reasons that cause poor process capability are: a). poor process centering and b). Excess process variability, as follow:

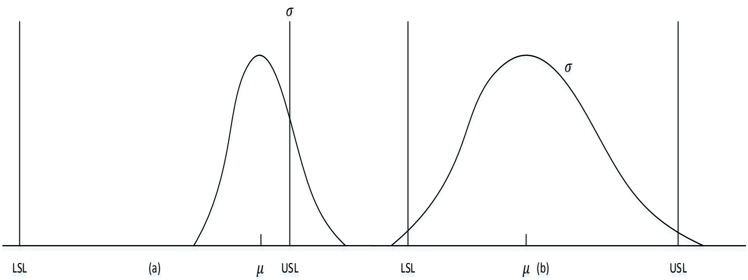

Fig. 1: Some reasons for poor process capability: a) poor process centering b) excess process variability (Montgomery, 2001, p.331)

2.4 Cost of Poor Quality (COPQ)

It is analyzed Cost of Poor Quality to know how many influence between the quality of process in product or services and the cost. Regarding Gryna on Juran's Quality handbook (1999), Cost of Poor Quality (COPQ) identified and analyzed with 3 reasons, are: to quantify the size of the quality problem to help justify an improvement effort, to guide the development of that effort, and to track progress in improvement activities. The quality costs in the range of 10 to 30 % of sales or 25 to 40 % of operating expenses.

Many categories to classify of Cost of Poor Quality (COPQ). Based on Gryna on Juran's Quality handbook (1999. p.8.5), categories of COPQ are:

1) Internal Failure Cost, costs of deficiencies discovered before delivery which are associated with the failure.
    a. Failure to meet customer requirement and need, for example: scrap, rework, reinspection, redesign, downgrading, etc.
    b. Cost of inefficient processes, for example: variability of product characteristics, inventory shrinkage, Non Value Added (NVA) activities, etc.
2) External Failure Costs, cost associated with deficiencies that are found after product is received by customer.

a. Failure to meet customer requirement and needs, for example: warranty defection, complaint adjustment, returned material, penalties, etc.
b. Loss opportunities for sales revenue, for example: customer defection, loss because of quality

3) Appraisal Cost, costs incurred to determine the degree of conformance to quality, for example: incoming inspection and test, final inspection, document review, audit, evaluation of stocks, maintaining accuracy of test equipment.etc.
4) Prevention cost, cost incurred to keep failure and appraisal costs a minimum, for example: process planning, new product planning, process planning, process control, quality audit, supplier quality evaluation, training, etc.

The scenario of integrated Cost of Poor Quality (COPQ) in Supply Chain network design will ensure the lowest overall cost, because it reduces the probability of defects and hence the probability of additional cost which might be due to corrective action (Ramudhin et al.,2008). Analyzing COPQ can be improved a chance to get higher profit. Failure cost must be decreased as a minimum so operational cost become smaller. Prevention and appraisal cost can be increased in appropriate level to avoid or prevent failure in the next process. Optimum cost for poor quality can refer to model of Gryna on Juran's Quality handbook (1999, p.8.22) as follow:

Based on the figure 2, failure cost cannot be decreased until zero because it is needed costs of appraisal and prevention more. Industries intend to get a failure cost in minimum and expend prevention and appraisal cost in appropriate cost. So, total quality cost is optimum when quality of conformance less than 100 percent. Many methods are used to get optimum value of the Cost of Poor Quality (COPQ). Based on Gryna in Juran's Quality handbook (1999, p. 8.16), they come from a reduction in variability of product or process characteristics and process losses such as redundant operators, sorting inspections, retrieving missing information and other non value added activities.

Now, industries try to eliminate non value added activities in their process from upstream to downstream. They used many tools to eliminate non value added analysis like value stream mapping with lean manufacturing approach. Lean manufacturing focuses on the methodologies and approaches that can help an enterprise to reduce the waste factors in its processes (Khataie and Bulgak, 2013). Many researchers try to integrate Cost of Poor Quality (COPQ) with other tools like Tsai (1998) states the long term goal of the integrated Cost of Quality (COQ) and Activity Based Costing (ABC) system is to eliminate non value added activities.

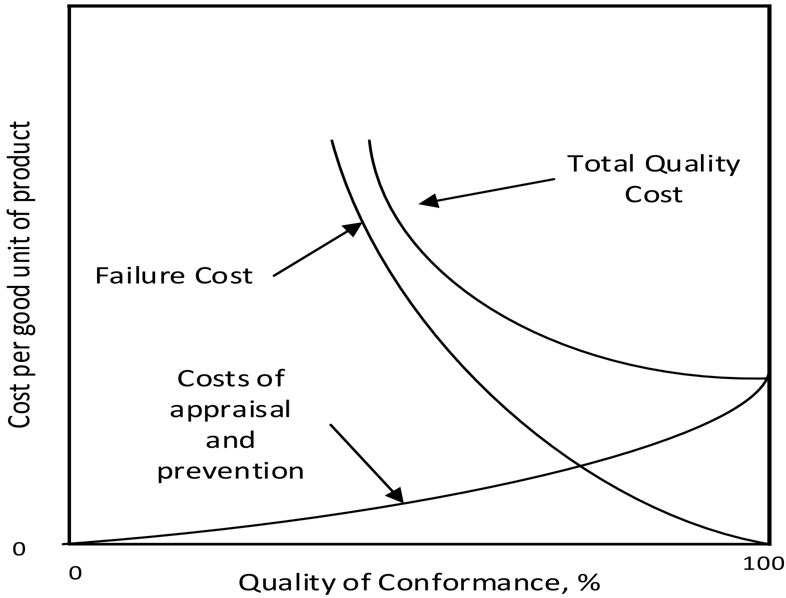

Fig. 2: Model for Optimum Quality Costs (Gryna on Juran, 1999,p.8.22)

3. Research Methodology

Data were collected by direct observation and interview with Logistics Service Department of CDG Port. This research follows Six Sigma methodology with

DMAIC (Define–Measure-Analyze-Improve-Control) steps. This research focused to Analyze steps to analyze Process Capability Indices (PCI) and Cost of Poor Quality (COPQ). Process Capability Indices is important to be analyzed to know the capability of process. This research proposed calculating Process Capability Indices in Supply Chain flow in port based on Kane (1986, p.41-45) as a measurement of actual process performance. Cpk is selected for calculating the Process Capability Indices (PCI) in actual process. It means, calculating PCI with considering the shifting of process mean. Cpkm cannot be used because all performance indicators in supply chain flow do not have Target of specification (T) or midpoint of Upper Specification Limit (USL) and Lower Specification Limit (LSL). These processes only have Upper Specification Limit (USL).

Ridwan (2013) states all performance indicators of Supply Chain flow in CDG port were obtained from all process that becomes a critical problem. So, all performance indicators in this research based on critical problem on Ridwan's research before. Data collection based on observation and discussion with person in charge at Logistic Service Department of CDG port, calculation of the Process Capability Indices took three cargos handling as example and represented cargos in CDG Port, as follow: fertilizer, slab steels, and iron ore. All performance indicators for cargos can be seen on next table (page 11, 12, and 13).

Cost of Poor Quality (COPQ) is analyzed to know impact of poor quality to the cost. This research refer to model for optimum quality cost from Gryna Juran’s Quality handbook (1999), applied in supply chain flow of cargos handling at port. After classification of COPQ in prevention cost, appraisal cost, and failure cost, then calculation percentage of COPQ to sales. Also, data collection based on observation and discussion with person in charge at Logistic Service Department of CDG port, for three cargos handling as example and represented cargos in CDG Port, as follow: fertilizer, slab steels, and iron ore. In the end of research, improvements are proposed to improve performance of supply chain flow, especially in cargos handling at port.

4. Result and Discussion

The results of research based on implementing in CDG Port as follow:

4.1 Calculate the Process Capability Indices

It is measured Process Capability Indices to know how the process can meet the requirement of customer. The Process Capability Indices indicate variation of process and capability of centered-process. This table below is summary of Process Capability Indices in Fertilizer cargo handling.

Cargo: Fertilizer

No	Process (performance indicators)	Upper Specification Limit /USL (minutes)	Average	Deviation Standard	Process Capability Indices
1	Unloading Fertilizer from the ship to hopper with Grab	1.2	1.24	0.172	-0.08
2	Loading fertilizer from hopper to the Truck	4	4.14	0.776	-0.06
3	Weighing time in weighing area	5	5.11	0.683	-0.05
4	Transportation to KBS Warehouse	15	12.87	2.241	0.32
5	Unloading fertilizer in the Warehouse	3	2.26	0.348	0.71
6	Bagging fertilizer in the KBS Warehouse	0.2	0.21	0.023	-0.14
7	Loading fertilizer from warehouse to the truck	1.5	1.50	0.081	0.01
				Average	0.10

Tab. 3: Summary of Average, Deviation Standard, Control Limit, and Process Capability Indices in Fertilizer cargo handling

Example for calculation: (no. 1, on page 11)

Unloading Fertilizer from the ship to Hooper with Grab

N = 100

Calculation of $\bar{X}$ as follow:

$$\bar{X} = \frac{\sum_{i=1}^{N} Xi}{N} = \frac{124.22}{100} = 1.24$$

Calculation of deviation standard as follow:

$$\sigma = \sqrt{\frac{\sum(Xi - \bar{x})^2}{N}} = \sqrt{\frac{2.948}{100}} = 0.172$$

Cargo: Slab Steels

No	Process (performance indicators)	Upper Specification Limit /USL (minutes)	Average	Deviation Standard	Process Capability Indices
1	Unloading slab from ship to the truck	6	6.07	0.738	-0.03
2	Transportation to KBS stockpile	15	15.36	1.638	-0.07
3	Unloading slab from truck in the KBS Stockpile	1	0.99	0.115	0.02
4	Loading Slab to the Truck in KBS Stockpile	1.75	1.80	0.152	-0.11
5	Transportation to KS stockpile	65	62.18	7.855	0.12
				Average	-0.01

Tab. 4: Summary of Average, Deviation Standard, Control Limit, and Process Capability Indices in Slab Steels cargo handling.

The company determines a target of unloading process of fertilizer is maximum of 1.2 minutes or Upper Specification Limit (USL) =1.2 minutes. There is no

Lower Specification Limit (LSL). With data is assumed to be normally distributed, so the calculation of Process Capability Indices (Cpk) as follows:

$$Cpk = \min[\mathrm{CPU},\ \mathrm{CPL}\,] = \min\ \left[\frac{\bar{\mathrm{X}}-\mathrm{LSL}}{3\sigma},\ \frac{\mathrm{USL}-\bar{\mathrm{X}}}{3\sigma}\right] \text{because there is no LSL, so}$$

$$Cpk = \mathrm{CPU} = \frac{1.2-1.24}{3\ (0.172)}\ = \frac{1.2-1.24}{3\ (0.172)}\ = -0.0775\ =\ -0.08\ (\text{be rounded})$$

Cargo: Iron Ore

No	Process (performance indicators)	Upper Specification Limit /USL (minutes)	Average	Deviation Standard	Process Capability Indices
1	Unloading Iron Ore from Ship to Conveyor	2	1.98	0.476	0.02

Tab. 5: Summary of Average, Deviation Standard, Control Limit, and Process Capability Indices in Iron Ore cargo handling

This table below is summary of Process Capability Indices (PCI)

Cargo	PCI
Fertilizer	0.10
Slab	-0.01
Iron Ore	0.02
Average	0.06

Tab. 6: Summary of Cost of Process Capability Indices (PCI)

The result of Process Capability Indices (PCI) in handling of cargo is 0.06 in average. This result shows that process capability in cargos handling at CDG port have not capable to meet the customer requirements. Upper Specification Limit (USL) was determined by customer and CDG port has not met the customer specifications. PCI become one of performance indicator in the process capability of cargos handling. Based on Gryna in Juran's Quality Handbook

(1999, p.22.17), if Cp <1, so heavy process control, sorting, and rework must be done for actions. For Six Sigma implementation, process must achieve Cp value at least 2.0 (Gryna in Juran, 1999).

Calculation of these PCI is focused in performance indicator for cycle time to get an optimal time for loading and unloading material from the ship to the warehouse. Speed of loading and unloading material in Supply Chain flow in port is very important to get the effective time in cargo handling. If the time is over from the contract, this port must pay a demurrage cost that is known quite expensive.

Causes for low PCI consisted of variation of process is high and centering of process is low (Montgomery, 2001). Based on observation and discussion in the field, variation and centering of process were caused dominantly by delay for equipments and supporting equipments for loading and unloading material like trucks or container trucks, cranes, loaders, excavators, etc. Delay for equipments and their supporting were caused by lack of maintenance and insufficiency of equipment and its equipment. Improvement plans have been proposed to solve the problems like upgrading equipment, periodical shutdown maintenance, selecting skilled operator for equipment, outsourcing for equipment, etc. Major improvement is proposed to implement Total Productive Maintenance (TPM) in maximizing overall equipments and running small group activities.

4.2 Cost of Poor Quality (COPQ)

Calculation of the Cost of Poor Quality (COPQ) was performed in three cargos handling and represent in CDG Port as follow: Fertilizer, Slab Steels, and Iron Ore. Based on observation and interview with person in charge at Logistic Service Department, Cost of Poor Quality (COPQ) for handling in Fertilizer, Slab Steels, and Iron Ore cargo as follow.

Based on the table 7 on p.16, prevention cost is 312,625.76 USD or about 49 % from Cost of Poor Quality (COPQ) and Appraisal cost is 110,462.77 USD or 17 % from COPQ. Also, prevention and appraisal cost is 423,088.52 USD or about 66% from COPQ. Meanwhile, failure cost is 217,612.85 or 34 % from COPQ.

Failure cost is still high although prevention and appraisal cost already have been increased. For next improvement strategy, prevention cost is decreased in the appropriate level and appraisal cost is kept. Cargo: Fertilizer:

No.	Item Cost	Cost (USD)
	Prevention Cost	
1	Repair and maintenance of cranes	90,350.53
2	Repair and maintenance of dump trucks	212,752.22
3	External training	333.33
4	Security services	7,500
5	Repair and maintenance of heavy equipments (forklift and front loader)	1,689.67
	Total	312,625.76
	Appraisal Cost	
1	Calibration of scales	4,560
2	Calibration for certificates	3,000
3	Vehicles testing and taxes for truck	447.92
4	Draft survey	2,980.38
5	Supervision from dock until destination warehouse	12,541.67
6	Custom Clearance from customs and excise	30,989.15
7	Re-bagging because stitching of bagging is not good	8,606.98
8	Emission of CO2 test for trucks and heavy equipments	458.33
9	Stevedoring companies	46,878.35
	Total	110,462.77
	Internal Failure Cost	
1	Loss of content from ship to warehouse	54,453.13
2	Bagging is damaged (dirty or trampled)	116,875.00
3	Delay of trucks, cranes, excavators, loaders, and workers	34,201.39
	Total	205,529.51
	External Failure Cost	
1	Demurrage (penalty)	0
2	Warranty	12,083.33
3	Accomplishment of Customer (loss of content, bagging is damage or dirty, etc.)	0
4	Returned product	0
	Total	12,083.33
	Grand Total Cost of Poor Quality (COPQ)	640,701.37

No.	Item Cost		Cost (USD)
Sales (USD)		1,871,000.00	
Percentage COPQ to Sales		34.24 %	

Tab. 7: Cost of Poor Quality of Fertilizer (Logistics Services Department of CDG Port, 2013)

Composition of the Cost of Poor Quality is shown below:

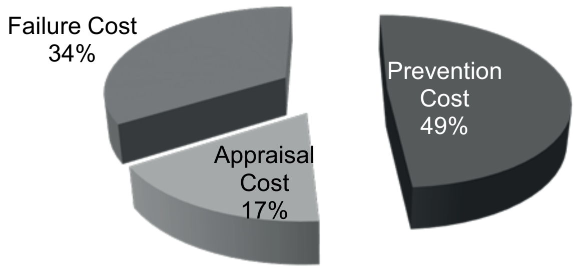

Fig. 3: Composition Prevention, Appraisal, and Failure cost for Fertilizer Cargo handling

Cargo: Slab Steels

Based on the table 8 on p.18, prevention cost is 111,942.82 USD or about 8 % from COPQ and Appraisal cost is 1,111,824.22 USD or 82 % from COPQ. Also, prevention and appraisal cost is 1,223,767.03 USD or about 90% from COPQ. Meanwhile, failure cost is 136,041.67 USD or 10 % from COPQ. Composition of the Cost of Poor Quality is shown below:

No.	Item Cost	Cost (USD)
	Prevention Cost	
1	External training	333.33
2	Repair and maintenance of cranes	111,609.48
	Total	111,942.82
	Appraisal Cost	
1	Supervision and labors for unloading on Jetty	41,782.77
2	Custom Clearance from customs and excise	27,703.70
3	Rent of forklifts	297,137.92
5	Stevedoring companies	668,049.00
6	Lift off process of slab steels from the truck	59,917.50
7	Installation and supervision of dunnage/block	5,083.33
8	Supervision by checkers	12,150.00
	Total	1,111,824.22
	Internal Failure Cost	
1	Delay of transportation (trucks), ship crane troubles, and delay of workers	136,041.67
	Total	136,041.67
	External Failure Cost	
1	Demurrage (penalty)	0
2	Warranty	0
3	Accomplishment of Customer Complaint	0
4	Returned product	0
	Total	0
	Grand Total Cost of Poor Quality (COPQ)	1,359,808.70

Tab. 8: Cost of Poor Quality of Slab Steels (Logistics Services Department of CDG Port, 2013)

Appraisal cost for this cargo is too high although failure cost is low. For next improvement strategy, appraisal cost must be decreased to appropriate level.

Based on the table 9 on p.20, prevention cost is 37,536.49 USD or about 37 % from COPQ and Appraisal cost is 12,015.63 USD or 12 % from COPQ. Also, prevention and appraisal cost is 49,552.12 or about 49% from COPQ. Meanwhile, failure cost is 51,284.72 USD or 51 % from COPQ. Composition of the Cost of Poor Quality is shown below:

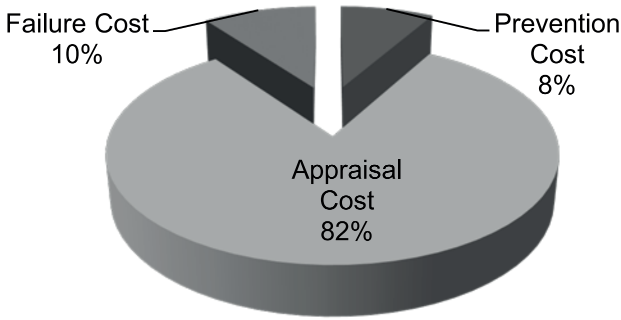

Fig. 4: Composition Prevention, Appraisal, and Failure cost for Slab Steels Cargo handling

Cargo: Iron Ore

No.	Item Cost	Cost (USD)
	Prevention Cost	
1	Repair and maintenance of ship unloaders	37,203.16
3	Internal trainings	333.33
	Total	37,536.49
	Appraisal Cost	
1	Supervisions and labors for unloading on Jetty	8,608.96
2	Cleaning process on Jetty	490.00
3	Port administration and sweeping	2,916.67
	Total	12,015.63
	Internal Failure Cost	
	Delay of ship unloaders, conveyors, stackers electrical, and mechanical	51,284.72
	Total	51,284.72
	External Failure Cost	
1	Demurrage (penalty)	0
2	Warranty	0
3	Accomplishment of Customer Complaint	0
4	Allowances	0
	Total	0
	Grand Total Cost of Poor Quality (COPQ)	100,836.85

Sales	1,666,666.67
Percentage COPQ to Sales	6,05 %

Tab. 9: Cost of Poor Quality of Iron Ore (Logistics Services Department of CDG Port, 2013)

Failure cost for this cargo is too high. For next improvement strategy, failure cost must be decreased in appropriate level. This table below is summary of Cost of Poor Quality (COPQ).

The Cost of Poor Quality (COPQ) in cargos handling is 700,449 USD in average and 39.02 % from the sales in average. Percentage COPQ to sales for Slab Steels cargo is too high. It is caused by appraisal cost is too high. Meanwhile, percentage COPQ to sales for Iron Ore cargo has been effective. Based on Gryna in Juran's Quality Handbook (1999, p.8.16), improvement strategy focused to decrease failure cost and appraisal cost and increase more prevention cost. For this research, all cargos must be decreased failure cost and appraisal cost. Whereas, prevention cost must be kept in appropriate level.

Fig. 5: Composition Prevention, Appraisal, and Failure cost for Iron Ore Cargo handling

Item	COPQ	Sales	Percentage COPQ to Sales
Fertilizer	640,701.37	1,871,000	34.24
Slab	1,359,808.70	1,771,583.33	76.76
Iron Ore	100,836.85	1,666,666.67	6.05
Average	700,449	1,769,750	39.02

Tab. 10: Summary of Cost of Poor Quality (COPQ)

Improvements are proposed to eliminate wastes in Supply Chain flow with lean in Supply Chain approach, so it can decrease failure and appraisal cost. Ridwan et al. (2013, p.47) resulted the biggest waste in the flow of fertilizer Supply Chain at CDG Port is transportation until 52.05%. So, it is focused to map all routes and optimize in each stream of Supply Chain flow. Annahhal et al. (2014, pp.157) state wastes of transportation is decreased, it means materials is delivered just in time, so another waste like inventory, can be decreased.

5. Conclusion

Process Capability Indices (PCI) in Supply Chain flow of cargos handling at port is 0.06 in average. It indicate that process capability in cargos handlings have not capable to meet the customer requirements. Meanwhile, the Cost of Poor Quality (COPQ) in Supply Chain flow of cargos handling at port is 700,449 USD in average and 39.02 % from the sales in average. This cost is still high if it is compared with the sales. Some improvements have been proposed for increasing PCI and decreasing COPQ. Major improvement to increase PCI with Total Productive Maintenance (TPM) approach to improve overall equipments for loading and unloading cargos. Whereas, major improvement strategy to decrease COPQ with Lean Supply Chain approach to eliminate wastes in Supply Chain flow.

6. Future Research

For the future research, it is investigated a model for causal relationship between Process Capability Indices (PCI) and Cost of Poor Quality (COPQ) with system dynamic approach. Then simulation is required to optimize all variables that can influence PCI and COPQ. With this research, it can be optimized all process in supply chain flow in ports to get high quality performance with the lowest cost.

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The Impacts of Team Management on Customer Service: The Mediating Role of Operation Flexibility

Fazli Idris and Jehad Mohammad

Abstract

The study aims to determine the impact of team management and service operations flexibility on customer service. Service operations flexibility is divided into external flexibility and internal robustness. A mediation model is proposed that links team management to customer service via operation flexibility. Drawing on a sample of 475 of operations managers of various service sectors in Malaysia and South Africa, Structural Equation Modeling (SEM) was employed to test the relationship using SMART-PLS procedures. It was found that a significant relationship was established between team management to customer service via both operations flexibility dimensions. Theoretical and managerial implications are offered to explain the results.

Keywords: team management, operations flexibility, PLS, service industry.

1. Introduction

The use of teams for achieving organizational performances have been recognized in the operations management literature (Pagell and LePine, 2002; Scott-Young and Samson, 2008 and Revilla and Knoppen, 2012). Furthermore, enhancing customer service through customer service initiatives are recognized in Total Quality Management (TQM) literature. When services are given in effective ways and delight the customers, organizations would be able to sustain their business. To realize these outcomes, one of the important factors in TQM is the utilization of teamwork to execute operations tasks. By the same token, the study of team effectiveness could also be traced from the human resource literature (Richards, Chillas, and Marks, 2012; Bacon et al., 2010).

What teamwork could possibly do is to enhance operations flexibility. This is true in many contexts since there is a synergy in doing work through team efforts. Organizations could effectively response to the needs of their customers and changing circumstances which will turn into a strategic competitive advantage to the organizations. And, the capability to be flexible must be aligned with the need of the customer. Customer service therefore should guide organizations to provide benefit to the customers. In the long run, customers will get more value for their money. Realizing the important of these constructs, this study assesses the relationship between these operations factors which could offer guidance to managers to make prudent decisions. Additionally, it can be said that not many studies of this nature have been conducted in a service setting. Hence, this study attempts to address these research gaps. In due course, a model depicting the link between team management, operations flexibility and customer service/service is proposed.

2. Theoretical Development

This model test the relationship between teamwork (TM), internal flexibility (IF), external flexibility (EF), and customer service (QF). It is conceptualized that TM will has positive and significant effect on IF, EF, and QF. Additionally, it is assumed that IF and EF will also have positive and significant effect on QF. Moreover, IF and EF will mediate the relationship between TM and QF.

Resource based view (RBV) was employed to support the relationships between the constructs of this study. This view emphasizes that firm's tangible and intangible resources as a vital element that helps organization to achieve competitive advantage (Peteraf and Bergen, 2003). This model assumes that firms can be distinct and unique with respect to the package of resources that they control. In addition, firm resources are perfectly immobile across firms, and thus heterogeneity (uniqueness) can lead to sustainable competitive advantage for firm (Barney, 1991).

As stated, RBV of the firm predicts that specific kinds of resources and capabilities owned and controlled by organizations such as team management have the potential to generate competitive advantage, which ultimately leads to organizational performance (Wernerfelt, 1984; Dierickx and Cool, 1989; Barney, 1995). Past studies have indicated for important relationships between organizational resources, capabilities, and competitive advantage (see Barney, 1991; 1995; Morgan, Kaleka and Katsikeas, 2004; King, 2007). For example, Gimenez and Ventura (2002) and Morgan et al., (2004), found that firm that characterize by high level of flexibility can achieved competitive advantage and comparatively better performance. Additionally, Datt, Guthrie and Wrigh (2005) and Rose and Kumar (2007a, 2007b) found that human resources are considered important factor in attaining a competitive advantage.

2.1 Hypothesis development

2.1.1 Team work and Customer service

Organization success and progress comes from forming and successfully implementing teams (Tanco, et al., 2011). When experts and professional work together, and innovate customers are likely to gain the best and most effective results (Borrill, et al., 2000). Thylefors, Persson and Hellstro (2005) argued that understanding and finding solutions for problems of external customers request gathering professional and skillful individuals in teams. Furthermore, Carter, Garside and Black (2003) contend that teamwork provides important opportunities for organization to improve the quality. In the healthcare sector Weller, et al. (2008), found positive association between the performance of healthcare teams and patient outcomes. Also Banker, Field and Sinha (1996) found that teamwork can contribute to improve the performance of manufacturing organization in term of productivity and quality.

The positive relationship between teamwork and customer service can be supported by using RBV. According to this theory, resources and capabilities possessed and controlled by firm have the potential to lead to competitive advantage (Barney, 1995). Accordingly, this study contend that skills, knowledge, and experiences that owned by group of individuals working together to accomplish certain goals have great potential to solve problems that organization can face, producing desirable outcome, and quickly and effectively responding to changes in customers' demands. These valuable human resources (teamwork) assist firm to gain competitive advantage in highly competitive environment.

On the basis of theoretical and empirical studies, there is enough support to assume that teamwork has the potential to affect customer service. However, there is a dearth of studies that address this relationship in the service sector, especially in cross culture setting. Therefore, this study aims to address this relationship in service sector in Malaysia and South Africa. It is assumed that when members of team are working in efficient, effective, and coherent way, they are more likely to identify and satisfy the need of customer. Accordingly, it is possible to propose that teamwork can affect the performance of firm in term of customer service. Based on this proposition the below hypothesis was developed:

- H1: Teamwork will have positive effect on the firm performance in term of customer service.

2.1.2 Teamwork and internal and external flexibility

Grant, Shani and Kr (1994) proposed that in order for organization to deal with flexibility, firm requires organizational arrangement such as cross functional teams. Besides, Bucki and pesqueux (2000) argued that infrastructural elements like teamwork, empowerment, and quality of leadership contribute significantly to operation flexibility in service organization. Similarly, Upton (1994) claimed that infrastructural elements can have positive effect on flexibility. In the same manner, Fazli et al. (2010) argued that flexibility of firm can be improved by a combination of structural and infrastructural elements.

The positive association between teamwork and internal and external flexibility can be justify using RBV. According to this theory, the firm's unique resources and capabilities play a major role to help firm to achieve competitive advantage (Peteraf and Bergen, 2003). This study argue that individuals who come from different discipline with various experience, talents, and capacities to form teamwork can be unique and valuable resources that have the potential to deal with and handle internal and external changes effectively and efficiently. This argument is consistent with Adler (1988) view i.e., organization ability to be flexible in uncertain environment helps to achieve advantage over other competitor in the market.

Based on above discussion there is sufficient evidences that support the hypothetical relationship between teamwork and internal and external flexibility. Based on this assumption the below hypotheses were developed:

- H2: Teamwork will have positive effect on internal flexibility
- H3: Teamwork will have positive effect on external flexibility

2.1.3 Internal and external flexibility and customer service

According to Daugherty and Pittman (1995), flexibility of operations can result in better response to customer needs. Moreover, a flexible operation system can lead to better cost performances in terms of reducing customers' costs; enhance employee productivity and increasing utilization (Daugherty and Pittman, 1995). Slack (2005) claimed that flexibility in operations impacts firms' performances, whether it is manufacturing or service companies. Additionally, Morgan et al., (2004), argued that firm that characterize by high level of flexibility can achieved relatively better performance. Furthermore, Idris et al. (2010) have confirmed the importance of flexibility to performance of service firms in term of customer service and financial performance.

On the basis of previous discussion this study claims that internal and external flexibility can have positive effect on customer service. Based on this argument the below hypotheses were developed:

- H4: Internal flexibility will have positive effect on customer service
- H5: External flexibility will have positive effect on customer service

2.1.4 Mediating role of internal and external flexibility

The mediating role of operation flexibility can be explained by resource based view. This view holds that organization valuable resources and capabilities are likely to assist organization to achieve competitive position in the market. Several studies (see Aranda, 2003; Slack, 2005; Swamidass and Newell, 1987) found positive relationship between team management, flexibility of operation and firm's non-financial performance. Therefore, one can assume that internal and external flexibility can mediate the relationship between teamwork and customer service. Based on this assumption the below hypotheses were developed:

- H6: Internal flexibility will mediate the relationship between teamwork and customer service
- H7: External flexibility will mediate the relationship between teamwork and customer service

3. Research methodology

3.1 Design of study

The unit of analysis in this study is service organizations from two countries i.e., Malaysia and South Africa. Organizations that were surveyed incorporate hotels, hospitals, banks, private colleges and universities, retail stores, accounting and architect organizations. Since it was difficult to get a list of all elements of the population, and our objective is not generalization, non-random sampling technique such as quota sampling suitable and therefore was used to achieve the objectives of this study. In quota sampling, a population is segment into mutually exclusive sub-groups. Then judgmental sampling can be used to select the subjects or units from each segment based on a specified proportion and characteristics (Zikmund, 2003).

3.2 Measurement instruments

In this study, the completed questionnaire consisted of two sections. The First section includes 18 questions related to QF, EF, IF, and TM. The second section includes 6 questions related to the respondent’s personal information. EF and IF were measured by using 10 items adapted from Idris et al. (2010) (e.g. “employees know what to do when there is a system failure such as blackout or accident”). Customer service was measured by using four items adapted from Idris (2011) (e.g. response to customer/clients’ requests). Additionally TM was measured by using four items adapted from Boyer and McDermort (1999) (e.g. many problems have been effectively solved through teams’ effort). Respondents were asked to indicate their level of agreement for each statement by using a 7-point Likert scale where 1 = strongly disagree and 7= strongly agree.

3.3 Data collection

Questionnaires were distributed to 600 managers from service organizations in two countries i.e., Malaysia and South Africa including hotels, hospital, bank, fast food restaurant, auto repair, colleges, accountant, and architect firms. Data collection process starts at same time in Malaysia and South Africa. In Malaysia researcher had contacts the human resource managers of these organizations to get their permission to participate in the survey. Survey packets were hand-delivered to management executives such as operations managers in each of these service organization that accepted to participate in this study. A postage-paid envelope was included in the packet to return the survey to the researchers. Among the 300 questionnaires that were distributed to service organizations in Malaysia 240 managers retuned the questionnaires, and 228 were found usable for further analysis. In South Africa, the lead researcher got help from some researchers in one of the prominent university in Cape Town. Same processes were implemented to collect data in 300 service organizations that accepted to take part in this survey. Among the 300 questionnaires that were handed to these organizations 247 were returned, and 224 were found usable (Table 1).

		Number/frequency
Malaysia	Number of questionnaires distributed	300
	Number of questionnaire returned	240
	Response rate	80%
	Number of usable questionnaire	228
	Effective Response rate	76%
South Africa	Number of Questionnaires distributed	300
	Number of questionnaire returned	247
	Response rate	82%
	Number of usable questionnaire	224
	Effective Response rate	74%

Tab. 1: Response rate

4. Data analysis and findings

4.1 Demographic background of respondents

The results of descriptive analysis (Table 2) show that majority of participants (69%) were managers. In term of respondents' tenure 83.1% of them have a 10-years work experience in the same organization. With respect to years of operations 65% of targeted service organizations have less than 15 years in the industry. The majority of participants (61%) were from local firms. Finally, the service organizations that have participated in this study contributed equally in term of number of respondents.

		Frequency (N)	Percentage (%)
Type of service	Hotel	55	12.2%
	Fast-food restaurant	51	11.3%
	Hospital	40	8.8%
	Auto repair	48	10.6%
	Retail store	47	10.4%
	Bank	54	11.9
	Private college	55	12.2%
	Architect	53	11.7%
	Accountant	49	10.8%
Profession	Manager	193	42.6%
	Middle manger	51	11.3%
	Top manger	68	15%
	Others	140	31%
Tenure	5 years and less	290	64.2%
	6 -10	86	19%
	11-15	44	9.7%
	16 years and above	32	7.1%
Years of operation	5 years and less	72	15.9%
	6 -10	128	28.3%
	11-15	94	20.7%
	16 years and above	158	35%
Firm's market	Local	279	61.7%
	Regional	53	11.7%
	Global	120	26.5%

Tab. 2: Demographic Background of Respondents

4.2 Descriptive analysis of the study variables

Table 3 shows the result of means, standard deviations, inter-correlations, and reliability (Cronbach's alpha) for the study variables. In this study, the correlation results among EF, IF, QF, and TM are positive and statistically significant ($p<0.01$) with values ranging from 0.456 to 0.66. In other words, the associations between the study variables were adequately robust to progress to the next stage of data analysis. Additionally, the internal consistency reliability of all constructs in terms of Cronbachs alpha exceeds the cut-off value of 0.70 (Nunnally, 1978), which means all items loaded highly on its respective construct.

	Mean	SD	Alpha	1	2	3	4
EF	5.34	1.06	0.898	1			
IF	5.13	0.92	0.730	0.660**	1		
TM	5.50	1.01	0.825	0.465**	0.488**	1	
QF	5.82	0.96	0.90	0.590**	0.553**	0.485	1

Tab. 3: Descriptive statistics, correlation among study variables, and values of alpha

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

4.3 Common method variance

The variables of this study are latent and data was collected using cross sectional method, hence, it was crucial to check for common method variance (CMC) (Podaskoff, et al., 2003). To address this problem, the current study used Harman 1-factor test on the four latent variables as suggested by Podaskoff et al. (2003). The results indicate that all factors in this study explain approximately equal amount of variance. Therefore, CMV was not serious problem in this study.

4.4 Model evaluation

The main concern of this research is to predict the relationships between the latent constructs of this study, and to maximize the explained variance in endogenous variables. Therefore, this study has adopted SEM-PLS to achieve these research objectives.

4.4.1 Assessment of measurement model

Assessment of the measurement model was determined based on two criteria i.e., reliability and validity of the model (Henseler, et al., 2009). Reliability of the measures refers to the ability of scale to produce similar results over time which is a good indicator that the scale is free from error (Cavana, Delahaye and Sekaran, 2001). In this study, reliability of constructs was examined based on values of factor loading and composite reliability as recommended by Hair et al. (2013). The widely recommended value for factor loading and composite reliability is 0.70 and above (Hair et al. 1998; Chin 2010). However, factor loadings with values grate than 0.40 is still acceptable as suggested by Hulland (1999). Table 4 demonstrates that all factors loading of all items exceed the cut off value of 0.50 and ranged between 0.61 and 0.90. Moreover, Table 4 also shows the values of composite reliability of EF, IF, QF, and TM are above the minimum threshold level of 0.70. These results provide support for the reliability of the measurement model.

The outer model validity was judged on the basis of convergent validity and discriminant validity (Henserar, et al.,2009). Chin (2010) has recommended to use average variance extracted (AVE) to assess convergent validity. The required value for AVE must be greater than 0.50, which means the construct explains more than 50% of variance in its respective construct (Henseler, et al., 2009). Table 4 illustrates that the values of AVE of EF, QF, IF, and TM are 0.71, 0.77, 0.57, and 0.657 respectively, which exceed the cut-off value of 0.50, which satisfy the convergent validity criterion (Hair, et al., 2006; Tabachnick and Fidell, 2007).

Construct	items	Factor Loading	AVE	CR
EF	EF1	0.845	0.710	0.925
	EF2	0.857		
	EF3	0.833		
	EF4	0.855		
	EF5	0.823		
QF	QF1	0.871	0.770	0.931
	QF2	0.885		
	QF3	0.900		
	QF4	0.855		
IF	IF1	0.782	0.570	0.840
	IF2	0.819		
	IF3	0.790		
	IF5	0.610		
TM	TM1	0.697	0.657	0.884
	TM2	0.847		
	TM3	0.877		
	TM4	0.809		

Tab. 4: Assessment of outer model

Note: AVE refers to average variance extracted, CR refers to composite reliability. Note2: IR4 was deleted to increase the value of AVE

Discriminant validity was assessed as well to validate outer model. It indicates that construct is more strongly related to its items rather than other constructs. In this study discriminate validity was evaluated by using Fornell and Larcker's (1981) criteria i.e., the square root of the AVE of a construct is needed to be greater than the correlations between other constructs. Table 5 demonstrates that, the square root of AVE (diagonal values) for all constructs are greater than the correlations between the construct and other constructs in the model (off-diagonal values), which satisfy the criterion of discriminant validity at the construct level (Fornell and Larcker, 1981).

	EF	IR	QF	TM
EF	**0.843**			
IF	0.728	**0.755**		
QF	0.601	0.579	**0.878**	
TM	0.469	0.480	0.489	**0.811**

Tab. 5: Discriminate validity at construct level

Note: Diagonals represent the square root of AVE while off-diagonals represent the correlations

Discriminant validity also was assessed at the items levels. Table 6 shows that the loading of each indicator on its respective latent construct is higher than all of its cross-loadings in row and column, which fulfills the criterion of discriminant validity at the item level (Chin 1998; Fornell & Lircker 1981).

	EF	QF	IR	TM
EF1	0.845	0.458	0.583	0.385
EF2	0.857	0.459	0.587	0.405
EF3	0.833	0.468	0.582	0.348
EF4	0.855	0.566	0.639	0.404
EF5	0.823	0.561	0.662	0.425
QF1	0.497	0.871	0.475	0.415
QF2	0.543	0.885	0.515	0.401
QF3	0.572	0.900	0.556	0.498
QF4	0.490	0.855	0.477	0.394
IR1	0.595	0.490	0.782	0.366
IR2	0.614	0.477	0.819	0.386
IR3	0.574	0.451	0.790	0.390
IR5	0.383	0.304	0.610	0.301
TM1	0.340	0.407	0.361	0.697
TM2	0.419	0.382	0.409	0.847
TM3	0.389	0.386	0.401	0.877
TM4	0.366	0.409	0.379	0.809

Tab. 6: Discriminant validity at item level

Based on the above discussion, it can be concluded that in this study the measurement model has demonstrated sufficient level of validity and reliability (see Figure 1).

Therefore; it is possible to move forward to examine the structural model.

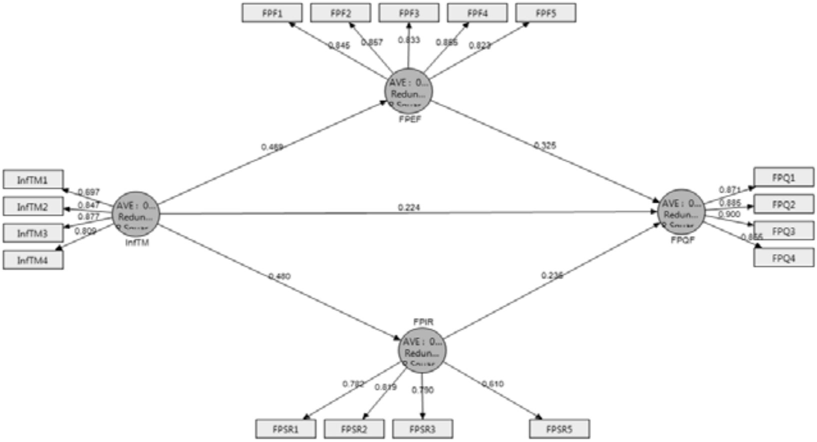

Fig. 1: Measurement model result

4.4.2 Assessment of the structural model

The evaluation process of inner model incorporates several steps as recommended by Götz, et al., 2010.

First, the assessment of the amount of variance explained in the endogenous constructs (R2). According to Cohen (1988), R2 values of 0.02, 0.13, and 0.26 are considered as small, medium, and large respectively. On the other hand, some researcher revealed that the acceptable value of R2 depends on research context, the role of construct in the model, and the number of independent variables in the model (see Henseler et al. 2009; Ringle, Wende and Will, 2010). In this study the values of R2 of QF, EF, and IF are 0.44, 0.22, and 0.23 respectively (Table 7). This indicates that the model ability to explain the variance is ranged between moderate to substantial (Cohen 1988).

Second, evaluating the effect size ($f2$). This refers to the contribution of exogenous constructs in explaining the variance in the endogenous construct. It can be calculated by using Cohen's (1988) equation i.e. $f2$ = R2incl – R2excl /1-R2incl. f squares' values of 0.02, 0.15, and 0.35 represent weak, moderate and substantial effect respectively (Cohen 1988). In the current research the values of $f2$ of EF, IF, and TM are 0.089, 0.071, and 0.061 receptively (Table 7). This signifies that EF was more important in explaining the variance in QF followed by IF, and TM.

Third, estimation the model ability to predict (Q2). The model's predictive ability is decided based on Stone-Geisser's Q2 (Geisser, 1975; Stone, 1974). The value of Q2 can be obtained by using a blindfolding procedure (Tenenhaus, et al., 2005). To determine the model ability to predict, cross validated redundancy was used as suggested by Hair et al (2013). Q2 value greater than zero indicate that the model has predictive ability (Fornell and Cha, 1994). In the current study the values of Q2 of EF, IF, and QF are 0.153, 0.13, and 0.336 respectively (Table 7). As these values are greater than zero, it can be concluded that the structural model has predictive relevance (Fornell and Cha, 1994).

	R2	Q2	$f2$
EF	0.22	0.153	0.089
IF	0.23	0.13	0.071
QF	0.44	0.336	
TM			0.061

Tab. 7: Structural model evaluation

4.4.3 Hypotheses testing

Testing the seven hypotheses developed in this study was based on the significant level of path coefficient (β). Path coefficient represents the strength of association between the constructs in the inner model. The significance level of the regression coefficient (β) was determined based on t-value, which was obtained using PLS bootstrap process with 5000 resample as suggested by Hair et al. (2013). Critical t-values are 1.65 ($p < 0.10$), 1.96 ($p < 0.05$), and 2.58 ($p < 0.01$) (Hair et al. 2011). Overall, the results of hypotheses testing show that all path coefficients were statistically significant at 0.001 levels (Table 8.

As can be observed in Table 8, TM was positively and significantly correlated with EF ($\beta = 0.469$, $p<0.001$), IF ($\beta = 0.48$, $p<0.001$), and QF ($\beta = 0.224$, $p<0.001$) respectively. This provides support for H1, H2, and H3. Moreover, EF and IF were positively and significantly associated with QF (β= 0.325, $p<0.001$; β= 0.235, $p<0.001$) respectively. Thus H4 and H5 were supported.

Hypotheses	Suggested direction	β	t-value	95%confidence interval	support
H1:TM>EF	+	0.469	11.519	0.403-0.535	Yes
H2:TM>IF	+	0.48	11.687	0.412-0.547	Yes
H3:TM>QF	+	0.224	4.981	0.151-0.296	Yes
H4:EF>QF	+	0.325	4.891	0.241-0.433	Yes
H5:IR>QF	+	0.235	3.554	0.127-0.342	Yes

Tab. 8: Path coefficient and hypothesis testing

Hypotheses 6 and 7 stated that EF and IF will mediate the relationships between TM and QF. To examine the presence of mediation effect, PLS algorithm, and bootstrapping procedures with 1000 resample was ran on the full model to obtain the path coefficient and the significant level of these paths. A close look at Table 8 shows that all paths are statistical significant which indicates for empirical evidence of mediation effect. To examine the statistical significance of the indirect effect, bootstrapping procedures with 5000 resample was implemented (Preacher and Hayes 2008). The bootstrapping analysis (Table 9) showed that the indirect effect β1 = 0.152 (0.469*0.325) was significant with a t-value of 4.50, $p<0.001$, 95%CI: 0.084-0.219). Thus it can conclude that the mediation effect of EF is statistically significant. Although, the bootstrapping procedures indicated that the indirect effect β2 = 0.113 (0.48*0.235) was significant with a t-value of 3.23, $p<0.001$, 95% CI: 0.044-0.181). Which provide support to the mediation effect of IF.

Hypotheses	Indirect effect	S.E	t-value	95%confidence interval	support
H6: TM>EF>QF	β1= 0.152	0.033	4.423	0.084-0.219	Yes
H7: TM>IF>QF	β 2= 0.113	0.035	3.23	0.044-0.181	Yes

Tab. 9: Hypotheses test for indirect effect

To assess the size of the indirect effect, this study employed the variance accounted for (VAF) value (VAF= indirect effect / total effect) (Iacobucci &

Duhachek 2003). In the current study, the values of VAF of EF and IF are 0.0.404 and 33.5 respectively, which means that 40.4% and 33.5% of the total effect of TM on QF is explained by the indirect effect of EF and IF respectively. Therefore, H6 and H7 are supported.

5. Discussion and Conclusion

This study found that a significant relationship was established between team management to customer service via both operations flexibility dimensions. With the increasing emphasis on high-quality, fast product innovation and improved customer satisfaction, many companies currently emphasizing the importance of forming teamwork to achieve these goals in environment characterized by high level of competition and uncertainty (Boyett and Conn, 1991).

The crucial role of teamwork stem from the idea that by identifying and solving problems related to work, teams can improve the performance of organization (Banker, et al., 1996). Therefore, in this study we found direct evidence that teamwork improve the operations flexibility of the operations. According to the literature, teamwork has received researcher attention for last few decades due to it is significant contribution in building an effective and efficient organization (Passos and Caetano, 2005). Teamwork includes the performance of individuals' outcome and the shared results of team members (Tanco, et al., 2011). Therefore, groups cannot become teams unless they develop a sense of shared commitment and work hard for synergy among members (Katzenbach and Smith, 1993).

The notion of flexibility has received researcher attention due to the crucial role that flexibility play inside organization. It motivate employees, enhance their productivity, and help organization to achieve competitive position especially in matters related to adoption and implementation of technologies (Adler, 1985; Fazli et al., 2010; Upton, 1994). Moreover, some studies found that organizations that characterized by high level of flexibility outperform other organization with less flexible operation (Merschmann and Thonemann, 2011; More and Subash

Babu, 2011). Flexibility of service organization involves the rapid introduction of newly designed service, handling changes in the service mix, handle variation in customer delivery schedules, ability to adjust operation capacity, and customization of service to targeted customer (Aranda, 2003).

The final outcome for organization having better team management and operations flexibility is enhancement of customer service, as proved in this study. Customer considers the most important part of quality process, and to understand their needs citizen of organization must work hard to enhance their knowledge about changeable needs of their customers.

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Critical Success Factors for Horizontal Logistics Collaboration

Lisbeth Broede Jepsen

Abstract

Research in transport and logistics has primarily focused on vertical collaboration (e.g. customer-supplier collaboration), whereas horizontal collaboration between e.g. competitors, has received only limited attention (Vanovermeire et al., 2013). Literature on collaboration has emphasized motivations, opportunities, antecedents and outcome (Cruijssen et al., 2007), but researcher have paid far less attention to the developmental processes of horizontal collaboration, i.e. the process through which collaborations are initiated, formed, and operated (Das et al., 2002). Furthermore, an investigation of critical success factors such as shippers' willingness and motives, their challenges, the selection of partners and the role of the network broker in regard to the initiation and creation of horizontal collaboration have been largely neglected in previous logistic research.

The purpose of this case study is therefore to bridge these gaps and investigate the critical success factors during the early development stages of a horizontal logistic collaboration. The research question guiding this paper is:

RQ1: What can be learned about critical success factors during the early development stages of a horizontal logistic collaboration?

This study contributes to theory generation suggesting a five-stage process for horizontal collaboration underlining the critical success factors during this process. Especially, the role of the network broker has been found essential for the successful creation of a horizontal collaboration.

This study is an example of real-life collaboration between producers, which have resulted in the development of new green transport corridor. Therefore, this case

provides valuable new learning about the process of creating a horizontal logistic collaboration.

Keywords: horizontal logistic collaboration, critical success factors, five-stages process, network broker

1. Introduction

Collaboration need to be considered in the context of where in the value chain it occurs. For many years, researchers investigated strategic partnerships and alliances and inter-organizational collaborations. The logistic literature has primarily focused on vertical collaboration, which is companies from different levels of the supply chain working together e.g. to optimize their logistic activities. Horizontal collaboration in transport and logistics, which e.g. involves collaboration between competitors, has received only limited attention (Vanovermeire et al., 2013).

Horizontal logistics collaboration is very important for transport and logistics for two reasons. First, by participating in horizontal collaboration, the companies are more likely to become more cost efficient and service effective (Cruijssen et al., 2007). Second, by making the operations more efficient (e.g. consolidation of flows) they will lead to more sustainable transportation and have a positive environmental impact (Audy et al., 2010).

Substantial research has been carried out on development process of collaboration. However, with a few exceptions, researchers have paid far less attention to the development processes of horizontal logistic collaboration and its critical success factors. Furthermore, little is known about the role of a neutral network broker during this process (Cannatelli et al., 2012).

In this study, I suggest that a network broker should follow some steps to correctly initiate and build a logistic horizontal collaboration. In particular, it involves; 1) an in-depth knowledge of the companies (e.g. challenges and motives); 2) a selection of the right partners (fit or match), and 3) an understanding of how to initiate the development of horizontal collaboration.

2. Successful horizontal logistics collaboration

2.1 Critical success factors

A horizontal collaboration should be established only if the company is willing to invest time and effort (Audy et al., 2010). The company's willingness to collaborate refers to the degree to which the company wants to collaborate with another company (even perhaps a direct competitor) about transport or logistic solutions that will benefit their businesses. Achieving a successful horizontal collaboration between companies is a challenging exercise. First of all, it is very relevant to identify critical success factors that strengthen the shipper's willingness towards horizontal logistic collaborate.

Research has suggested that internal motives such as monetary rewards and future earnings, reputation of partner companies (Jepsen et al., 2011), but also external motives such as regulation, customers, and competitors (Hall, 2001) are the driven forces for companies to participate in collaborations.

Horizontal collaboration might involve two or more competing companies with different backgrounds, cultures and view of the future. Trust is therefore a critical element for effective horizontal collaboration (Cannatelli et al., 2012). Trust amongst partners will avoid potential conflicts among partners and prevent opportunism. Researchers argue that the most preferred partners are usually also the most trusted partners (Li et al., 2008). In other words, trust can be achieved if the preferred partners are selected for the horizontal logistic collaboration.

The selecting of partners has also been found to matters a great deal in with respect to successfully horizontal collaboration (Benford, 1993). Research has shown that it is important to check the match or fit between two companies willing to initiate horizontal collaboration. Therefore, the concept of fit has received attention. This concept is defined as the fit between strategy, the wider environment, and/or agreed aim or project goals (external) and the fit between organizational structure, individuals within or across-borders of the companies (internal fit).

Liu et al. (2006) also study inter-organizational collaboration and the importance of correctly choosing the partner, based on its internal fit between companies regarding skills and management philosophy, etc. Personal commitment and involvement of individuals (including supply chain mangers and management) have a positive impact on collaboration projects (Hanna et al., 2000). Being clear on why each party is entering collaborative projects and setting up individuals and teams up for success is absolutely key (Hammant, 2011). Personal relations inside and across company borders have been found to influence the performance of collaborations (Hammant, 2011). Individual may gain personal benefit such enhanced social relations, enhanced reputation, privileged access to social relations, and so on. In other words, the internal fit between individuals of the different companies and consequently other people related elements are essential to success (Kirkels et al., 2010).

Furthermore, Rosas et al. (2011) suggest that a competency assessment process links to two types of competency hard competencies and soft competencies. Hard competencies refers to the ability of an organization to perform activities or tasks aimed at achieving a specified number of outcomes, while soft competencies refers to a general aptitude to perform a behavior such as the ability to exchange knowledge. These competencies should both be considered when selecting the right partner.

2.2 The initiation and creation of horizontal collaboration

The creation of inter-organizational collaborations follows similar steps. Gonzalez (2001) suggests establishing partnerships based on a five-step process. First, the strategy for collaboration is determined, such as the specific needs for the company, the collaboration objectives, etc. Second, the partners are selected. Third, the legal framework of the relationship is established. Forth, the collaboration has then to be managed properly, based on many inter-organizational meetings and mechanisms to settle conflicts. The fifth stage involves evaluating the failure or the success of the relationship. Das et al. (2002) suggest a three-stage model which includes a formation, operation, and outcome stage. During the formation stage the strategy is formulated, partners are identified, deals negotiated, and the collaboration is set up. In the operation stage the companies start the collaboration and implement the agreement. In the outcome stage results are obtained and evaluated. Mejías-Sacaluga et al. (2003) propose a four-stage implementation model based on the evolution of the relationship: friendly negotiations, cooperation, coordination, and then collaboration.

The creation and development of a horizontal collaboration is difficult. The manager of such collaboration must be able to look across company boundaries and be able to deal with the complexity that this entails. Each party needs to protect its own interests. What information to share, which truths to acknowledge and how much to commit are complex decisions that can be made easier by the engagement of an independent network broker, especially in the early stages of a relationship (Cannatelli et al., 2010). A number of researchers have discussed and analyzed the role of a broker and knowlegde institutions have been found to function as a neutral and trustworthy partner to profit organizations (Winch et al., 2007). Researchers have pointed out that direct and stable social relationships between neutral trustee (network broker) and potential partners are important, so that the network broker will have more knowledge of individual motivations and be more effective in defining a rewarding goal (Taylor et al., 1993).

3. Method

The research performed here is a longitudinal case study with an exploratory purpose. The empirical case study was triggered through the Interreg IVB project: Connecting Food Port Regions – Between and Beyond (Food Port) (www.food-port.eu) that aims to improve the efficiency, effectiveness and sustainability of the food supply chains within the North Sea Region.

As part of Food Port project, knowledge organizations (e.g. universities) from the different North Sea Regions undertook interviews with food producers (shippers) to obtain insights into shippers freight flows. The objectives were to identify green transport corridors and to create new partnerships for collaboration in food and logistics realize collaboration opportunities.

The field case analysis carried out focuses on successful development of a horizontal collaboration between four food producing companies in Denmark. Getting internal access to a proven successful initiative is consistent with the purpose of theoretical sampling, which focuses on cases with “rare” qualities and whose dynamics may be easily detected, allowing processes that can exist in other contexts to emerge sharply (Eisenhardt, 1989). Hence, I could access information providing answers to the research question. To lead an in-depth case study makes it possible to explore causal links that are too complex to be analysed, for example, through a survey (Yin, 1994; Eisenhardt, 1989). Indeed, adopting a longitudinal perspective is consistent with the research objective - to explore the dynamics where horizontal collaboration is created. Again, longitudinal perspective is also a key tool to advance new insights in the logistic field.

The study is based on in-depth semi-structured interviews with logistic or supply chain mangers of 22 food producing companies, direct observations were made by the author during two workshops, workshops which were followed up by 4 additional in-depth interviews, and 3 small telephone interviews. Data collection is an on-going process. It started in November 2011 and the latest interview was in June 2014.

4. Results

The case study provides evidence for the success criteria for a successful horizontal logistic collaboration. Furthermore, the case study suggests four main stages in the development process of horizontal collaboration. The five stages are presented in figure 1 and analyzed in the following sections. Extracts from the interviews are reported to provide an understanding of the critical success factors in each stage of the process.

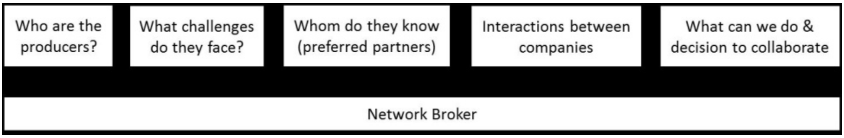

Fig. 1: The development process of horizontal logistics collaboration

4.1 The willingness and openness of the producers

The first stage occurs in response to a broad business opportunity (the creation of a horizontal collaboration) identified through Food Port by the author (in this case the network broker). At this stage 22 interviews with different Danish food producers (shippers) were undertaken in order to identify who they are.

It shows that several producers from the Danish Food industry are willing and open towards horizontal collaboration. Especially, the producers from the bread, meat, dairy, and vegetables industries are highly willing and open towards horizontal collaboration.

The findings also show that the interviewed companies have no or only limited experience with horizontal collaboration. But as long as the partners are open and willing to invest in the collaboration, the producers are very optimistic about collaboration: "We have no prior experience with this kind of collaboration. But as long as people come up with something then we are convinced that it (horizontal collaboration) will work". Another company agrees: "We have no problems in cooperation vertical or horizontal around practical problems". The supply chain manager continues: "We are very open and we have always been" and "What I have seen many times is that people see ghosts. We feel most comfortable with saying things as they are. We do not hide anything". A third company argues that successful collaboration requires: "Openness and a willingness to contribute with something. We have tried this within our own group and it's really really hard. You can't just sit and listen you must offer something".

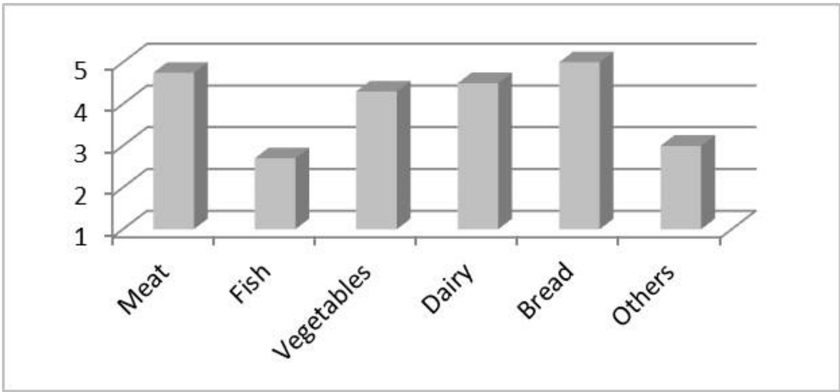

Fig. 2: The willingness to horizontal collaboration

4.2 What challenges do they face

First, the producers were asked about their internal and external motives for horizontal collaboration. Second, they were asked to identify several challenges and therefore opportunities for horizontal collaboration.

The findings show that internal motives for participating in horizontal collaboration are transactional, operational, and repetitive such as costs reductions. Some of the interviewed producers are not able to fill up the trucks due to because of weight limitations. One company states “We need to address specific challenges related to the transport of heavy goods”. In other words, if this shipper could consolidate freight it would be possible to reduce costs. Improvements in customer service level (speed e.g. timely delivery, damage avoidance), and delivery of special freight are also pointed to as some of the main motives for horizontal collaboration. Other motives are also identified from the interviews regarding the participation in horizontal collaboration. As stated by one of the producers: “The argument for participating in this kind of collaboration was that this would give us the opportunity to sit at the table with the aim to really develop a new setup. It was not the environmental part that was the driving force behind it. It was a combination of monetary benefit and competition – but also to be involved and set an agenda for future transport possibilities”. In other words, the participation in horizontal collaboration can help producers to establish their reputation and improve the company’s status.

The external motives identified from the interviews are the requirements of the customers, due to shorter product life cycle or the demand for new packing which may require new transportations mode. As pointed out by one of the companies: “Our customers put more and more pressure on the transport-related setup, because the shelf life is so extremely important for the large retailers”. The customers set the agenda: “They dictate the market” and the case companies agree that the requirements of the customers are driving many of the collaboration initiatives.

From the interviews we learn that external competitors also act as a driver for supply chain projects. As one company states: “If we want to maintain our role in the market then we cannot offer a poorer set-up then our largest competitor”. In other words, the conditions set by the competitor are a necessary condition.

Furthermore, the pressure to reduce environmental impact is also identified in this study as drivers for the producers to participate in horizontal collaboration. One of the supply chain mangers points out: “With the economic pressures that have been on us over the last 2 years, the environment has not been a priority. The company has only benefited from the gains that were given for free from environmental initiatives. But the environment is becoming more and more of priority in our system. It gets a more and more important, and it will also be something I will be measured on in future”. In other words, environmental factors such as regulations encourage firms and their employees to participate in horizontal collaboration in order to reduce environmental impact.

The findings show that especially problems and inefficiencies in regard to the food producers' transportation to one specific country (such as high ship rates, vehicle-restrictions in Germany, branding etc.) are considered a big challenge for many of interviewed food producers.

Having identified the motives and challenges of different food producers, the next step for the network broker was to identify a common goal for a horizontal collaboration. In other words, a realistic and beneficial business case (pilot project) for horizontal collaboration needed to be created. The network broker chose the creation of a horizontal collaboration between food producers regarding their shipments to this specific country as a business case. The main focus was on carbon footprint and on logistic collaboration, not on creating a customs transport corridor.

4.3 Whom do they know (preferred partners)

Once the specific business opportunity was identified, the producers who were the most willing and open towards exploring collaborate opportunities regarding food transportations to this specific country were identified from the data.

New interviews with producers from the meet, bread, and vegetable industry were undertaken, and the companies were ask to name the potential partners with whom a collaboration could be valuable.

The companies first mentioned the names of someone they knew, liked and trusted. In other words, companies pointed at partners with whom they had prior experience through e.g. previous interactions in another context. Some of the interviewed companies knew each other from prior collaboration experience, but only a few of the companies had experience with each other from horizontal collaboration in regard to transportation. Secondly, they mentioned companies about whom they had some but limited knowledge.

The supply chain or logistic managers from the different companies also knew each other as former colleagues and from Network Groups: "We can talk together. The supply chain manager at our competitor is one of my colleagues"

and "We participate in the same Network Group". In other words, personal relations are of great importance when selecting partners for collaboration.
The interviewed producers had no problems in regard to horizontal collaboration with their competitors. One company is even willing to take into account the benefits of all the collaborating companies: "We really do not care if we need to collaborate with one of our main competitors. We have no preferences if it can benefit all".
Through the interviews the companies more or less choose each other. One of the selection criteria for the potential partners was the requirements for food transportation (e.g. refrigerated trucks): "We just have some requirements. It's fresh food, so it's restricted what types of food that you can mix with it. So it gives some limitations".
The producers are emphasizing the importance of the match between partners. One producer stated: "It's important that you find someone with whom you have some synergy. I think it is important that we look alike. It is not important that we look like each other all along, but we must have similar challenges. If I had to collaborate with a company that makes screws and nails, I would not be able to relate to that company. It must be the same lead time products". In other words: "Producers of products that have the similar short shelf life challenges and just-in-time requirements".
After the interviews, the network broker selected the producers who were perceived as the best match in terms of external fit (food requirements etc.) and internal fit (personal relations).

4.4 Interactions between companies

The next step was to explore of new collaboration opportunities between the selected producers. In other words, the producers were invited and accepted to participate in a workshop. In other words, the network broker initiated interaction between the producers. At this stage the network broker participated in the practical problem solving and closely observed the process.

No concrete goals were identified before the workshop. The overall goal for the workshop was to identify business opportunities for the creation of a horizontal collaboration between the selected food producers regarding their shipments to this specific country. The main focus was on logistic and on carbon footprint.

At the workshop the companies discussed different experienced challenges and possibilities in regard to this specific market. But they also discussed the strengths and weakness of their companies. Even though the individual producers identified different challenges and interests, the producers were open towards identifying and exploiting win-win situations and thus opportunity for each partner. One of the companies was straightforward: "This is our world and how we adapt. How does it fit into your business and how does what fit into ours". All of the companies agreed that if they would join this pilot project, the main goal was to optimize collectively.

From the workshop different suggestions were made e.g. the product flows of the producers could be consolidated and shipped through the existing port-to-port links or road-to-road links. The third option was to create a new green food port corridor between Denmark and this specific country; A new intermodal connection consisting of rail transport, short-sea shipping and road.

It was decided that the network broker together with colleagues should undertake a feasibility study in order to reveal the most sustainable logistic solution for the food producers. Therefore a comparison of existing and potential food port scenarios, which included calculations on economic efficiency and carbon footprint, was undertaken.

Before moving forward with the collaboration, it was decided that all partners signed a non-disclosure agreement and a date for a new workshop was set. Soon after the workshop the network broker developed a non-disclosure agreement, which was distributed and signed by the partners.

4.5 What can we do and decision to collaborate

At the next workshop (which took place at one of the participating companies), the network broker presented the results from the feasibility study. The aim of this workshop was to make a decision to co-create the new business opportunity and make a commitment.

The companies all agreed to continue with a horizontal collaboration and from the feasibility study a common goal was chosen to pursue. A Letter of Intent was distributed and signed.

From new interviews with the individual producers, they all emphasized the requirements to quality and food. Each of them is certified according to some standards and break-down procedures which must be followed. Otherwise the companies will get a note and then will have to be re-certified.

So before the start-up of operation, there still need to be a formal negotiation and contract. But none of the producers consider this as a constraint for start-up of the collaboration.

The decision to collaborate does not strictly focuses on a cost-reduction perspective. The findings show that there also exist several other benefits (e.g. CO2 reduction and influence) than cost-reduction to perform horizontal collaboration in transport and logistics. However, cost-reduction is by far the most important of the potential benefits.

5. Discussion

The results show that it is important to gain in-depth knowledge about the producers (who they are), their openness and willingness towards collaboration, their motives and challenges. Today's demanding customers expect their goods to be delivered to the right place, at the right time, in the right amount, in perfect condition, and all at the lowest price. Therefore, participating producers mostly utilizes road transportation. However, the problems and inefficiencies in today's road transportation make it necessary to look for alternatives in regarding these transportations. They have similar motives and challenges regarding transportation to this specific country. In other words, I argue that their willingness and openness towards for horizontal collaboration is positively influenced by the attractiveness of the business in terms of reduction of costs and higher customer

service. This finding is supported by the findings of Cruijssen et al. (2007). However, this study also reveals that motives such as reputation and being involved in the creation of new business models such as "setting a new agenda for future transportations.
Even though, the companies have not had prior experience with each other in terms of horizontal logistic collaboration, some of them have collaborated in other business areas. This finding suggests that prior collaboration experience has a positive influence on the successful creation of a horizontal collaboration. Strong personal relations by being former colleagues and part of the same Network Group is also found as important. In other words, companies that have a deep understanding of the skills and capabilities, products, business objectives and organizational culture of their potential collaboration partners would be more willing to collaborate openly and intensely. This finding is supported by Li et al. (2008) who argue that prior partners that have had previous interactions are more likely to understand each other's know how, operating routines, and managerial practices (Li et al., 2008). The finding from case study also suggest that participants will contribute more if they believe that their contributions are important to the performance of the entire collaboration are identifiable and if they like and trust the group they are working with.
Disadvantage by this self-selection process among old colleagues and former partner can prevent companies from looking beyond their own existing pools of social relationships and missing out on opportunities (Ellis, 2000). The findings however suggest that the involvement of a neutral network broker can avoid this by locating partners who possess several synergies but would not otherwise have been connected.
The findings suggest that continuous interaction over time is positive related to higher willingness to collaborate. But it takes time and resources to establish, maintain and develop business relationships between companies (Anderson et al., 2000). This case shows that a network broker such as knowledge organizations can be effective in terms of convincing partners to join a horizontal collaboration, enhance interaction and creating informal agreement or contracts

(Non-Disclosure-Agreement and Letter of Intent), which all contributes to a successful creation of a horizontal logistic collaboration.

6. Conclusion

The lessons learned from this case study are multi-faceted. First, the case is a successful example of how a horizontal logistic collaboration between Danish food producers (some of them even competing within the same industry in international markets) can be supported by a network broker in the creation and early development stages of a horizontal collaboration. The willingness and openness of producers, common motivations and challenges, the right combination of partners and interaction with strong executive support by a network broker are key success factors for this result.

Second, contradictive to existing research (e.g. Das et al., 2002), the case shows that the collaboration starts with (1) Identification of open and willing partners, (2) Common challenges and motives, followed by a (3) selection of partners, (4) Interaction, (5) Task definition and decision to collaborate.

Third, in order for the collaboration to move from one development stage to the next, the findings suggest the following success criteria: (1) the members possess a high degree of openness and willingness to collaborate, (2) must be each other's preferred partner, and (3) see the win-win opportunity for all.

Fourth, the results suggest that the network broker through the expertise and knowledge role gain respect from the companies to initiate, participate and contribute to the collaboration, and that involvement of an independent network broker results in the relational agreements and commitment for the horizontal collaboration.

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Managing Common Goods in Supply Chain: Case of Agricultural Cooperatives

Tarik Saikouk and Ismail Badraoui

Abstract

This paper synthesizes research findings on managing common goods with an application on the agricultural supply chain. Effective management of common goods highly depends on the effort and contributions of each member of the group and the equitable sharing of the added value. However, this contribution is not automatically guaranteed as some members tend to behave opportunistically, which leads to operations inefficiency and higher costs along the supply chain, resulting in lower benefits for the whole group, and ultimately, in the failure of the business. The objective of the paper is to analyze members' behaviors in an attempt to understand their dynamics within the supply chain. In this regard, we rely on the social dilemmas perspective to suggest a resolution mechanism to reduce opportunism and improve the management of common goods within the supply chain, highlighting the importance of communication, group identity, group size, and informal sanctions. The data collected for the case study accounts for nearly 1500 farmers belonging to 147 cooperatives, each one having to manage a common good. The results of this analysis allow us to confirm the relevance of recognizing and resolving social dilemmas in supply chain. We also discuss implications for the sustainable development of agricultural supply chain.

Keywords: collaboration dynamics, social dilemma, common goods, sustainability, supply chain

1. Introduction

In a context characterized by increasing physical flows, product diversification, pressure to reduce inventory and the soar of energy and transportation costs, collaboration has become essential to every firm in order to survive. In this paper, we try to tackle the cooperation between several firms from a social dynamics perspective, putting the light on social dilemmas as a crucial side to consider in any collaboration. The research focuses on the management of common goods in a collaboration relationship between different actors, with an application of the finding on the case of agricultural cooperatives in Morocco. The effective management of common good relies on the contribution of every member of the alliance, with each one participating through rational usage and maintenance. However, the decisions taken by the members do not automatically tend towards the wellbeing of the alliance, and the contribution in the management of the common goods in not automatically guaranteed. In fact, because of structural and motivational reasons, individuals tend to act opportunistically, and favor the personal interests over the group interests, which leads to different types of defects, operations inefficiency and higher costs along the supply chain, resulting in lower benefits for the whole group, and ultimately, in the failure of the business. Through this paper we attempt to understand members' behavior from a social dilemma perspective and suggest resolution mechanisms both at the structural and motivational levels in order to mitigate the probability of facing opportunistic behavior from the members of the group. As a case study, the papers analyses the case of agricultural cooperatives in Morocco.
In order to cope with the several limitations the agricultural sector has been suffering from, the Ministry of Agriculture and Fisheries lunched the Green Morocco Plan (GMP) which aim, among others, is to bring together farmers and their respective lands for the implementation of viable agricultural investment projects. These projects essentially target small farmers in marginal areas with limited financial means and poor management skills.

The state puts in place agricultural projects aiming to bring an initial investment (plantations, irrigation infrastructure, transformation units,…) into those areas and gather the farmers as producers' organizations (cooperatives, Unions, Federation, etc.) capable of managing by themselves the business (technically and economically) once the state's contribution is over. The objective behind this approach is to allow these entities to produce fresh agricultural products, transform them, and sell the added value product, thus, catching the value that used to go to intermediaries. The model adopted by the green Morocco Plan creates entities that produce a higher value product through the management of a common good, which is the transformation unit. Therefore, the success of the business highly depends on the effort and contributions of each member of the group, which makes it an interesting case to consider for this research. The data collected for the case study accounts for nearly 1500 farmers belonging to 147 cooperatives, each one having to manage a common good.

2. Theoretical approach

In the modern economy, a firm can no longer be considered as an isolated entity. It is an actor belonging to a one or several networks of firm called supply chain (Mentzer et al., 2001; Min et al., 2008). A supply chain can be understood as a set of inter-organizational relationships embedded in a social network (Chen and al, 2014) in which continues interactions enable setting its organizational configuration as transverse processes allowing actors to seize the opportunities in their markets and to achieve their economic, ecological and social objectives. This organizational configuration represents à hierarchical, dynamic, and sequential network of autonomous firms that are economically interdependent, from the very first supplier to the very last customer. These firms are generally connected through the different types of flows (physical, financial and informational) both at the upstream and downstream levels, and also by other types of relations from conflict to collaboration strategic alliances.

According to Johnsen and al. (2010), the introduction of supply chain as a research area allowed us to better understand and analyze the inter-organizational relations dynamics. In fact, the management of inter-organizational relations within the supply chain overtakes the traditional frame of contractual arrangements (Vanpoucke and al., 2009) in order to form a particular type of strategic alliances that are favorable to the new competition paradigm that happens between supply chain networks (Vanpoucke and al., 2009). Generally, the objective of alliances is to add superior value to the fundamental activities of the partners by improving flexibility and allowing each actor to focus on its distinctive competencies (Monczka and al., 1998)
In an alliance, benefits must be fairly dispatched between the different parties. The term alliance generally refers to a cooperative strategy and collaboration agreements in which the partners explicitly accept to cooperate and manage the ressources and the common activities, believing that they would be more competitive this way than working alone (Zeng and Chen, 2003, McCarter and Fawcett, 2012). In this regard, Ring and Van de Ven (1994) consider that alliances are social mechanisms that facilitate the collective action, and that are constantly shaped and restructured by the actions and interpretations of the concerned parties.

2.1 Social dynamics and supply chain management

The supply chain is a social system which management represents a social dilemma hanging between the individual interest and the supply chain interest (McCarter and Northcraft, 2007). The supply chain management is based on the pooling of and skills of each party and on the synergy that exists to collectively create a value that superior to the sum of all value created separately.
However, despite the fact that cooperation is essential in creating and sharing value, supply chain management is subject to opportunistic behavior which leads to operational failures. In fact, supply chain management is characterized by an acting game between clients and suppliers (Johnsen and Ford 2005), ranging from cooperation to competition through a hybrid coopetition strategies (Zouaghi,

Saikouk and Spalanzani, 2010). Behavioral variations are observed ranging from cooperation to defection, due to social uncertainty, giving place to instabilities and failures compromising the value creation process. The social uncertainty that characterizes the supply chain dynamics comes from a lack of information and the intentions of the supply chain partners. According to (Park and Ungson, 2001), social uncertainty schakles inter-organizational cooperation through lack of trust between partners. This prevents efficient contribution to the value creation process (McCarter and Northcraft, 2007).

In contrast, the fact that the supply chain partner voluntarily choose to cooperate does not necessarily guarantee that the alliance will be a success. Unfortunately many strategic alliances fail to achieve their value creation potential, resulting in several non-performances (Malhotra and Lumineau, 2011) and ultimately the failure of the supply chain management (Fawcett and Magnan, 2001; Vanpoucke and Vereecke, 2010).

In order to explain the failure of alliances, Tenbrunsel and Northcraft (2010) suggest three different causes which are: (1) the partners don’t perceive the costs of benefits of the alliance the same way, (2) each partner perceives differently the alliances stakes, and (3) each partner thinks they can pull out their resources while thinking the others will remain cooperative.

In order to better understand the supply chain social dynamics, we suggest rallying the social dilemma perspective according to which mutual cooperation between partners is essential to their performance (Zeng and Chen, 2003).

2.2 Social dilemma perspective

A social dilemma is defined as a choice between undesirable alternatives (Merriam and Webster, 1974). In a social group, a member is in a social dilemma if has the choice to participate or not in the collective actions of the group. A social dilemma is a paradox that emerges in situations where undertaking certain actions requires the intervention of several participants (Van Lange, Joireman, Parks and, Van Dijk, 2013). The social dilemma perspective focuses on how cooperation perception and incentives influence the individual will to find compromises that can satisfy both individual and collective interests when they are in contradiction (Dawes, 1980).

Research in this area has focused on primarily on the collective decision taking and how the motivation to cooperate and the actual situation in which the partner is affects their choice (Weber, Kopelman and Messick, 2004). The main stake in this situation is to know how to persuade the actors to cooperate and contribute to the collective action, when adopting an opportunistic behavior can be more profitable.

A classic social dilemma has been presented by Hardin (1968) called “the common tragedy”. The researcher studied a group of farmers who got together to use range land no member could afford on his own. The collective interest in this situation is that all members should contribute to the maintenance of the common good by rationally using it, while in reality no one really does so, which represents a form of defection. Every farmer relied on the others to maintain and rationally use the land. The group ended up overusing and not maintaining the land, which had a negative impact on the common good and also on the livestock. At the individual level, the defection seems to be a rational choice if all the other continue to participate in the collective action. However, if all farmers think the same, they lose. The major stake in this social dilemma is to find out how to motivate all members to still participate even in situation where adopting an opportunistic behavior seems to be more profitable.

The two reasons that explain the failure of the collective action are the offensive defection Zeng and Chen, 2003) and the defensive defection (McCarter and al., 2011). A defensive defection happens when a partner does not contribute to the supply chain activities and does not invest in the common resources (Zeng et Chen, 2003), while an offensive defection refers to the situation where à partner wants to reach short term profits while taking advantage from the cooperative with other partners (McCarter et al., 2011). In this regard, Fawcett, Magnan and McCarter, 2008) have shown that when several partners behave opportunistically, the supply chain management fails and so does competitivity.

2.3 Social dilemmas consequences

In a social dilemma, participating in the collective action does not always have the same signification (McCarter, Mahoney and Northcraft, 2011). On one hand, it sometimes means giving and contributing in the collective action, while on the other hand, it might mean not taking or not overusing the shares resources. These two types of cooperation refer to the defensive defection (to not contribute) and the offensive defection (taking what you should not). The defections can have immediate or long terms impact (Messick and Brewer, 1983; McCarter, Mahoney and Northcraft, 2011). This distinction means that the consequences of those defections on the supply chain management are not necessarily the same. Table 1 presents examples of offensive and defensive defection on the short and long term.

	Short term	**Long terms**
Defensive defection (ex ante)	- Information retention; - Non-investment traceability systems (Vowels, 2009; Saikouk and al., 2011);	- Bullwhip effect; - Increasing Inventory and lead time (DeMarco and al., 2012; Kumara and al., 2011);
Offensive defection (expost)	-Requiring very short payment plans on the powerful partner; - Take advantage of an innovation in the partners processes (McCarter and Northcraft, 2007);	Increaing need for working capital; Mitigated financial performance for the supply chain (Akgün and Gürünlü, 2011)

Tab. 1: Defection consequences on the supply chain

To conclude this section, we can consider that the existence of social barriers results in decreasing short term investments in the resources dedicated to the supply chain partners, which compromises the long term creation of value (Fawcett, Magnan and McCarter, 2008). This phenomenon characterizes the situation where à partner decide to outsource one part of his supply chain costs leaving the other partner make the necessary investments to create value. This behavior results a value creation problem (Kollock, 1998). In the offensive defection, a partner expropriates on the short term the value created by several partners. This behavior usually results in maintaining the long term relationship (Kollock, 1998; Fawcett, Magnan and McCarter, 2008).

The success of an alliance depends on the ability of partners to collectively manage the value creation problem in the supply chain. As we have shown earlier, the resolution of these problems depends primarily on managing relationships and contributions among partners. Solving a social dilemma prevents, or at least mitigates the negative impact of the offensive and defensive defections.

Because social dilemma problems have negative consequences on the supply chain success, understanding the structural and motivational mechanisms that trigger defections is of very high importance (McCarter, Mahoney and Northcraft, 2009).

2.4 Solving social dilemmas

In this section, we will analyze the most common solutions present in the literature that enable the resolution the social dilemmas and the motivation of partner to cooperate (Kollock, 1998, McCarter, Mahoney and Northcraft, 2009, McCarter and Fudge, 2012). The presented solutions are split into two main categories, structural and motivational. The motivational solutions assume that partners are not selfish and value the results of their partners, thus giving more importance to non-zero-sum solutions (Kloock, 1998). These solutions do not suggest changing the structure of the dilemma. The structural solutions consider that partners are not completely selfish, and suggest modifications at the level of ground rules on the structure, strategic reorientation, and clear procedure for dispatching the added value (McCarter and Fudge, 2012).

Several taxonomies have been developed in order to solve social dilemmas (McCarter and Fudge, 2012). The first taxonomy appeared in an article published by Messick and Brewer (1983). This taxonomy focuses particularly on the necessary solutions to motivate partners to cooperate. The objective is to determine whether the solution has to be imposed on the partner who takes independent actions, or on the whole group, and whether it should be a unilateral on join decision.

Contrarily to the first taxonomy, the second one by Zeng and Chen (2003), essentially based on Kloock (1998) article, suggest a solution that focuses primarily on the way partners perceive the structure of the social dilemma (structural solution) and how these partners perceive each other (motivational solution). These two taxonomies are complementary in several ways. The two consider trust between partners (Ostrom, 1998, p. 13) and their efficiency in the alliance (Bandura, 1977; Kerr, 1996) effective mechanisms to encourage partners to cooperate.

Integrating the two taxonomies has allowed us to group all the solutions found in the social dilemmas literature, as shown in table 2.

	Structural	**Motivational**
Joint	I Mutual interdependence Number of partners	II Interdependence perception by the partners Orientation of social value
Unilateral	III Informal sanction Alliance efficiency	IV Communication level Alliance identity

Tab. 2: Integrative social dilemmas solutions taxonomy

Quadrant I contains joint/structural solution. These solutions must be coordinated and applied by all partners in order to change the way they perceive the social dilemma that represents the alliance. Quadrant II contains joint/motivational solutions that should be coordinated and applied by all members in order to change the way they see each other. In parallel, quadrant III regroups unilateral/structural solutions which could be put in place by each member separately, with the objective of changing the way each member perceives the other. Last but not least, quadrant IV contains unilateral/motivational solutions which objective is to influence the way partners perceive each other.

3. Case of the agricultural cooperatives in Morocco

Before beginning this chapter, we would like to highlight the lack of literature that analyses the structure and characteristic of agricultural cooperatives in Morocco. This being said, our analysis is based on primary data collection.

3.1 Brief description of agricultural cooperatives in Morocco

According to the Moroccan law n° 24-83, relative to the cooperatives status, a cooperative is a group of individuals who agree together to create a company that they have to operate and manage in order to provide, for their exclusive satisfaction, the product or services they need. The members of the cooperatives are shareholders who participate in its capital and have equal voting right at the annual assembly no matter their weight in the organization, which can be measured in terms of cash, assets and services/work.

The agricultural cooperatives follow the same structure and obey to the same laws. The analysis their environment and organization allowed us to identify, besides the presence of a common good, five main characteristics which are: high number of members, lack of communication, law schooling level of the members, classic internal organization, and a competitive business environment. As explained in chapter 1, the agricultural sector in Morocco suffers from excessive land fragmentation. Therefore, in order to design viable agricultural project, a high number of farmers need to be gathered into one single organization, i.e. a cooperative, owning a transformation unit (TU), which type depends on the crop chosen for the project. The fresh agricultural products produced by the farmer’s land constitute the primary source of raw materials for the transformation unit. As shown in figure 1, 65% of the created agricultural cooperatives between 2010 and 2012 gather more than 300 farmers (Agency for Agricultural Development, 2012), making control operations and communication very complex.

Members of the cooperatives, who are farmers coming from the rural areas where the project is being implemented, have a low schooling level. According to (Achy, 2010), the illiteracy rate among the population aged 15 and above in rural areas of Morocco is around 63%, which, on one hand would not allow them to effectively run the business operations, and on the other hand, makes them unaware of their rights and obligations towards the group.

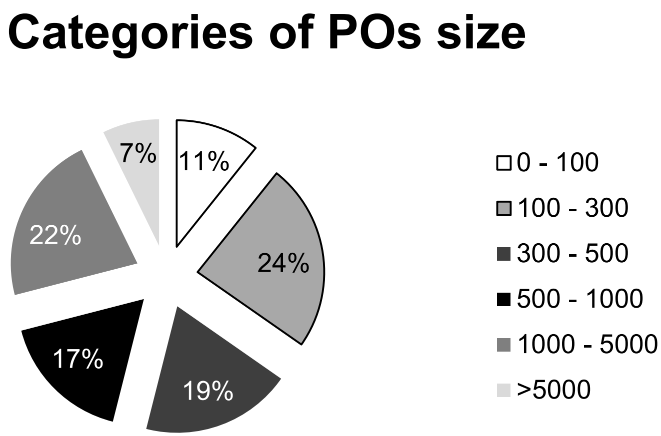

Fig. 1: Cooperatives distributions according to their size (number of farmers)

Moreover, agricultural cooperatives are involved in a highly competitive market. The agro-food sector gathers more than 1981 firms, which represents 25% of the total number of industrial firms in Morocco. Those firms produce annually nearly 67 billion dirham worth production (Ministry of Economy and Finance, 2010). Also, Morocco imports food products for a total value of $ 5.581 billion (World trade Organization, 2013), which makes the offer on the market worth 114 billion dirham. In terms of demand, the average annual consumption per household in Morocco is estimated to 49,333 dirham, from which 41% is dedicated to food products (Haut Commissariat au Plan, 2013). In 2012, Morocco has nearly 6.81 million households (Haut Commissariat au Plan, 2013), making the demand for food products worth nearly 138.8 billion dirham. This being said, the ratio demand to supply is 1.2 which shows that there is a very limited gap to cover in terms of demand. This competitiveness requires from the cooperative a high level of efficiency if it wants to survive.

In 2012, the Agency for Agricultural Development, in collaboration with the Regional Directorates of Agriculture, led a survey based evaluation among a sample of farmers and cooperatives from projects launched in 2010 and 2011 in the 16 regions of Morocco. The survey integrated question about farmers' satisfaction, communication within the cooperative, organization of farmers, farmers' capacity development, working capital, management, and other technical issues. The size proportional stratified sampling was used in order to select a representative sample of farmers to interview. The computations led to a sample of 1504 farmers belonging to 146 cooperatives.

Concerning the communication between farmers and the cooperative managers, 45% of farmers said to have no or partial information about the different project components. This represents nearly half of the farmers and shows a clear lack of interaction between the two parties. Furthermore, 55% of the interviewed farmers did not benefit from awareness campaigns, which suggests that 10% of farmers have had the information from other sources than the cooperative official themselves. When asked about whether or not debriefing meetings were held, 56% of the POs said to regularly hold debriefing meetings. However, comparing this to the previous results, we can see that this percentage is similar to the percent of farmers who are informed about all the components of the project (55%), but slightly lower than the percent of farmers who say not to have benefited from any awareness campaign (58%). Perhaps information does not reach the entire farmers and there should be more efforts on spreading it, or some debriefing meetings may just be held within the board of the PO.

The survey also gives insights about how the cooperative plans to manage the transformation unit. 43% of the POs interviewed said they know how to do so. However, their explanations were limited to who is going to be in charge and not how technically and financially the unit is going to be run. Out of those 43%, only 4 POs stated that they will recruit a qualified person to take care of it, which suggests that most of the cooperative rely on their members to manage the transformation unit.

Moreover, it appears from the survey that the cooperatives also have a classic internal organization, as they try to comply with the minimum legal obligations. They are composed of a president, a vice president, a general secretary and a treasurer. Such an organization is not adapted for managing different sorts of operations, both at the technical and managerial levels. The managing members are the only ones which jobs and attribution are clearly identified, while all the others are considered as simple members.

3.2 Mapping the relationships

Matching the defection identified through the social dilemma approach to supply chain management and the characteristics of the agricultural cooperatives is an imported step in order to identify what applies and what doesn’t, and also to test the solutions taxonomy suggested in chapter 2.

As explained in the previous section, the cooperative members are farmers with a low schooling level and very limited managerial capacity. This makes it harder for them to, first understand their rights and obligations, and also to clearly perceive the added value of sticking together as a group to maximize the added value. In order to reach that level of understanding and cohesion, communication and awareness campaigns should be undertaken within the cooperative. However, based on the survey results presented in the previous section, more than half of the interviewed farmers say to not have benefited from any awareness campaigns, which exposes the cooperatives to high risks of opportunistic behavior from the farmers. This lack of communication is further emphasized by the classic internal organization of the cooperative, which on one hand does not allow them to effectively reach all the members, and on the other hand, when combined with the high number of members, results in information asymmetry and increases the risk of opportunistic behavior (Williamson, 1988).

The opportunism can show up in the three different defection forms previously explained, which are the free riding and hold up.

Free riding, which represents an ex ante defection, happens when a partner (member of the cooperative) does not fully contribute in the supply chain activities. As a result of poor understanding of their rights and obligations and lack of visibility, and given their position as producers of the fresh agricultural products, farmers might choose to sell their products to other products to higher bidders, to perform intercropping, leak information to competitors, or follow some agricultural practices that seems suitable for their personal interest but that are not in compliance with the cooperative needs. These types of defections have an extremely negative impact on the supply chain such as shortages in supply, quality issues, underutilization of the production capacity, and ultimately unsatisfied demand and poor supply chain performance.

The holdup defection, which happens after the value creation (ex post), results from the will of a partner to take short term advantage by taking advantage of the cooperation relationship with the other partners. The holdup defection can show up both at the level of farmers and deciders. In absence a clear procedure for dispatching of the benefits made by the cooperative, some members, who have no contributed as much as other, might claim an equal part of the added value, taking advantage of the poorly informed members and their low level of awareness. In the same situation, deciders (who could also be farmers) might also try to take advantage of the situation by aiming to capture a greater reward for their managerial positions. The holdup defection generally leads to a “giving up” feeling from the other members, leading to discontinuities or free riding defections afterwards.

From the above discussion, we can conclude that the current configuration and internal practices of the agricultural cooperatives expose them to high risks of defections. Matching the characteristics of the cooperatives with the possible defection triggers allow us to identify several actions that should be carried out by the cooperatives.

Action	**Description**
1. Identifying members and their roles in the PO	Create a transparent governance system within the cooperative by identifying the members and their roles. Increases trust and reduces behavioral uncertainty and opportunistic behavior (Bijman and Wollni, 2008). Reduces free riding
2. Increasing members awareness of their rights and obligations and include them in the decision making process	Make all members aware of their rights and obligations. Reduce free riding
3. Setting up a transparent reward system for dispatching the added-value (benefits).	Clarifies the benefits dispatching procedure in order to avoid conflicts within the PO. Increases trust and mitigates holdup probability.
4. Introducing a penalty system stating the appropriate sanctions to the corresponding defections	Reduces the risk of observing opportunistic behavior from members and falling into defects
5.Creating specialized task units with clear roles in the organization (covering all kinds of operations)	Facilitates operations control and communication within the cooperative.

Tab. 4: Actions that should be undertaken by cooperatives

4. Conclusion and discussion

Nowadays, firms are more aware of the importance of their relationship with the other partners in the supply chain. An efficient management of those relationships becomes an important performance pillar.

We have shown the social dilemma perspective focuses on the mechanisms that influence the mutual cooperation within a group in terms of collective decision making and how motivation and situation perception influences the members' choices. We have also demonstrated that the resolution of a social dilemma enables us to find compromises that can satisfy both personal and collective interests. When costs and benefits of the cooperation are not perceived in the same manner by the different members, disparities will appear in how each member thinks his contribution to the alliance should be. We think that the analysis of the actors' behavior within the supply chain as well as their perception of the situation they are in is critical.

Concerning the specific case of agricultural cooperatives, it is clear that their actual configuration is conducive to the appearance of defensive and offensive defects. The combination between the low communication level, the poor internal organization, the high number of farmers and their low schooling level opens several gaps that could easily trigger opportunistic behavior from the members. It is therefore of high importance to follow the solutions taxonomy and specifically undertake the actions suggested in this paper.

This work has first demonstrated that taking into consideration the social dynamics within the supply chain and solving social dilemmas resulting from it is a lubricant to the relationship between the partners. Second, the results of this research have shown that psychological and relational variables (trust, communication, value sharing) play an important role in the success of the cooperative model. Communication and strengthening the collective identity represent an important complementary governance model to the contractual governance model, which is characterized by the power imbalance between the different parties. The social dilemma perspective allows taking into consideration the perceptions and will of the supply chain partners. Third, we have shown that the success of a collective action such as the supply chain, three factors should be taken into consideration, which are: communicating on the importance of cooperation in the process of value creation and on the fair dispatching of the added value in order for the members to better perceive the costs-benefits of the collective action, reducing social uncertainty by improving the communication level and reinforcing the group identity, and ensuring complementarity between the contribution of the different partner and avoid redundancies (Kollock, 1998).

The methodology followed in this work as well as the results obtained can be easily applied to other countries. Grouping farmers into cooperatives is not a new concept. Several countries have adopted this system in order to restructure the agricultural sector and ensure its development. According to the World Bank Report “World Development Report 2008”, from 1982 to 2002, the world has seen a great expansion in the number of producer organizations (PO). An increase from 8% to 65% in terms of villages with POs was recorded in Senegal and from 21 to 91% in Burkina Faso. In India, the dairy cooperative networks gathers more than 12 million farmers and produces 22% of the country's milk supply. The fact that we have tackled this issue from a general theoretical point of view before applying it to the Moroccan context enables us to reuse the findings and apply them to a new situation while following the same methodology. Given the importance agricultural cooperatives in the process of restructuring the agricultural sector in many developing countries around the world, especially in Africa, this research offers a conceptual framework which aim is to help cooperatives to mitigate the risks of falling into defects resulting from adopting such a structure.

Several conceptual contribution of this work should be highlighted. The main one lies in the adoption of a multidisciplinary approach (social psychology, game theory) to explain the actors’ behavior within the agricultural supply chain in Morocco, where the cultural inking is very important. We have shown that the behavioral dynamics that govern the supply chain, particularly the simultaneous cooperation and competition, can be understood by rallying the social dilemmas paradigm. This paradigm, which results from research on both game theory and social psychology, represents a study framework of individual behavior. First, we reviewed the dynamics of social dilemmas by examining the scenarios that illustrate them in the supply chain, the different types of opportunistic behavior that lead to these dilemmas on first and second order. Then, in line with the work of Kollock (1998) and McCarter and Fudge (2013), we developed a taxonomy of possible mechanisms resolving dilemmas. The social dilemmas perspective represents a theoretical framework that strongly explains the inter-organizational dynamics within the supply chain, which are usually forgotten according to Mentzer and al (2001). Therefore it can be a basis for further reflection on inter-organizational management practices such as collaboration, resources sharing, knowledge and capacity sharing.

As any research work, this paper opens several perspectives for further research. We hereby suggest few of them. Using the social network theory approach seems to be an interesting way to analyze and resolve social dilemmas, since it addresses the structural and motivational characteristics of a social network. We also invite researchers to study the impact of all structural and motivational mechanisms to solve social dilemmas on the performance of the supply chain.

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Cooperation in Empty Container Logistics

Carlos Jahn and Johannes Schlingmeier

Abstract

Seaborne container transport volumes have doubled between 2001 and 2011 from 59 to 118 million TEU. The demand for container transport also induces demand for empty container repositionings, as not all import locations have an equally large demand for export of containerized cargo. As a result, empty containers have to be transported from equipment surplus- to deficit-locations. Around 25% of all transported containers are empty, resulting in costs of USD 33 billion in 2011. Since overcapacity in the industry has put margins under pressure and empty transports are often not paid for by the shipper, limiting those expenses is crucial for carriers.

While technology-, pricing- and operations research-related approaches have been implemented widely, cooperative strategies have received little attention in practice. The literature attributes this to the fact that the benefits of such a strategy have not been proven yet.

Based on the network-model, we believe, that an interchange of equipment between carriers in surplus- and deficit-locations will reduce the required number of empty moves. The paper constitutes the first empirical analysis of the potential of equipment interchange and will reveal that between 5-10% of moves can be avoided. The analysis is conducted as a case study and based on actual container moves collected from nine global container carriers. By proving t he benefits of equipment interchange, we hope to contribute to further cooperation among carriers.

Keywords: empty container logistics, cooperation, equipment interchange, imbalances

1. Introduction

Worldwide container transports at sea have doubled between 2001 and 2011 from 59 to 118 million TEU (Drewry Martime Research, 2012; Global Insight, 2011). To conduct containerized transports, shippers require empty equipment, which – if not available – needs to be repositioned to the export location (Di Francesco, Crainic and Zuddas, 2009, p.758). These repositionings help to absorb the transport imbalances by moving empty equipment from surplus to deficit regions (Moon, Do Ngoc and Konings, 2013, p.107). However, the amount of empty repositionings is significant: Every fifth seaborne container and 40% of all equipment transported over land are empty (Konings et al., 2001, p.334, Karmelic, Dundovic and Kolanovic, 2012, p.223). Already in 2005, 82 million containers were loaded and unloaded empty in ports (Vojdani and Lootz, 2011, p.2). The cost arising from empty logistics for carriers alone amounted to USD 33 billion in 2011 (Notteboom and Rodrigue, 2008, p.167; Vojdani and Lootz, 2011, p.2). This equals 7-10% of operating expenses for carriers. Hence, empty container logistics requires significant efforts from carriers and deserves their attention. Because of carriers' currently low earnings, their overall profitability is dependent on the efficiency of their empty logistics (Flämig, Wolff and Herz, 2011, p.5; Olivo, Zuddas, Di Francesco and Manca, 2005, p.367; Feng and Chang, 2008, p.470; Lam, Lee and Tang, 2007, p.265; Song and Carter, 2009, p.292)

This efficiency can be reached in multiple ways. Levers to reduce costs for the carrier in empty container transportation include logistics, technology, pricing and management/organization. These levers can be classified in those that reduce the number of required empty transports and those that reduce the cost per empty transport by raising the transport efficiency (e.g. by improving the network design). The approaches are internal or external (cooperative).

While logistical, technological and pricing levers have received significant attention and are widely implemented, managerial and organizational levers – and especially cooperative ones – are barely relevant in practice, although receiving significant theoretical coverage. Several reasons have been identified, why equipment interchange or even pooling is difficult to implement. One – and according to literature the most important – is that if carriers have similar imbalances, then exchanging equipment will not reduce the number of required empty repositionings (Lun, Lai and Cheng, 2010, p.161). Braekers, Jannsens and Caris (2011, p. 697) state, that "Future research could identify cost-saving opportunities from cooperation among carriers". The following chapters aim to answer this question and by achieving this to remove one of the most prominent roadblocks to cooperation in empty container logistics.

2. Problem description

2.1 Root causes for empty container logistics

Empty equipment is the prerequisite for the transport of containerized cargo. If no empty equipment is available, the shipper cannot fill a container and hence the transport cannot be conducted. Therefore, empty containers have to be transported to an export location, if supply is insufficient. There are four major root causes for empty container logistics: structural trade imbalances, seasonal demand for transportation, equipment type imbalances and the large number of equipment owners (Song and Dong, 2011, p.92; Olivo et al., 2005, p.4).

Global and regional trade imbalances are the biggest reason for the transport of empty containers. If a region has more containerized exports than imports, automatically this region has an under-balance of containers (Boile, Theofanis and Mittal, 2004, p.3; Hüttmann, 2013, p.31; Pawlik, 1999, p.119; Bandeira, Becker and Borenstein, 2009, p.383). This phenomenon leads to global imbalances. On top of the region-wide imbalance, each trade, i.e. the transport between two regions, can be unbalanced which may require empty repositionings even in overall balanced regions (Brito and Konings, 2011, p.1; Diaz, Talley and Tulpule, 2011, p.218).

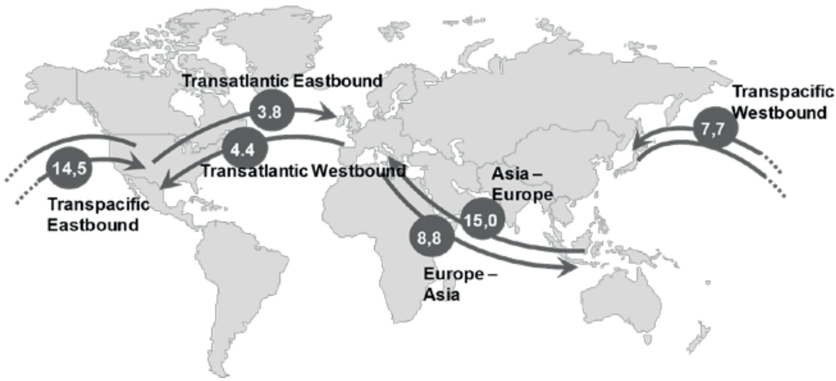

Fig. 1: Container flows 2012 in million TEU (Drewry Martime Research, 2012)

The most prominent examples of global imbalances are the transpacific trade and the trade between Europe and Far East Asia. In both cases, the export surplus of Far East Asia causes the imbalance. The Transpacific trade connects North America with the Far East. While, in 2012, 14.5 million TEU were shipped eastbound, only 7.7 million TEU were shipped in the opposite direction, leaving a trade imbalance (and hence demand for empty repositionings) of 6.8 million TEU. A similar imbalance can be found on the trade between Europe and Far East. On top, empty repositionings also occur intra-regionally (Braekers, Janssens and Caris, 2011, p.681). While urban areas are usually net-importers of cargo, hence have an empty-container surplus, industrial centers are often net-exporters of cargo, requiring additional empty containers to be repositioned. Weight differences between the regions' export cargoes also add to trade imbalances (Konings, 2005, p.224; Olivo et al., 2005, p.204; Hüttmann, 2013, p.35).

A trade that is balanced over the course of a year can still show temporary imbalances. These imbalances arise from seasonal cargo flows ("temporal imbalances"). Such flows are typically caused by seasonal products (fruits and vegetables) or special events, such as the Chinese New Year. Trades with a large share of seasonal transports are between Northern Africa and Europe and between Latin America and Europe (Lei and Church, 2011, p.754; Braekers, Janssens and Caris, 2011, p.681; Olivo et al., 2005, p.204; Hüttmann, 2013, p.35; Konings, 2005, p.224; Karmelic, Dundovic and Kolanovic, 2012, p.223).

Beyond overall trade-surpluses or -deficits, cargo requirements can cause "operational imbalances" (Song and Dong, 2011, p.92). Certain cargo requires the use of special equipment, for example, perishable cargo needs to be transported in a reefer container. Light cargo on the other hand is preferably transported in 40-foot-containers, instead of 20-foot-containers to save cargo handling expenses (Song and Carter, 2009, p.294). If one export location requires the use of a certain equipment type which cannot be used for the next export of the previously receiving location, then this equipment needs to be repositioned empty – even on a trade which may otherwise be balanced.

Since containers are owned by different actors, these actors' trade structures can also add to the imbalances. While regional, temporal and operational imbalances can be classified as structural, "company specific imbalances" arise from the specific customer mix and trade structure of each company. Since in principle, each owner only uses its own equipment, empty transports are regularly required even in an overall balanced location. As company-specific imbalances are not structurally caused, they can be avoided to some extent. This paper investigates the potential to reduce empty repositionings caused by company-specific imbalances (Shintani, Konings and Imai, 2010, p.762).

2.2 Effects of empty container logistics

As every form of imbalances requires the repositioning of empty containers, the dimensions of empty logistics are significant, making it an integral part of every carrier's planning. About 22% of all containers transported at sea and about 40% of all inland moves are empty (Mongelluzzo, 2004, p.10; Shintani, Konings and Imai, 2010, p.750; Crainic, Gendreau and Dejax, 1993, p.104). This results in company, environmental and societal effects.

For carriers, the costs of empty repositionings are significant. In 2011 the direct costs of the empty container logistics for carriers summed up to USD 33 bn. These direct costs include transportation and terminal cost and the cost for maintenance and repair of the container. On top of these direct costs, empty repositioning also causes indirect costs such as higher investments in a larger equipment fleet and increased administrative efforts. Empty container logistics also have significant effects on other actors, such as leasing companies, shippers, terminal and depot operators (Lun, Lai and Cheng, 2010, p.151). But also society and the environment are affected by empty container logistics – mainly because empty transports increase overall traffic. Additional traffic increases both emissions and the utilization of infrastructure which adds to an already high utilization of infrastructure bottlenecks (Flämig, Wolff and Herz, 2011, p.49). Last but not least, unnecessary transports also lead to waste of non-renewable fuel (Hüttmann, 2013, p.52).

3. Research gap

The topic of empty container logistics has received significant attention by literature. Current summaries can be found in Hüttmann (2013) and Brito, Konings (2011). Earlier works reach back to the 1970s – the early years of containerized cargo shipping (White, 1972; Ermolev, Krivets and Petukhov, 1976; Pezier, Cresswell and Davenport, 1979). But attention has not ceded since. Especially the cost and efforts of empty repositioning have been discussed widely (Olivo, Di Francesco and Devoto, 2003; Notteboom and Rodrigue, 2008). Most publications have in common that they do not only describe the effects of empty container logistics but also offer potential solutions. As shown earlier, these strategies can be grouped in internal (optimizing) and external (cooperative) strategies. Also, they can be grouped in strategies to avoid empty container transports and to efficiently conduct empty transports (figure 2).

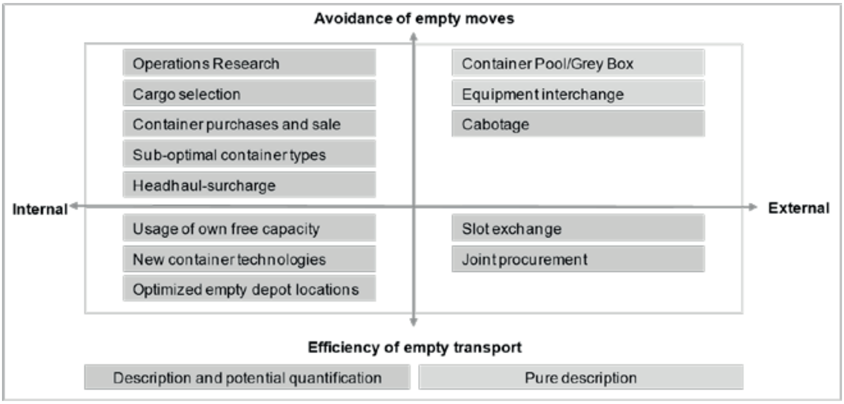

Fig. 2: Status of research on carriers' empty container strategies

Extensive descriptions and potential quantifications have been made for internal strategies and for cooperative strategies to efficiently conduct empty container transports (Song and Carter, 2009, p.292). However, little quantitative research has been conducted on cooperative strategies to avoid empty transports. Dang, Yun and Kopfer (2012, p.708) comment on the status of research as follows: "[…] little research has been reported on the coordinated optimization of empty container positioning […]". Several authors have described the logic of reducing the number of required empty transports through equipment interchange. Boile (2006, p.65f.) calculates a theoretical potential. Song, Carter (2009, p.301f.) establish a mathematical model using a fictive imbalance-breakdown to individual carriers. Neither of the authors conducts a detailed qualitative assessment based on actual data.
Even less empirical research has been conducted on a container-pool or grey-box-pool. The concept is to move the ownership of equipment from the individual carrier to a new 3rd party company. Theoretical discussion of this strategy has started in the early 2000s (Hanh, 2003; Lopez, 2003, p.350). Mongeluzzo (2004) describes the advantages of equipment pooling, however sees significant problems in realizing such form of cooperation. Other authors discussing equipment pooling in container shipping are Notteboom, Rodrigue (2008), Ferulli

(2010) and Hüttmann (2013). Song, Carter (2009) have also assessed the potential of equipment pools – however based on fictive data and on an aggregated trade level. Braekers et al. (2011, p.697) summarize the lack of quantitative research on the potential of equipment interchange: "Future research could identify cost-saving opportunities from cooperation among carriers […] Technological developments […] seem to be interesting options to facilitate and/or reduce the costs of empty container management. However, so far, there has been little research on the potential savings of these technologies. Finally, most research takes the perspective of a single ocean carrier or transportation company."

4. Research methodology

Based on the network-model, we believe, that the interchange of equipment between carriers in can reduce the required number of empty moves (Weber, 2008, p.63; Delfmann et al., 2010, p.45; Vahrenkamp, Kotzab and Siepermann, 2012, p.10; Klaus, Krieger and Krupp, 2012, p.445; Doborjginidze, 2005, p.21). This paper will assess the impact of container interchange between carriers on the total number of empty moves required in the system trough a case study. In order to close the research gap - the lack of a quantitative potential analysis - actual empty container transport data was collected. Eleven global container carriers were approached to submit their empty container transports in 2012. Of those, nine carriers actually participated and provided detailed data on their empty moves. These nine carriers constitute ~46% of the global container carrier fleet – making this is very well usable sample (Alphaliner, 2013). The sample includes carriers from all relevant global shipping regions.
Each empty container move was recorded including information on the month, the origin and destination locations, the equipment size-type and the carrier's name. In total, ~35 million empty container moves were provided for this study. Only dry containers were investigated, as the different reefer systems make an interchange more complex than for dry equipment.

If one carrier has a surplus of empties (i.e. more equipment than he needs to transport the export cargo), he could in theory provide this equipment to a carrier who has a shortage of containers. In such a case, an exchange of equipment would make sense from a system's point of view; however individual carriers may still chose not to provide containers for competitive reasons or to optimize individually. If on the other hand both company's containers were owned by a third party, the exchange of containers would not be the choice of an individual carrier but one that takes into account overall system optimization. Analysis of the destination of the equipment has been excluded, as this would only be relevant to assess the potential of equipment interchange between carriers who still own their equipment. Those carriers would need to know the destination where they would receive back their equipment as this would be the origin for any future shipments. If however all equipment is owned by one entity, this company would need to serve all shipments anyways – regardless of the equipment's origin.

Each empty export or import that can be avoided is called a match. For a match as defined in this analysis, three conditions need to be met. First, the import and export from a certain location need to be from two different companies. Second, the containers need to be of the same equipment type and size. Third, both import and export need to happen in the same month of the year 2012. If those conditions are met, a match is possible and will be counted for the analysis. The results of the empirical analysis are described in the next chapter.

5. Case study results

In total, ~35 million moves in 308 geographic clusters across all regions were analyzed. It was assessed in detail whether the individual carriers' empty container flows had opposing directions in the same month of the year 2012. By applying the rules for a successful match outlined above, globally over two million empty moves could have been avoided in 2012 by exchanging equipment between liners – based on the sample covering ~45% of the total market. This equals six percent of total empty moves.

Equipment can be exchanged in all regions. Only 95 analyzed clusters did not have any matching potential. Of these, only one carrier was active in 45 clusters, making any cooperation impossible. Hence, only 50 clusters show equal imbalances for all carriers. Europe and North America have the largest relative matching potential with 13% of empty moves each - significantly higher than in the third major region of containerized activity – North East Asia (2%). Most other regions show a similar share of avoidable empty transports between three and seven percent.

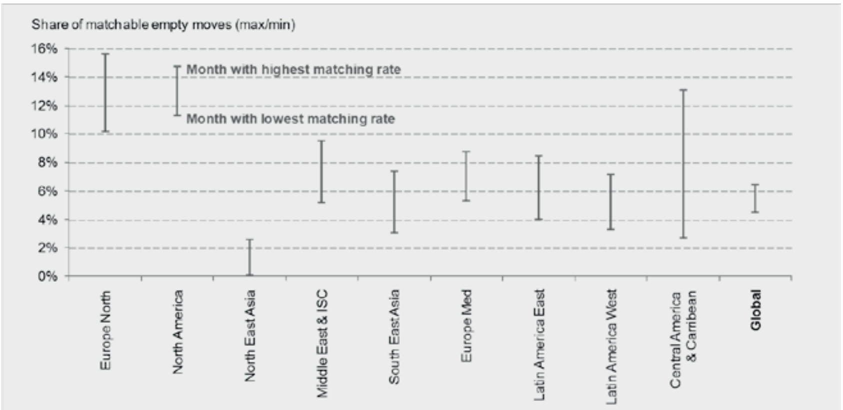

Fig. 3: Range of monthly shares of avoidable empty moves per region

During the course of the year, the share of empty moves that can be matched varies by region. Figure 3 shows the maximum and minimum monthly matching rate per region and globally. In North America, this quota for example varies from 11-15%. In Central America and the Caribbean, the quota varies between 3-13%. Matching quotas however are fairly stable between equipment types. In most regions, the share of matchable transports does not vary significantly between 20-ft, 40-ft und 40-ft High Cube equipment.

6. Discussion

This research quantifies the impact of pooling container equipment on the number of required empty container transports. It was shown, that cooperation between carriers – or a joint equipment-owning unit can have a positive effect on the number of required moves. This can be attributed to the fact, that carriers have different equipment imbalances, i.e. the equipment imbalances are partially company-specific. This means that six percent of imbalances are company-specific, which in turn quantifies the predominant perception in literature: Lun et al. (2010) and Theofanis, Boile (2008) among others assume that the majority of imbalances are similar between carriers (Theofanis and Boile, 2008, p.59; Lun, Lai and Cheng, 2010, p.161). This research proves this but on the other hand shows that a significant share is company specific - hence avoidable. This study also provides an answer to Braekers, Janssens and Caris' (2011, p.697) request to identify the cost-saving opportunities from equipment interchange, closing this research gap.

The results of this study also support the research on cooperation in empty container logistic by removing the fundamental argument against the solutions offered (e.g. equipment interchange, container pooling, etc.) – that all carriers have similar imbalances. The same holds for cooperative solutions in practice. By proving the potential, this research may help in leveling one the major roadblocks to cooperation in empty container logistics.

7. Conclusion

While this paper has shown transport- and cost-saving potential from exchanging equipment in empty container logistics, the study was conducted ex-post. I.e. all empty moves were foreseeable. Therefore, one should call this potential a theoretical potential as likely only a share could be realized in practice, as not all equipment surpluses and deficits are foreseeable to the extent necessary to exchange equipment.

On the other hand, this research offers a good indication as it shows what the absolute maximum benefit of an equipment pool would be and what any equipment pool could be measured against. Future research should compare the theoretical potential of an ex-post analysis with actually realized potential in other industries (e.g. pallet pools, airfreight containers). This paper also deliberately ignores behavioral aspects of equipment interchange. A company may for example not be willing to share its equipment for competitive reasons.

In order to increase the practical relevance of the shown result, future research should also investigate the drivers of the cooperation potential. As was seen, the share of avoidable empty moves significantly varies between regions, equipment types and over time. Hence, the value of an equipment pool could be increased if it was clear what drove the potential, i.e. what factors influence, whether an equipment interchange is promising.

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The Bullwhip Effect in Expanded Supply Chains and the Concept of Cumulative Quantities

Wilmjakob Herlyn

Abstract

The bullwhip effect is a recurring problem in expanded supply chains and one of the most discussed problems in the last years. The word “bullwhip” describes the increasing variability (amplitude) of demand in a supply chain. This logistic phenomenon is observed at the interfaces between the partners during the transition of demand. Many authors see the reason for the bullwhip effect in the distortion of information and the separate calculation of dependent demand. This paper investigates the question whether the concept of cumulative quantities can tackle or even avoid the bullwhip effect.

First the concept of cumulative quantities and order calculation are explained. Then a common production and material flow structure of the expanded supply chain is defined that is mandatory for lead time calculation between preceding cumulative curves of dependent demand. The results are demonstrated on a chart by a simple example with a constant Master Production Program. Thereafter the constant Master Production Program is changed into a sporadic one and the consequences for the cumulative curves of dependent demand and order calculation are explained. Then some special factors like additional demand are analyzed that influence cumulative curves and order calculation in expanded supply chains. At least a resume is given and some conclusions are made.

Keywords: concept of cumulative quantities, preceding cumulative curves, bullwhip effect, expanded supply chains

1. Introduction

"The bullwhip effect occurs when the demand order variability's in the supply chain are amplified as they moved up the supply chain. Distorted information from one end of a supply chain to the other can lead to tremendous inefficiencies" (s. Lee Hau et al 1997, p. 93). The bullwhip effect was discovered for consumer goods where customer demand fluctuates widely, the market demand is anonymous and difficult to predict. Therefor many studies and papers focused primarily on the area of distribution logistics (cf. Arnold et al. 2008, p. 29 ff., Cachon, 2007, Hongchun, 2011, Lee Hau et al. 1997a, Warburton, 2004).
Nowadays an increasing number of original equipment manufacturers (OEM) won't longer produce to stock (BTS) but to customer order (BTO). Therefor the procurement logistics and supply chain play an increasingly important role and not the distribution chain. This applies mainly for companies that manufacture complex technical products with a wide range of variants and a lot of components. The globalization of the world economy has the consequence that multinational companies build production sites on all continents and spread out their supplier network, whereby the suppliers spread out their network too. Thereby the number of cooperating firms and material flow interfaces are growing steadily and "the problem of demand order variables in enterprise-wide value-added systems" increases (s. Göpfert, 2013, p. 29) and can provoke a bullwhip effect. "The solution of the bullwhip effect appears simple. All cooperating companies in the supply chain must have direct access to the demand information of the end customers and replace their current practice of independent planning of production and stocks on available resources and capacities in the supply chain through a global view." (s. above p. 30). This paper investigates the question whether the concept of cumulative quantities (CQ) is suitable to struggle or to avoid the bullwhip effect as far as possible so the above postulation can be fulfilled.

2. The concept of cumulative quantities

2.1 The calculation of cumulative curves

The concept of cumulative quantity (CQ) starts with the calculation of 'cumulative curves' (CC) for the final products that are stored in the Master Production Plan (MPP). The cumulative curve is created by the singular values for final products in the time-units of a timeline. The cumulative quantity for a time-unit in the timeline is calculated by adding all previous values up to the obtained time-unit. The result is a more or less rising curve (s. Heinemeyer, 1992, S. 163 ff.). The time-units in the timeline has to be normalized by a 'production calendar', which transfers the Gregorian calendar data into an equidistant calculation calendar. This means: every calendar day without working hours is removed or marked as "free day" and all calendar days with work reduction or shortage has to be congruently 'cut'. This is mandatory to allow a correct lead-time calculation in the supply chain (see below). This normalization of the timeline also applies to different time-units in the timeline like shifts or hours or what else.

2.2 Order calculation based on cumulative curves and the control loop principle

The determination of order quantities in the concept of CQ bases on the control loop principle. Each particular cumulative target quantity in a time-unit is compared with the cumulative actual quantity. Based on the target-actual deviation a control mechanism (this is the software for requirement demand calculation) determines the regulator: the order of delivery or production. If the actual cumulative value falls below the cumulative target value an order is generated in the level of the measured deviation. In other words: an order is triggered only at the point (time-unit) where the cumulative target curve exceeds the actual cumulative curve (s. fig. 1). If the actual cumulative value exceeds the target value no order is generated.

For regulation also a certain lot size, a time-oriented algorithm or another logistic control mechanism can be used. If a lot size has to be taking in account then the order quantity normally exceeds the target value. This 'event' acts only at the concerned time-unit because the next following order is only then generated when the next cumulative target quantity is lower the cumulative order quantity. This leads to a certain temporarily variability and fluctuation in the short run but in the long run it can't lead to a bullwhip effect. It has to be noticed that the new calculated orders are at the same time used for creating the cumulative in the future so we can build the target-actual deviation and calculate new orders also for the future (s. Chap. 2.3).

In general the magnitude of order variability and fluctuation depends firstly on the granularity of the timeline, secondly on the amount of required quantities and thirdly on the lot size for transportation or production. These factors have obviously no substantial influence to the principle method of calculation and will not be treated in detail here.

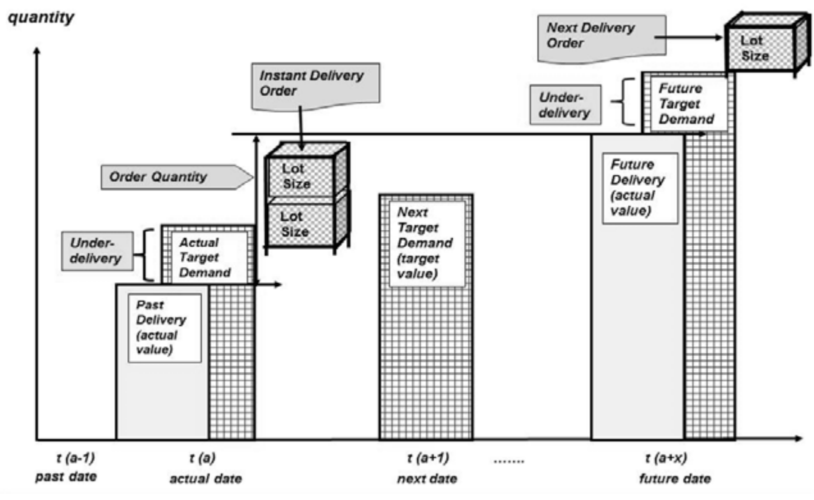

Fig. 1: Calculation of delivery orders (simple example)

The control loop principle includes the automatically adjustment of over- and under-delivery or over- and underproduction, no matter what the reasons for the differences are. This includes subsequent changes in the MPP, customer order definition and product documentation. Also the cleanup of errors is included in the next requirement demand calculation run. These errors can be mistakes, failings and deficits in the processes and the documentation like: failing in the BOM-data, errors in product order definition, inaccurate or late data collection, mounting of false component or incorrect termination of technical changes. These casual factors can't predict and lay outside the normal process and procedures, but they lead to a change in the cumulative target or actual curve. Such retroactive changes and corrections are obvious intended and necessarily taken in account in the control loop principle for exactly requirement demand calculation and lead to 'certain' fluctuations in cumulative target curve and especially for the instant or next order.

2.3 Preceding cumulative curves in supply chains

The cumulative target curve for final product orders in the MPP is the starting ground for the calculation of the required demand for all components (single parts, assemblies, units, raw parts). The calculation of the dependent demand requires to determinate a common production and material flow structure (PMF-structure) for the entire supply chain. An oriented material flow can be described by an ideal Boolean interval algebra, where an interval within maps a certain section or stretch in the supply chain (cf. Herlyn, 2012, p. 131 ff.). An interval can represent any kind of production or transportation, also a stock area or whatever is needed. The beginning of an interval is always defined by a 'counting point' (CP) and the end is bounded by the CP of the next following interval. Between two following intervals no lack or overlapping does exist so that the PMF-structure maps the entire supply chain concisely and consistently. Each interval can be divided into subintervals and so on, whereby these subintervals don't have any lacks or overlapping too.

This is followed by the interval of assembly mounting (Int-AM) followed by the section of unit assembling (Int-UA), whereby the word 'unit' is another expression for a main resp. an essential assembly for the final product. The last section represents the assembling of final products (Int-FA). Each of these main intervals is divided into two subsections one for production activities and the other for transportation activities. They could be divided in further subsection for more exact calculation but for our purpose this has no substantial relevance.

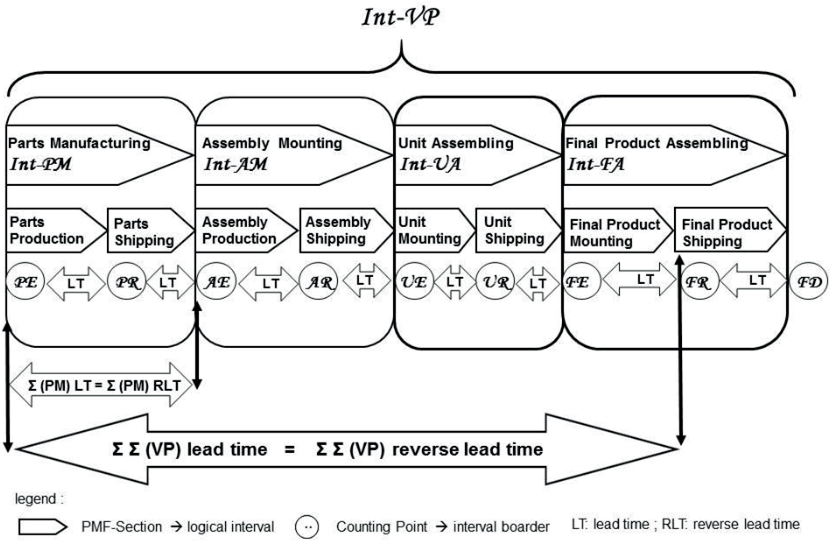

Fig. 2: Production & Material Flow Structure and (Reverse) Lead Time

The requirement demand calculation starts 'at the right' vice versa to the material flow with the cumulative target curve of final products assembling that is referred to the CP "Final Product Ready" (FR), which represents the upper boarder of the PMF-Structure. Thereafter the calculation goes backwards from one CP to the next preceding CP and ends at the counting point "Part Entry" (PE), which represents the lower boarder of the PMF-structure. The requirement demand is calculated step by step backwards to the physical material flow and supports a pull-system-oriented procedure. Hereby the cumulative curve of final products is the dominant curve and the superior boarder for the preceding cumulative curves for the depending demand of all components.

The calculation of preceding cumulative curves is a simple shift by lead time (LT) and is especially adequate continuously production and material flow (cf. Wiendahl, 1997, p. 33 ff.). The LT is defined individually for each PMF-section. The LT from one CP to the next one is used as the Reverse Lead Time (RLT) for backwards calculation. The single LT's of preceding intervals can be added up so that the total LT for a component is the sum of the LT's for all concerned intervals. To calculate e. g. the entire RLT for a single part from 'Parts Entry' (PE) up to the end of final product assembly (FR) the single LT's of all PMF-sections the part passes through have to be added. The more detailed the PMF-structure is described fined and the smaller the PMF-sections are defined the better are the LT determined and the more accurate will be the result of the requirement calculation.

The chart below (s. fig. 3) shows a typical progress and shape of several preceding cumulative target curves based on a MPP with constant production of 50 items per day. Until 'today' 300 final products are cumulative produced and at the end of the cumulative curve for 850 final products have passed the counting point (FR). The cumulative curve at the counting point 'Parts Entry' (PE) represents the "earliest" target demand in time and the curve for the counting point 'Final Products Ready" (FR) represents the "latest" target demand. Between these 'corridor' you can see the cumulative curves for the other counting points like 'Parts Ready' (PR), 'Assembly Ready' (AR), 'Unit Ready' (UR) and the 'Final Product Entry' (FE). In our example we suppose a continuous material flow without lot sizes so the cumulative curve for final products is shifted along the timeline. Only the last cumulative curve for 'Parts Entry' has some little kinks because of lot size for delivering. In this case the delivery order is calculated with a lot size of 40 items and the curve is exceeded at the time-unit, where the required target demand is lower than the actual demand. The impact of a lot size works only temporarily at some certain time-units and doesn't cause an increasing whipping up in the demand of the supply chain. It has to be noticed that in case of a huge lot size that exceeds the cumulative curve in the long run the order calculation has to be adjusted. An extremely lot size or an extremely low demand needs a 'special treatment' for limitation. That means it has to be ensure that the actual order curve doesn't exceed the target curve in the long run, especially at the run-out of demand.

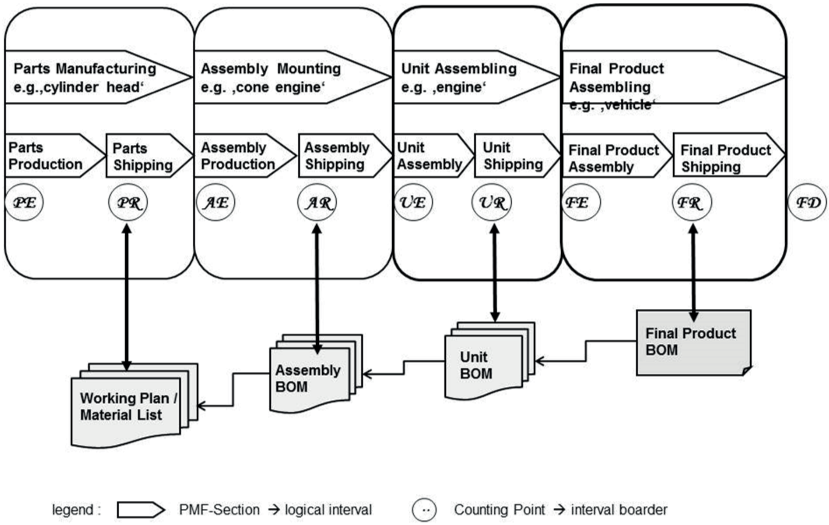

Fig. 3: Cumulative curves for a constant Master Production Program

Because the LT is an attribute for a PMF-interval and not for a PMF-object the LT must be transferred to each PMF-object that passes the concerned PMF-interval. Every change of the LT for a specific interval (or subinterval) can instantly be transmitted to all of the concerned PMF-objects. So no more additional data input for each single PMF-object in the master data is necessary. This powerful method is especially important for a complex product with many variants and a lot of components.

2.4 Changes in the Master Production Program

There are two types of changes in the MPP that have different impacts on cumulative curves of the final product and the preceding cumulative curves. The first type changes only the distribution of final products in the MPP inside a certain time-window whereby the cumulative amount at the end of the time-window remains the same. Such a change can often be observed in companies with BTO-Production where the sequence of the final products is optimized or adjusted because of different events. The limitation of a time-window is not a precondition and no restriction for the method but only done for better demonstration. In the next example the constant distribution in the MPP is changed into a more or less sporadic distribution of the final products (s. fig. 4). That means that on some days none or only a few final products were produced and on some other days a bigger amount of final product were manufactured. In the consequence you can observe same days where the cumulative quantities of two or three cumulative curves are equal. The reason is that the lead time of a PMF-section is shorter than the days without production therefor none of the concerned items are in this PMF-section. In the middle of the timeline you can see a big increase (860 □ 1260) at results from the strong rise of final production of 200 items in two days (450 □ 650). Some other little changes come from the lead time of the preceding PMF-sections.

This fictive example can be handled separately but here it is done for a better understanding of the method. In practice the described change from a constant to a sporadic distribution of final products in the MPP can happen vice versa. This can be seen properly by final products with a lot of options and very different customer orders, where a balancing of the assembly line is necessary.

The second type changes not only the mix of product variants or the distribution of final products but the total amount of final products at the end of the defined time-window. So the MPP is not only temporarily but substantially revised. Those changes can be observed if there are not enough real customer orders in the MPP and the MPP is filled-up with fictive customer orders.

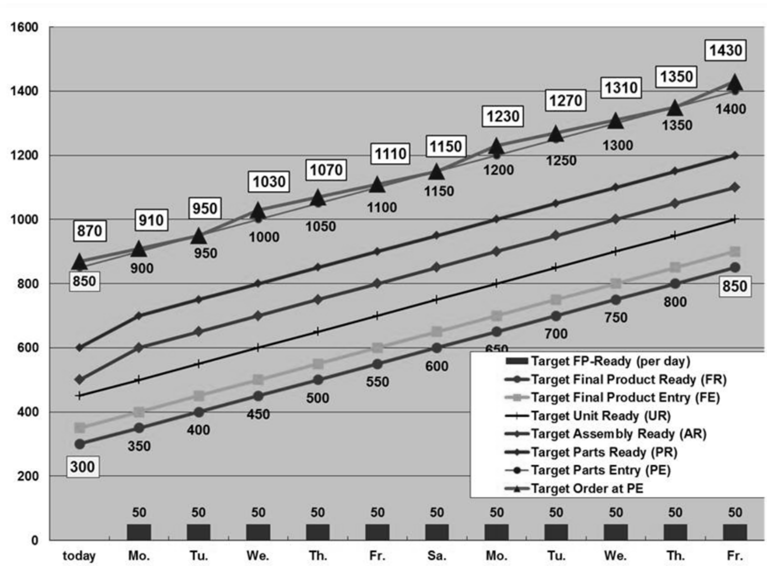

Fig. 4: Cumulative Curves for a 'sporadic' distribution of final product

As soon as there are real customer orders the fictive orders will be substituted. Some BTO-Manufactures have a special systematic to handle this type of change (s. Herlyn, 2012, p. 202 f.). Because the concept of CQ still works in the same manner and therefore no extra examples are developed here. Of course the change from a constant to a sporadic product distribution in the MPP can happen vice versa. This can often observe as assembly-line balancing properly by products with a lot of options and very different customer orders. So the results for the cumulative curves and the order calculation are vice versa too.

2.5 The influence of product structure and BOM-Data for dependent demand calculation

For the calculation of cumulative demand it is mandatory to have a Bill of Material (BOM) in which the product structure and the relations between the components are documented. This BOM-data are necessary to disaggregate the final product into its components. This is a precondition to transmit the superior demand of

final products to the upper demand of its components. The product structure must match with the PMF-Structure and can be referenced at the counting points in the PMF-structure. In our case there are Counting Points that represents the end of manufacturing activities so that four BOM's are required (s. fig. 5).
If a component is used more than once at a certain usage point the quantity is multiplied by the 'usage factor' in the BOM.

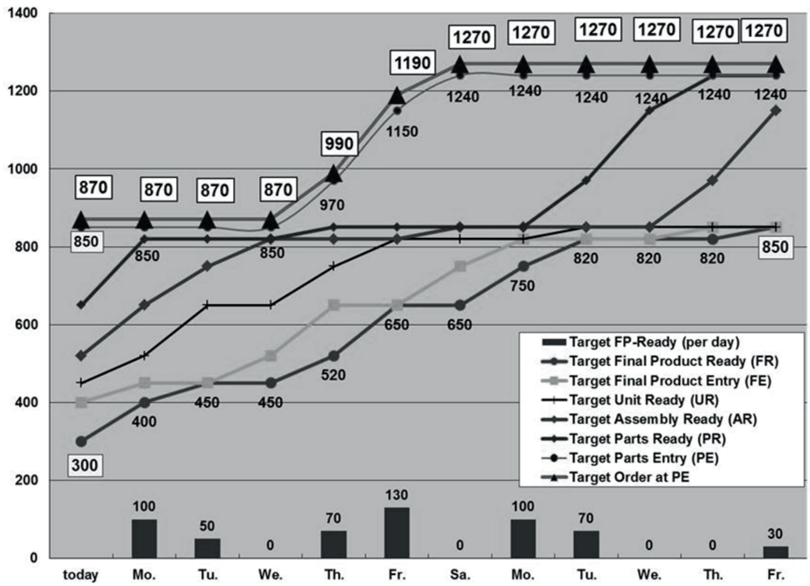

Fig. 5: Product Structure with linkage to the PMF-Structure

The cumulative curve is expanded proportionally but the characteristic shape of the curve remains. If a component has more than one usage point in same observed PMF-section than several curves build a common cumulative curve at the concerned counting point. Such components are often 'standard parts' like screws, bolts, washer, plugs etc. These are normally components that don't belong to a specific product variant, so the common cumulative curve is a mixture of quite different curves. In this case it is a huge effort to trace back all and every single curve. But both cases are although no reason for a bullwhip effect. In addition there are some factors that can't be determined exactly for example: mounting with selective need, mounting of alternatives parts or producing parts with stochastic results. In this case the concerned cumulative curves have to be calculated as bundle to adjust the curves. This should here not further be investigated.

2.6 Splitting and merging of material flow

Beside the described demand calculation the splitting in material flow and demand (e.g. several suppliers or manufacturers) and the merging of material flow and demand (e.g. different product variants) cause changes in the shape and height of the preceding cumulative curves.

If there is a splitting in the PMF the cumulative curve has to be split into the different sections and in the consequence the demand is divided. For this a rule is needed which describes the specific regulation for 'splitting'. This rule can be a quotation of orders or another alternation of delivery and production. As a consequence of this the order quantities have more or less peaks and lows at certain point in the timeline. This depends on the gradient of the cumulative curve and the height of the lot size. In any case this is not a reason for a bullwhip effect but only an inherent procedure in the concept of CQ.

In the next charts the actual delivery orders for two suppliers A and B with a delivery quotation (splitting) of '70:30' percent are shown. For both the lot size for delivery order is 40 items. The chart 6 shows the order-line for the constant MPP (s. fig. 6) therefore the order-line is also very constant. Because the lot size is a little bit below the daily demand, there are only two orders of 80 items.

The orders for sporadic MPP follow the sporadic MPP. The peak you can see in the middle covers the peak of the final production therefore it is not a bullwhip effect but a normal reaction (s. fig. 7).

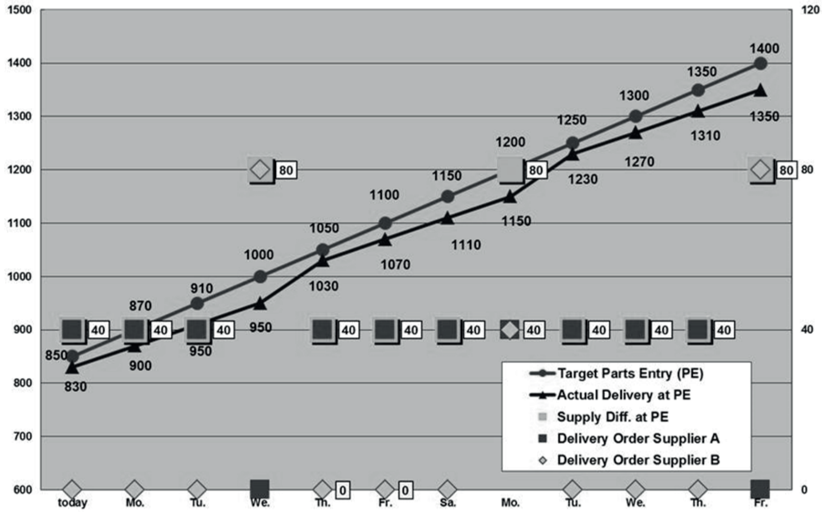

Fig. 6: Delivery order splitting for the constant MPP (cf. fig. 3)

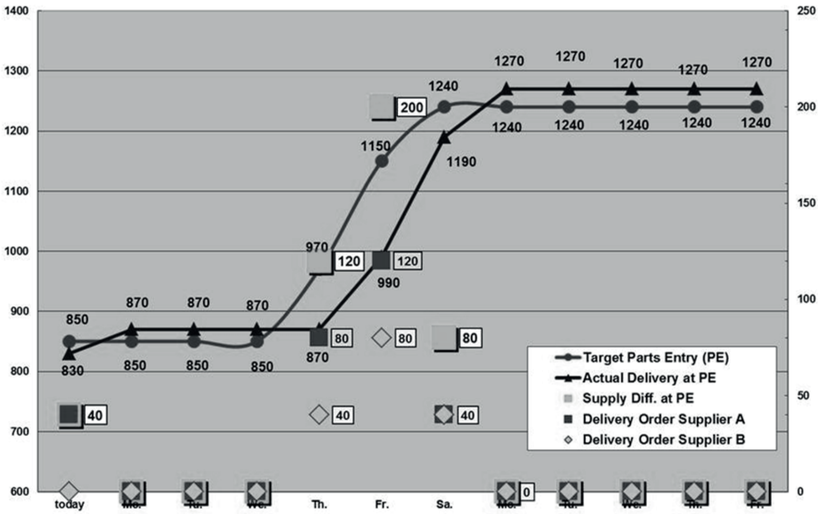

Fig. 7: Delivery order splitting for the sporadic MPP (cf. fig. 4)

If there is a merging in the PMF-Structure, the different cumulative curves (of demand) has to sum up and a new cumulative curve is the result. Therefor it's not easy (e. g. for the partners inside the SC) to recognize the original curves of the superior demand. The original demand can only be traced by all individual cumulative curves. The more complex a product is and the more expanded the supply chain is, the more difficult it is to trace back the dependent demand to the final product though this is not a reason for a bullwhip effect.

3. Additional demand to final products demand

A more or less big factor that influences the shape and height of the cumulative curve are additional demand sources for components of the final products. The mainly additional demand comes from the spare parts, industrial partners or other allied companies of a group. Another additional demand comes from several consumers inside a company. They need components for their internal tasks like Prototyping in the Design Department or Trying-out in the Production Department to check out the manufacturing tools and industrial equipment. Another additional demand is caused by manufacturing of defect and deficient components. Also components were destroyed during or after manufacturing or transportation. Anyhow: All additional demands have to be added to the target demand from the final product. So the additional demand is included in the cumulative target curve and will heighten the cumulative target quantity. The concept of CQ is still working in the same manner and to that fact no bullwhip effect will occur.
It has to be remark: if there is a combination of different additional demand sources for a component it is very difficult to recognize the reason for a concrete actual order. This can only be analyzed by separating the cumulative curve for the several demand sources. There exists no inherent systematic between the demand for components deviated from the MPP and the additional demand. So the preceding cumulative curve are changed in a certain casually way and can cause an unpredictable order change but no bullwhip-effect.

4. Short resume and conclusion

The globalization of the world economy leads to globally production and procurement networks of multinational companies. Thereby the number of cooperating firms and interfaces are growing steadily and the phenomenon of a bullwhip effect can be observed in the expanded supply chain. A growing numbers of OEM's build their product no longer to stock but to customer order. In this situation a powerful concept for requirement demand calculation is needed for the expanded supply chain.

The concept of CQ is a very simple and robust method for requirement calculation of dependent demand in an expanded supply chain. This concept integrates the control loop principle that is able to avoid a bullwhip effect. It starts with the calculation of the cumulative target curve for final products from the MPP. Thereafter the dependent demand of components is calculated step by step backwards along a common PMF-structure. The results are cumulative curves for all relevant Counting Points in the supply chain. This concept is especially appropriate for continuous flow production and transportation with an ongoing demand of high amounts. Some impacts from outside and inside the company, mainly the additional demand for components, can be integrated into this concept.

To transfer this concept into practice all cooperating partners in the expended supply chain have to use this same concept. As a fundamental base they have to define and use a consistent PMF-structure with common counting points. All partners have to give their target and actual values to their partners. This includes to collect actual data just in time and to use a common communication platform. It doesn't matter if the interfaces between the cooperating partners are inside a group or outside because the PMF-sections and the counting points are only material flow items and not juridical items. Therefore the above postulation can be fulfilled by the concept of cumulative quantities. If the partners work together on this concept the bullwhip effect can be avoided in expanded internal or external supply chains.

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A Theory-Based Perspective on Maturity Models in Purchasing and Supply Management

Jörg Schweiger

Abstract

The goal of this contribution is to critically analyze and discuss the published maturity models in scientific literature and management-oriented models offered from specialized consulting companies over the last three decades. In detail, 18 maturity models published from authors with an academic or scientific background and 14 maturity models offered from consulting firms were examined. In this research the following main issues that contribute to maturity in PSM were detected: purchasing controlling and performance management, a differentiated supplier (relationship) management, ICT (information and communication technology) support for routine tasks and for decision support, cross functional trained and skilled employees, clear interfaces and communication structures within a company and with the most important suppliers as well as a long-term strategic and goal orientation in purchasing and supply management (PSM).

Based on these preliminary findings and a clear plan for further examination, a framework of an ongoing research project will be presented, with the goal to establish an original purchasing maturity framework that can be adapted according to a firm's characteristics and contextual aspects.

Keywords: purchasing maturity, purchasing excellence, purchasing development, research paper

1. Introduction

With a 60 to 70 percent share of total revenue, the costs for purchased parts have the greatest leverage effect on operating results in the main industries like metal, automotive or electronics (Arnolds et al., 2013; Wallner, Schweiger, 2012; BME, 2011; Ortner et al., 2011). This is mainly due to the ongoing trend of cutting the internal value adding process and relocating parts of the value chain to different suppliers worldwide. Besides this economic impact, Purchasing and Supply Management (PSM) has to face several internationally driven trends (Spina et al., 2013; Tate et al., 2013; Aberdeen, 2014; Roland Berger, 2014) that have to be anticipated and managed in a professional way. Examples are the management of volatility and risks, the integration of the supplier base within the value chain, intelligent spend management and sustainability issues.
To cope with that a high level of professionalism in the purchasing function is crucial (Rozemeijer et al., 2003). More and more companies are becoming aware of the fact that a strategic and innovative orientation within the purchasing department can have a major impact on a company's success. Examples are the employment of strategic purchasing managers, the establishment of comprehensive IT- and controlling tools as well as programs for green procurement and sustainability or structured development of suppliers. These initiatives mark the will of a company and its purchasing department to become more professional (Schweiger, 2009). PSM professionals often see (too) many things to (concurrently) improve, but the link from the initiatives to the overall PSM and firm's performance is not always easy to define. Moreover, the handling of too many initiatives and actions alongside daily business inevitably leads to more diversity and complexity for the employees in the purchasing department, which may again provoke counter-productive effects. This is a serious aspect, especially for small and medium sized companies with limited organizational resources as well as an operational focus on getting the materials to a good price, in the defined quality and in time (Sollish/Semanik, 2012). Based on the facts

above, it appears crucial to gain the knowledge and abilities for setting proper priorities in order to achieve a more powerful and competitive PSM.

In this context, purchasing maturity models (PMM) can be applied. Over the last decades several scientific as well as practical oriented PMM have been developed, that describe "several stages an organization is expected to go through in its quest for greater sophistication” (Schiele 2007, p.274). These models offer many suggestions what a company - and in this specific context the PSM department - should do to reach the next maturity level. The hypothesis is that mature purchasing organizations apply best practices, while unsophisticated organizations fail to employ them (Chiesa et al., 1996; Ellram et al., 2002). The assumption is that greater maturity is associated with better (business) performance.

2. Research goals and methodology

The goal of this contribution is to present an overview of the published maturity models in scientific literature and management-oriented models offered from specialized consulting companies in this field over the last three decades. The focus lies on the areas of maturity assessment covered in these models. Besides, it should be determined if there are content-related or methodical deviations between the academic compared with the management-oriented PMM (table 1).

- Research Question 1: What are the critical success factors that decide about the maturity level of an industrial purchasing department based on PMM?
- Research Question 2: Is there a deviation in the focus of the academic compared with the management-oriented PMM?

In order to give a critical, objective and transparent overview of the existing scientific PMM, a literature review was conducted (Rousseau et al., 2008). Therefore, the list with the most important peer-reviewed journals in PSM, analytically derived from Wynstra (2010), was taken as a basis and was extended with other scientific journals and databases in the PSM area (table 2).

Research Question 1	What are the critical success factors that decide about the maturity level of an industrial purchasing department based on PMM?
Research Question 2	Is there a deviation in the focus of the academic compared with the management-oriented PMM?

Tab. 1: Research questions

In order to identify the relevant contributions for the defined research goal, an iterative approach has proven to make particular sense (Sartor et al., 2013). As a first step a (1) title search for the mentioned journals for the period 1984-2014 was carried out, followed by a (2) keyword search (all except full text). The initial keywords were "Purchasing Maturity", "Supply Management Maturity", "Procurement Maturity", "Supply Chain Management Maturity" and "Supply Maturity" and "Maturity models". Subsequently and based on the first results, the following keywords were added to the keyword search: "Purchasing Excellence", "Supply Management Excellence", "Procurement Excellence", "Supply Chain Management Excellence", "Supply Excellence", "Purchasing Audit", "Supply Management Audit", "Procurement Audit", "Supply Chain Management Audit", "Purchasing Power", "Supply Management Power", "Supply Chain Management Power", "Procurement Power", "Worlds Class Purchasing", "World Class Supply Management", "World Class Supply Chain Management" and "World Class Procurement". Simultaneously, a (3) crosscheck was undertaken by searching the electronic databases Emerald, ABI/Inform Global - T&I ProQuest, EBSCO Business Source Premier and Wiley separately. For a final countercheck and as a necessary means of gaining information about management oriented maturity models, a (4) keyword search on www.google.de was conducted.

Relevant PSM-journals (1999-2008) based on Wynstra (2010)	Journal of Purchasing and Supply Management Journal of Supply Chain Management Supply Chain Management: An International Journal

	International Journal of Operations and Production Management
	International Journal of Production Economics
	International Journal of Production Research
	Journal of Business and Industrial Marketing
	Journal of Business Research
	Journal of Operations Management
	Industrial Marketing Management
Extended list	International Journal of Physical Distribution and Logistics Management
	Journal of Business Logistics
	Supply Chain Management Review
	Harvard Business Review
	MIT-Sloan Management Review
	Industrial Management
	Benchmarking

Tab. 2: Selected journals for literature review

At the same time (5) webpages of specified consulting companies in the area of PSM (Forbes- and Vault-Ranking of TOP-Consulting Companies; Brand Eins, Special Edition “Consulting Companies") and well known PSM institutions were searched for useful information and if possible a direct contact by mail and telephone was established (table 3).

Contacted Consulting companies	Accenture, adcpi Consulting, ADR international, Arthur D. Little, A.T. Kearney, Bain & Company, Boston Consulting Group, Bearing Point, booz&co, Cell Consulting, Effico-Consulting, futurepurchasing, H & Z, Horváth und Partner, Innovative Management Partner, Insight Sourcing Group, Kerkhoff Consulting, McKinsey, MHP, OC&C Strategy Consultants, Oliver Wyman, OptiAchats, PA Consulting Group, pm2Consult, PMMS Consulting Group, Porsche Consulting, Purspective, PricewaterhouseCoopers, Roland Berger, sourceone Management Services, Spring Procurement, Strategic Procurement Solutions, synGroup
Contacted PSM institutions	Aberdeen, Bundesverband für Materialwirtschaft, Einkauf und Logistik e.V (BME), CAPS Research/University of Arizona, Chartered Institute of Purchasing & Supply Management, Gartner, Institute of Supply Management, National Procurement Institute, Supply Chain Management Association, The Institute for Public Procurement, The International Federation of Purchasing and Supply Management

Tab. 3: Consulted PSM consultants and institutions

3. Purchasing maturity models at a glance

At this stage of research (07/2014), it was possible to deduce a list of 18 scientific maturity models and 14 management-oriented models that include both operational and strategic aspects of holistic PSM. Purchasing maturity models with a focus on single PSM aspects were excluded. Examples are maturity models in the area of global sourcing maturity from Trent/Monczka (2003), supplier integration/supply chain integration from Childerhouse et al. (2012), Facett (2008), Johnson (1997) and Cox (1996) or a maturity model concerning MRO purchasing from Barry/Cavinato (1996) or supply chain operations from Netland (2011). In order to develop an original PMM, the findings of these models as well as maturity aspects from holistic management frameworks in PSM (e.g. Four pillars of purchasing and supply chain excellence by Monczka et al., 2009; Cycle of holistic purchasing management by Schweiger et al., 2009; Supply Management Navigator by Jahns, 2005; see table 7) and results from current studies about challenges and trends in Purchasing (e.g. Aberdeen, 2014; Roland Berger, 2014; Spina et al., 2013; A.T. Kearney, 2011) will be considered (see also chapter 5).

As table four shows, the different PMM distinguish between three to ten different maturity levels (see also Schumacher et al., 2008 and Schiele, 2007). The average of maturity levels is between four to five. Whereas some authors deduced the maturity aspects mainly from theory (e.g. Van Weele, 2010/1998, Monczka et al., 2010; Dobler et al., 1996; Sysons, 1989/1994) others also included the opinion of (practical) experts (e.g. Paulraj et al., 2006; Burt, Doyle, 1994; Freeman, Cavinato, 1990; Bhote, 1989; Reck, Long, 1988) in form of interviews or applying the Delphi method (Reyes, Giachetti, 2010). Only six models have been empirically tested so far (Reyes, Giachetti, 2010; Schiele, 2007; Cousins et al., 2006; Paulraj et al., 2006; Lockamy, McCormack, 2004 and Monczka, Trent, 1991/1992).

Twelve out of 33 contacted consulting companies replied on the request if they ever had a PMM in their portfolio and forwarded direct feedback or detailed further information. Some of them - like McKinsey or Arthur D. Little - changed the name of their PMM over the time and carried out some adaptions. There is also a close interrelation between the models from Arthur D. Little, IMP Consulting and Cell Consulting (together with University St. Gallen) as those are based on the "Purchasing Performance Index" from 2002 (Vollrath, Nase, 2003). As scientific models, also the management-oriented PMM distinguish between different levels of maturity. The number of stages here ranges between three (Purchasing EmPowerment) and five (e.g. Stages of purchasing maturity). When the name of the author/s is/are added in brackets (Table 5), publications (journals or books) are available for this PMM. In the other cases, the information was gathered from the respective website or from directly contacting and interviewing the company.

Name of PMM	Author(s)	Year	Levels
Strategic stages in purchasing	Reck/Long	1988	4
The four stages of supply management	Bhote	1989	4
Fitting purchasing to the strategic firm	Freeman/ Cavinato	1990	4
Towards purchasing excellence/MSU	Monczka/ Trent	1991/ 1992	10
American Keiretsu	Burt/Doyle	1992	4
Purchase position benchmarking	Sysons	1989/ 1994	3
From reactive to strategic procurement	Dobler et al.	1996	4
Purchasing development model	Van Weele et al.	1998	6
Purchasing development stages	Jones	1999	5
World Class Supply Management	Burt/Starling	2002	4
Supply chain management process maturity model	Lockamy/ McCormack	2004	5

Tab. 4: List of scientific PMM

The main difference is that the authors of the management-oriented models emphasize on the integration of their consulting experience into their PMM. Scientific and academic findings are of course indirectly integrated into these models, but the consideration of specialized expertise and thorough knowledge of various industries makes them unique. For assessing the PSM maturity the management-oriented PMM usually follow a two-step approach. First, the respective company is asked to fill out a questionnaire for a self-assessment and subsequently gets a first feedback about the performance in each of the evaluation areas (e.g. Innovative Management Partner, OptiAchats). Based on that, detailed fee-based workshops, analyses and interviews are usually offered in order to derive rooms for improvement. The PMM of Cell Consulting, A.D. Little and A.T. Kearney are based on a benchmarking to evaluate the progress of the purchasing function in the different industries and sectors. By filling out a questionnaire, a company can take part in the survey. As a result, the company receives a maturity profile relatively to the relevant industry or other options of comparison.

Company	PMM
McKinsey & Company	Stages of purchasing maturity (Cammish/Keough, 1991, Keough, 1993) Stages of purchasing suphistication (Kraljic, 1983)
Roland Berger	Purchasing EmPowerment (Voegele/Schientek, 2002)
H&Z	Management-oriented purchasing analysis (Schumacher et al., 2008)
Horváth & Partners	360° Procurement Performance Analysis
A.T. Kearney	Assessment of Excellence in Procurement
Arthur D. Little	Purchasing Value Excellence Purchasing Performance Excellence
Cell Consulting/ University St. Gallen	Purchasing Performance Index
OptiAchats	Purchasing Maturity Model

Company	PMM
Innovative Management Partner	Procurement Performance Excellence
Strategic Procurement Solutions	360° Supply Management Efficiency Review
Mercer	Levels of Procurement development (Anderson/Katz, 1998)
ADC Performance Improvements	Best Value Procurement

Tab: 5: Management-oriented PMM

4. Content-related and descriptive findings

4.1 Common consensus of PSM maturity

For the development of the original PSM maturity framework it was interesting to find out if there is a common consensus about maturity in PSM. For that reason each of the assessment areas from the single maturity models were listed and compared with each other in a matrix. By doing that, it was possible to detect the following eight main areas of professionalism out of 50 sub-areas by clustering the elements that substantially belong together:

- Controlling & Performance Management (CO)
- Organization & Internal interfaces (ORG)
- Supplier (Relationship) Management & External interfaces (SRM)
- Strategy & Plans (S&P)
- Process Excellence & ICT (P&IT)
- Talents & Skills (T&S)
- Innovation & Methods (I&M)
- Sustainability Issues (SUS)

Schiele (2007) who also did a comparison between the PMM published between 1988 and 2006 chose the clusters "Planning", "Structural organization", "Process organization", "Human Resources", "Controlling" and "Collaborative supply relation". By doing so, especially the strategic, the innovative as well as the talent management and sustainable aspects are not sufficiently emphasized (even though they are partly integrated and addressed as sub-areas in his PMM).

Also by analyzing the most frequently mentioned areas of maturity within the considered scientific PMM, ten areas were detected. Those ten points can be applied as a sort of PSM maturity quick check (table 6) to determine if the PSM department in a company is already on a high maturity level or if a detailed maturity analysis and improvement project would make sense.

The management-oriented models differ from the scientific based PMM only in one of those ten aspects mentioned above: A clear commodity structure with clear defined lead-buyers and differentiated strategies is defined as one of the top 10 maturity issues. All the other issues are of equal importance.

Only aspects/criteria of the category "innovation & methods" (e.g. carry out benchmarking studies to continuously improve PSM, bringing innovation to the company through intensive market scans, positioning PSM personnel as entrepreneurs) and "sustainability issues" (e.g. code of conduct/CSR agreement with suppliers, regular green procurement initiatives with suppliers) did not make it on the top ten list. This appears interesting considering the vast number of studies and publications that point out the necessity of this issue (Kornegay,Olson, 2013; Ageron et al., 2012; Reuter et al., 2010). It is plausible to deduce that sustainability issues are important and that there is a need for such an intense discussion, but in a sense of maturity the other aspects are currently of priority interest.

No.	Aspects of high PSM maturity
1.	Established Controlling and Performance Management: Key performance indicators are defined and regularly reported. Based on that, initiatives for improvement are implemented. PSM is able to link its influence on the firm's overall performance. (CO)
2	Structured supplier (relationship) management is established: First, a closed loop from supplier scouting and analysis using a replicable supplier evaluation in a cross-functional team is implemented. Furthermore, supplier qualification programs and consistent supplier assessment methods with fixed feedback of results as a basis for supplier development are applied. Clear rules for the phasing-out of suppliers are documented. Supplier motivation programs or supplier awards are also part of the companies' SRM. (SRM)
3	Early PSM/supplier involvement: PSM is an integral part in new product development projects. Moreover, PSM takes over the role as the integrator of knowledge from the supplier market into product or process innovation projects. (SRM)
4	ICT/eProcurement support: For routine tasks and for decision support ICT is available and the PSM personnel is trained to use the systems in an effective and efficient way. The PSM personnel has the right level of information concerning PSM specific ICT. (P&IT)
5	Defined interfaces: The process interfaces as well as the communication structures are clearly defined to the relevant departments (e.g. production planning, logistics, sales, R&D). Temporary cross-functional teams for e.g. new product ramp up are installed with a fixed member of PSM. The core PSM processes are documented and fulfill the compliance guidelines. (ORG)

No.	Aspects of high PSM maturity
6	Lean processes: Core processes concerning the information and material flow with all the key-suppliers are established. Logistic systems (e.g. VMI, consignment stocks) are discussed and implemented if necessary. (SRM)
7	Professional Training: There is a structured skill and talent management for PSM employees, e.g. employees are sent for internal and external education/training and job rotation is offered. (T&S)
8	Long-term strategic orientation: Based on a corporate strategy, PSM develops short-, mid- and long-term plans. The PSM team knows about the plans and can participate in the creation of the plans. All the plans are available in written form. (S&P)
9	Customer orientation: The needs of the internal and external customers are known and PSM regularly asks for feedback. (ORG)
10	TOP Management commitment/visibility: There is a high visibility of the Purchasing Manager and the PSM team in the Board of Directors. The PSM department is at a senior hierarchical level. At least PSM topics are regularly on the agenda of the Top Management meetings. (ORG)

Tab. 6: PSM maturity quick check

4.2 Points of further discussion

As mentioned before, the analyzed PMM offer three to ten stages that should be auditable. The respective maturity level is usually determined by the evaluation of answers, check-list points or assessed statements (usually on a Likert scale) in a self- or external evaluation.

Most of the models - especially the scientific models - describe one final stage a company is expected in order to reach for being "world class". This issue needs further research, which also considers various contextual aspects. Also, it is highly unlikely and nearly impossible to apply a single PMM to all types of companies and branches; however this is what most of these models do. As an example, there must be rather one most appropriate maturity level depending on the business and corporate context (e.g. Rozemejer et al., 2003; Keough, 1993) and not one best maturity point. Especially when thinking of the imbalance of power between a big supplier and a small buying firm some maturity aspects like "supplier integration with VMI" or "long term contracts to fix optimum price level" would be theoretically right but in most of the practical cases unrealistic. This suggests that there is one theoretical highest point of maturity to reach, and one realistic maturity point to reach with proportional effort. It makes sense to benchmark with the best comparable companies (e.g. branch, size, geography). That means that when assessing the maturity of a PSM department not the absolute value within the different areas of maturity should be of primary interest. The maturity value compared to companies of a similar/comparable size or/and from the same branch should be the first benchmarks to look at.

Another relevant aspect in the discussion is that a minimum maturity level is required for applying sophisticated methods and strategies (Schiele, 2007). This implies that for applying advanced methods, instruments or processes that should lead the PSM department to a higher maturity level, a basic training of the PSM personnel is needed. In this context, Lockamy/McCormack (2004) speak about a culture of process excellence that is a necessary foundation to achieve the subsequent levels. If a company does not ensure this culture and the necessary abilities, the performance level of the department can go down instead. Reasons for that are demotivation or overcharging the PSM personnel because of asking them to do things they are not able/trained and willing to do. This effect can be defined as "counterproductive effect of maturity initiatives", leading to one missing question in the PMM discussion that should be also part of further research: How to manage the change process of reaching and staying on the higher maturity level?

5. Further research steps to design a new PMM

For designing an original purchasing maturity model that should be theoretically grounded but also applicable, it seems to make sense to include both theoretical (primarily based on dominant scientific theory) and practical (primarily based on project experience) aspects, and to go through the following process to collect the main aspects of a mature PSM:

- Analysis of the existing PMM
- Analysis of management models/frameworks in PSM
- Analysis of studies about trends and challenges in PSM
- Expert Circles to get practical input

As presented in this contribution, the existing maturity models of the last three decades were analyzed and based on the preliminary research eight main areas of maturity could have been deduced. In a next step the following management models/frameworks in PSM (2000-2014, table 7) will be analyzed to match the criteria:

Subsequently, the criteria of professional PSM according to the PMM and the analyzed frameworks will be compared to the results of studies (2000-2014) about trends and challenges in PSM. A final expert circle with PSM professionals from Austrian companies as well as experts from specialized consulting companies in the PSM area is planned until the end of 2014.

Based on these findings, a new PSM maturity framework (figure 1) will be developed. To verify and to ensure the applicability, the model will be discussed with the expert circle mentioned above and then tested in three case studies in 2015.

The framework consists of a self-assessment module, to locate the maturity level of a company. The detected maturity level can then be displayed compared to

the theoretical/scientific opinion about excellence, or to the relevant industry benchmark. For this reason a benchmark database has to be set-up.
Optionally, an in-depth analysis and assessment executed by a third party in form of an Purchasing Audit (van Weele, 2010; Scheuing, 1989) can be carried out. After the assessment of the maturity level, standardized improvement paths will be displayed.
Finally, the PSM maturity framework will be tested in three case studies. Therefore it will be introduced in three companies in the beginning of 2015. Based on the initial assessment, rooms for improvement will be deduced together with the company and responsibilities for the implementation and the controlling of the realization will be defined. In autumn, the assessment will be repeated in order to examine if there is an improvement due to the adoption of the theoretical advice. This approach of accompanying a company over a longer period of time using the PMM as a management framework and not only to examine the maturity level at a single point of time is a still unexplored area of research (Reyes/Giachetti, 2010). Doing that, it is possible to study the causal strength between adopting the improvement advice and actual long-term improvements.

Model/Framework	Author(s)	Year of publication
SCOR Model	SCC	2012
Management of requirements in collaborations	Ortner et al.	2011
Four Pillars of Purchasing and Supply Chain Excellence	Monczka et al.	2009
Cycle of holistic purchasing management	Schweiger et al.	2009
Potential Analysis in Purchasing	Wildemann	2008
Framework for Managing External Resources	EFQM	2006
House of Sourcing and Supply Management	Eßig	2005
Supply Management Navigator	Jahns	2005
Model/Framework	Author(s)	Year of publication
The 21st Century Logistics framework	Clossa/Mollenkopf	2004
Supply Chain Management Excellence Model	Wong	2003
The strategic supply wheel	Cousins	2002
Integrated St. Galler purchasing management approach	Jahns	2001

Tab. 7: Management models/frameworks for PSM

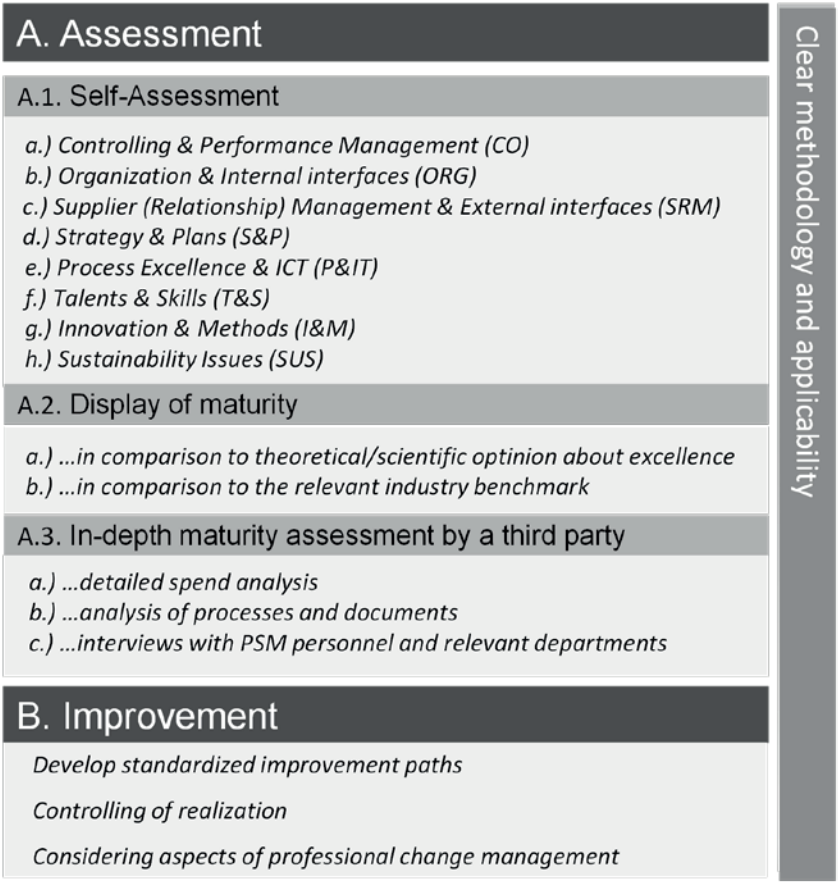

Fig. 1: PSM maturity framework

6. Conclusion

The goal of this contribution was a theory-based perspective on Maturity Models in Purchasing and Supply Management as well as to present the first research results of a project to develop an original PSM maturity framework. 32 purchasing maturity models, 18 with a scientific/academic background and 14 with a more management-oriented background, were analyzed and a common consensus of PMM maturity in terms of a quick check was derived. It was also possible to show that there are not any serious substantial differences between the scientific and the management-oriented PMM.

Based on these findings and continuing research, the developed model should be designed as a management framework starting from the initial assessment of the PSM maturity in a company until the realization of the improvement paths that should lead to higher maturity.

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Workshop Layout by the Method of Vote and Comparison to the Average Ranks Method

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Abstract

The problem of workshop layout was highly considered in literature and several methods, which are widely used nowadays, were proposed namely: the method of links, the average ranks method, the method of the anteriorities, the method of the nearness.

The machine layout problem seeks to find the optimal arrangement of machines within each cell.

We will contribute to the resolution of this problem by proposing a new method. To do so, we will adapt a vote method as this of Schulze for the setting-up of the workshop. Then, we will compare its results to those of the average ranks method.

These methods will be applied to data which are results of our previous works.

These data are the families of manufacturing sequences obtained thanks to the classification method of manufacturing sequences based on the language theory.

Keywords: workshop layout, schulze method, ranking, comparison

1. Introduction

Several methods arise from the society or are bio-inspired. The vote in political elections in favor of the favorite candidates is one of them. The vote takes place when a group has to unite preferences to make a global decision. Unfortunately, it is not always easy to make a single choice when we arrange preferences of many voters. The methods of vote designate every type of process that allows making this choice. An enormous number of vote methods exists; we distinguish generally three big families of electoral systems:

- The first one includes the systems of exhaustive ballot, govern by the logic of "the winner gains everything", in other words the candidate or the list of candidates arrived first is the only one represented.
- The second groups the systems of proportional ballot, which try hard to attribute representatives to all the political formations according to their respective results.
- Finally the family of the mixed ballots which includes all the electoral systems combining the effects of the systems stemming from the two other families.

The most used system is the one of the exhaustive ballot, but there are also situations in which we could ask the voters to give a complete ranking of a number of alternatives, as in a survey of marketing. The theory of the vote became an object of university study at the time of the French Revolution (O'Connor & Robertson, 2002). Jean-Charles de Borda (Borda, 1791) proposed an election method of the members of the Academy of Science. His system was disputed by the marquis de Condorcet, who proposes rather the method of comparison by pairs which he had conceived (Marquis de Condorcet, 1785). And which is the basis of methods of multicriteria decision (on ranking).

While Condorcet and Borda are generally considered as the founding fathers of the theory of the vote, recent researches showed that the philosopher Ramon Llull had discovered at the same time the method Borda and a method which satisfies the criteria of Condorcet in the XIIIth century. The manuscripts in which he described these methods had been forgotten by the history, until their rediscovery in 2001 (Hägele & Pukelsheim, 2001). In 1958, Duncan Black built a method which mixed the methods of Condorcet and Borda. Namely, the winner in the method Black will be the Condorcet winner, unless he doesn’t exist, then, the winner Borda will be chosen (Ratliff, 2002).

The works of the Marquis de Condorcet inspired F. Marcotorchino and P. Michaud to create the relational analysis in 1977. It is a theory based on the relational representation (comparison by pairs) of various variables and on the optimization under linear constraints of the criterion of Condorcet. The relational analysis allowed having theoretical advances and consequent practices.

The method of Condorcet presents a paradox. Condorcet shows how the majority vote can lead to a non-transitive, in particular cyclic collective preference.

The Schulze method allows solving most of the conflicts generated by the paradox of Condorcet. The Schulze method is a voting system developed in 1997 by Markus Schulze who chooses a simple winner in a vote with classification of the candidates. The method can be also used to create winners' ordered list. If a candidate wins all his duels during the confrontations by pairs with the other candidates (winner of Condorcet), the Schulze method guarantees that this candidate will win. Because of this property, the Schulze method is, by definition, a method of Condorcet. Contrary to the methods Borda and alternative vote of Ware for example, who can choose another winner than the winner of Condorcet.

The Schulze methfod (Schulze, s.d.) allows resolving most of the conflicts generated by the paradox of Condorcet but does not guarantee a unique winner. We will use this method to obtain an order of the machines in a cell (layout).

Many heuristics were proposed for the resolution of the Schulze method. The most important heuristics are the path heuristic and the Schwartz set heuristic. In spite of their very different aspect, they give quite the same result.

We are going to choose the Schwartz set heuristic because the path heuristic considers the candidates not listed as placed after the others and with the same preference degree. And this condition can falsify our results when we consider the not existing machines in a sequence as placed after the others.

2. The proposed method

We are going to apply the Schulze method to the data of cells stemming from the sequences classification (Akbib, et al., 2013) with the aim of finding the effective layout of every cell. The Schulze method will allow creating an order of machines susceptible of minimizing the intra-cells movements. We consider the products' manufacturing sequences as the voters' ballots which contain the ranking of the candidates according to their preferences.

2.1 The Schulze method with the Schwartz set heuristic

With the concept of Schwartz set, the Schulze method can be described in a very concise way(Schulze, s.d.).

2.1.1 The Schwartz set

The definition of a Schwartz set, as used in the Schulze method, is as follows:

- An unbeaten set is a set of candidates of whom none is beaten by anyone outside that set.
- An innermost unbeaten set is an unbeaten set that doesn't contain a smaller unbeaten set.
- The Schwartz set is the set of candidates who are in innermost unbeaten sets.

2.1.2 Procedure

The voters cast their ballots by ranking the candidates according to their preferences, just like for any other Condorcet election.

The Schulze method uses Condorcet pairwise matchups between the candidates and a winner is chosen in each of the matchups. We establish then a balanced directed graph: summits are the candidates. If the candidate X confronted with the candidate Y wins n confrontations and loses p and if n> p, we create an arc of X towards Y balanced by " n - p ". This method is comparable to the method Prométhée with n: positive flow, and p: negative flow.

From there, the Schulze method operates as follows to select a winner (or create a ranked list):

- Calculate the Schwartz set based only on undropped defeats.
- If there are no defeats among the members of that set then they (plural in the case of a tie) win and the count ends.
- Otherwise, drop the weakest defeat among the candidates of that set. Go to 1.

2.2 Application of the Schulze method to the workshop layout

We are going to use the Schulze method with the aim of creating an ordered list of the winners (in our case machines). In our previous work (Akbib, et al., 2013), we proposed a new approach based on the language theory for product family grouping according to their manufacturing sequences. This approach uses linear sequences of the manufacturing products which are assimilated to the words of a language. We have chosen the Levenhstein distance for sequence classification. And we have obtained four families of products (tables 1.a, 1.b, 1.c, 1.d).

Sequences	Sequences	Sequences	Sequences
S1: TEHKSF	S5: TDCHKEF	S13: ACPEHK	S24:AEGHKF
S2: TCHKF	S6: TCIHKMEF	S20: ABHKL	S25: ACHKF
S3: TDCHKF	S9: TDCHKLEF	S22: ACHKLF	S29: ABK
S4: TCGHK	S10: TDCHKLEF	S23: ACHKF	S31:ACHKEF

Tab. 1.a: Elements of the family F1

Sequences	Sequences

S11 :ABPEHIKM	S17 :ADPEGKJNRQ
S16 :ADPEGKJN	S19 :ABKMGIJN

Tab 1.b: Elements of the family F2

Sequences	Sequences
S12:ACPEHKLMOJRQSN	S15:ACPEHKMORQN
S14:ADPEHKLSMOQN	

Tab. 1.c: Elements of the family F3

Sequences	Sequences	Sequences
S7:TCHKMUQFN	S21:AEHKSMIQFN	S28:ADHKLEMIQFN
S8:TCHKMUQFN	S26:ABHKMIQFN	S30:ABHKLMIFN
S18:AEKLIHFN	S27:ADHKLEMIQFN	

Tab. 1.d: Elements of the family F4

Every family designates a production cell. We will apply the Schulze method on these families in order to find the cells layout. We will consider the products' manufacturing sequences as the voters' ballots and the quantities of products as the number of voters. The ordered quantities of products are illustrated by table 2:

Products	Average of the quantity /Week	Products	Average of the quantity /Week	Products	Average of the quantity /Week
P1	60	P11	65	P21	60
P2	55	P12	70	P22	55
P3	60	P13	60	P23	65
P4	55	P14	70	P24	60
P5	60	P15	65	P25	50
P6	65	P16	60	P26	55
P7	60	P17	60	P27	65
P8	60	P18	60	P28	55
P9	55	P19	65	P29	55
P10	50	P20	60	P30	50
				P31	60

Tab. 2: The ordered quantities of the families' products

2.2.1 Family F1

We make the confrontations by pairs (table 3):

	d[*,A]	d[*,B]	d[*,C]	d[*,D]	d[*,E]	d[*,F]	d[*,G]	d[*,H]	d[*,I]	d[*,K]	d[*,L]	d[*,M]	d[*,P]	d[*,S]	d[*,T]
d[A,*]		115	290	0	180	290	60	410	0	465	115	0	60	0	0
d[B,*]	0		0	0	0	0	0	60	0	115	60	0	0	0	0
d[C,*]	0	0		0	350	575	55	690	65	690	160	65	60	0	0
d[D,*]	0	0	225		165	225	0	225	0	225	105	0	0	0	0
d[E,*]	0	0	0	0		410	60	180	0	180	0	0	0	60	0
d[F,*]	0	0	0	0	0		0	0	0	0	0	0	0	0	0
d[G,*]	0	0	0	0	0	60		115	0	115	0	0	0	0	0
d[H,*]	0	0	0	0	290	695	0		0	870	220	65	0	60	0
d[I,*]	0	0	0	0	65	65	0	65		65	0	65	0	0	0
d[K,*]	0	0	0	0	290	695	0	0	0		220	65	0	60	0
d[L,*]	0	0	0	0	105	160	0	0	0	0		0	0	0	0
d[M,*]	0	0	0	0	65	65	0	0	0	0	0		0	0	0
d[P,*]	0	0	0	0	60	0	0	60	0	60	0	0		0	0
d[S,*]	0	0	0	0	0	60	0	0	0	0	0	0	0		0
d[T,*]	0	0	400	225	290	405	55	460	65	460	105	65	0	60	

Tab 3: Confrontations by pairs of the family F1

We constitute the directed graph of the duels (figure 1).

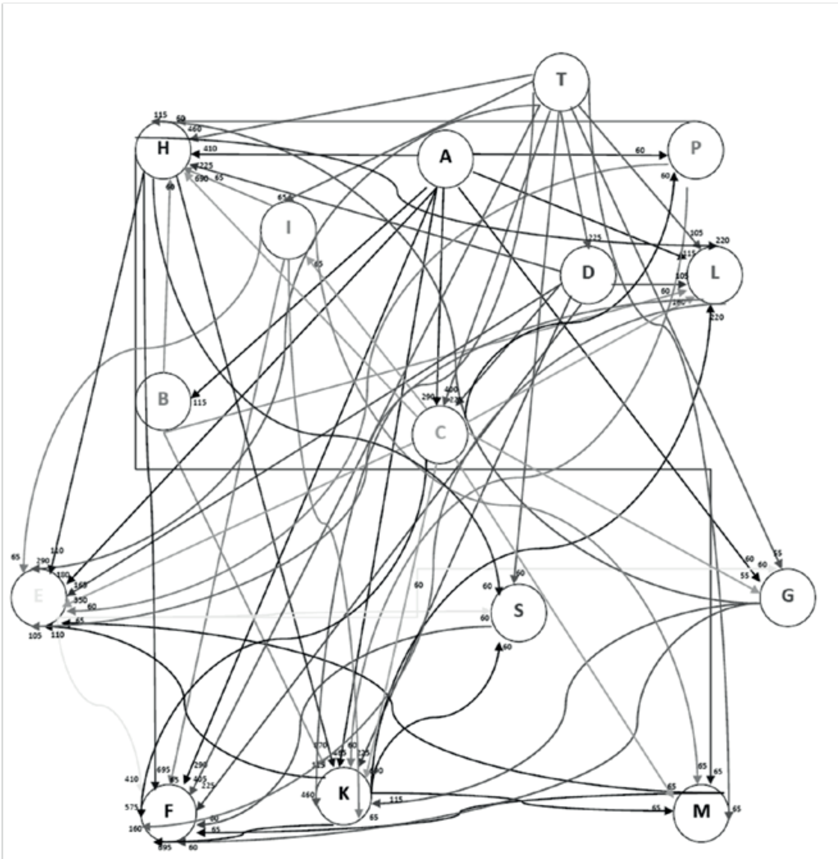
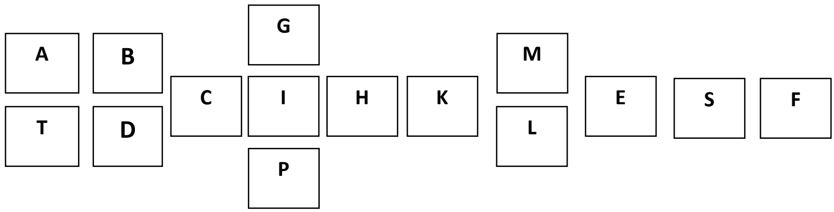


Fig. 1: The directed graph of the duels for the family F1

The Schwartz set is constituted by the set {A,T}. The candidates A and T are then the first winners. So both machines will be positioned in parallel.
After a candidate wins, we eliminate him to find the 2nd winner (the one who will win if the first winner does not exist anymore).
If we do not find a winner, we eliminate the arc of the smallest defeat.
We repeat the application of the heuristic until we obtain an order of the machines.

For the first family, and consequently, the first cell, the layout will be as follows (figure 2):

Fig. 2: Layout of the first cell (family F1)



2.2.2 Family F2

We make the confrontations by pairs (table 4):

	d[*,A]	d[*,B]	d[*,D]	d[*,E]	d[*,G]	d[*,H]	d[*,I]	d[*,J]	d[*,K]	d[*,M]	d[*,N]	d[*,P]	d[*,Q]	d[*,R]
d[A,*]		130	120	185	185	65	130	185	250	130	185	185	60	60
d[B,*]	0		0	65	65	65	130	65	130	130	65	65	0	0
d[D,*]	0	0		120	120	0	0	120	120	0	120	120	60	60
d[E,*]	0	0	0		120	65	65	120	185	65	120	0	60	60
d[G,*]	0	0	0	0		0	65	185	120	0	185	0	60	60
d[H,*]	0	0	0	0	0		65	0	65	65	0	0	0	0
d[I,*]	0	0	0	0	0	0		65	65	65	65	0	0	0
d[J,*]	0	0	0	0	0	0	0		0	0	185	0	60	60
d[K,*]	0	0	0	0	65	0	65	185		130	185	0	60	60
d[M,*]	0	0	0	0	65	0	65	65	0		65	0	0	0
d[N,*]	0	0	0	0	0	0	0	0	0	0		0	60	60
d[P,*]	0	0	0	185	120	65	65	120	185	65	120		60	60
d[Q,*]	0	0	0	0	0	0	0	0	0	0	0	0		0
d[R,*]	0	0	0	0	0	0	0	0	0	0	0	0	60	

Tab. 4: Confrontations by pairs of the family F2

We constitute the directed graph of the duels (figure 3).

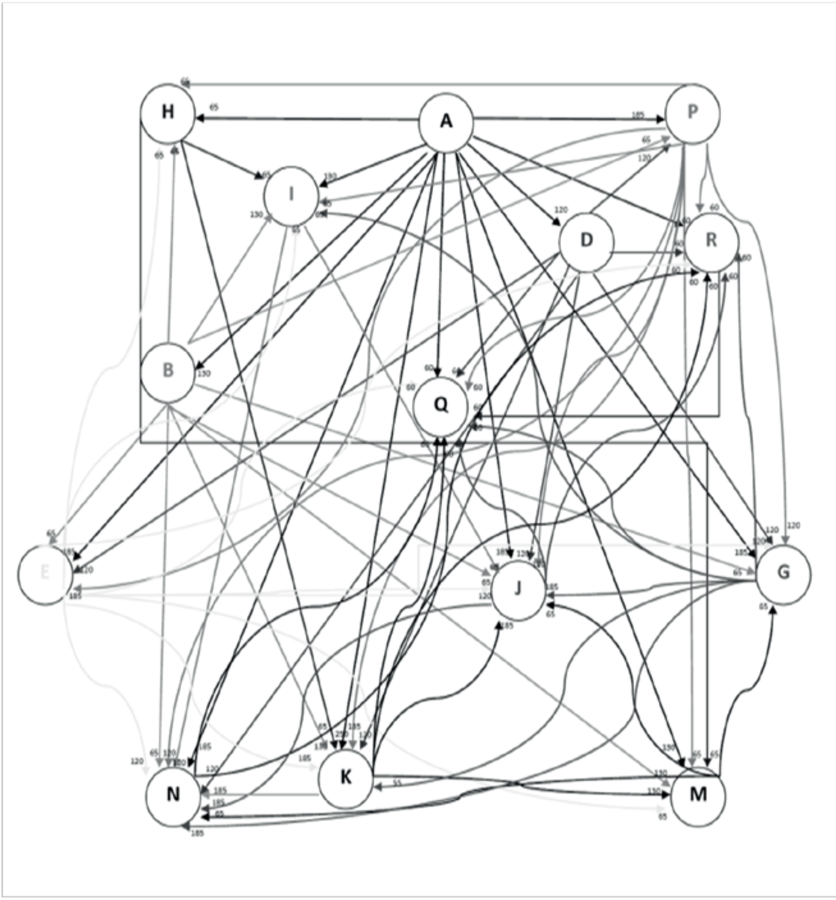


Fig. 3: The directed graph of the duels for the family F2

The Schwartz set is then constituted by the singleton {A}. The candidate A is then the first winner. We repeat the application of the heuristic until we obtain an order of the machines.

For the second family, and consequently, the second cell, the layout will be as follows (figure 4):

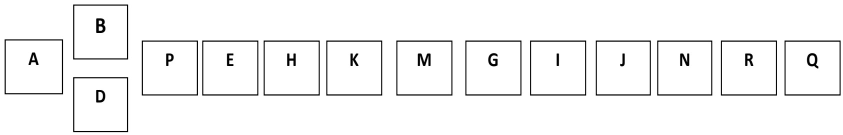


Fig. 4: Layout of the second cell (family F2)

2.2.3 Family F3

We make the confrontations by pairs (table 5):

	d[*,A]	d[*,C]	d[*,D]	d[*,E]	d[*,H]	d[*,J]	d[*,K]	d[*,L]	d[*,M]	d[*,N]	d[*,O]	d[*,P]	d[*,Q]	d[*,R]	d[*,S]
d[A,*]		135	70	205	205	70	205	140	205	205	205	205	205	135	140
d[C,*]	0		0	135	135	70	135	70	135	135	135	135	135	135	70
d[D,*]	0	0		70	70	0	70	70	70	70	70	70	70	0	70
d[E,*]	0	0	0		205	70	205	140	205	205	205	0	205	135	140
d[H,*]	0	0	0	0		70	205	140	205	205	205	0	205	135	140
d[J,*]	0	0	0	0	0		0	0	0	70	0	0	70	70	70
d[K,*]	0	0	0	0	0	70		140	205	205	205	0	205	135	140
d[L,*]	0	0	0	0	0	70	0		140	140	140	0	140	70	140
d[M,*]	0	0	0	0	0	70	0	0		205	205	0	205	135	70
d[N,*]	0	0	0	0	0	0	0	0	0		0	0	0	0	0
d[O,*]	0	0	0	0	0	70	0	0	0	205		0	205	135	70
d[P,*]	0	0	0	205	205	70	205	140	205	205	205		205	135	140
d[Q,*]	0	0	0	0	0	0	0	0	0	205	0	0		0	70
d[R,*]	0	0	0	0	0	0	0	0	0	135	0	0	135		70
d[S,*]	0	0	0	0	0	0	0	0	70	140	70	0	70	0	

Tab. 5: Confrontations by pairs of the family F3

We constitute the directed graph of the duels (figure 5).

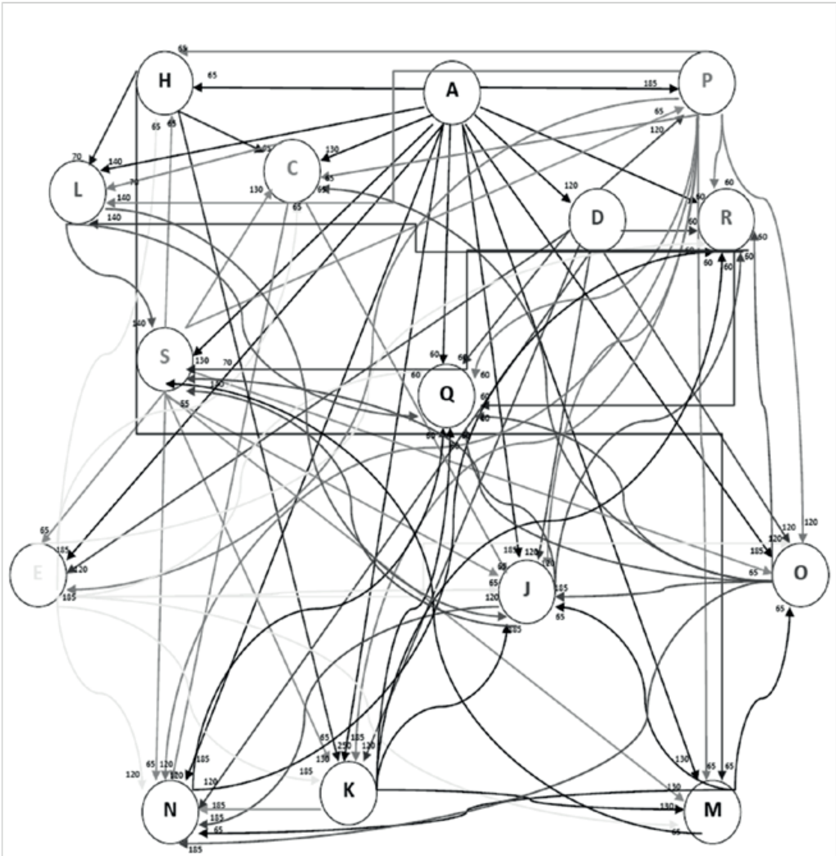


Fig. 5: The directed graph of the duels for the family F3

The Schwartz set is then constituted by the singleton {A}. The candidate (machine) A is then the first winner. We repeat the application of the heuristic until we obtain an order of the machines.

For the third family, and consequently, the third cell, the layout will be as follows (figure 6):

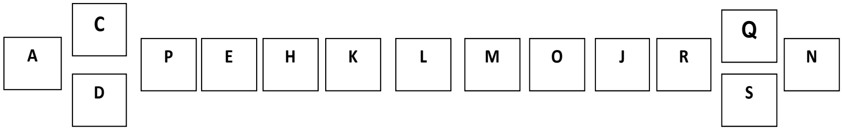


Fig. 6: Layout of the third cell (family F3)

2.2.4 Family F4

We make the confrontations by pairs (table 6):

	d[*,A]	d[*,B]	d[*,C]	d[*,D]	d[*,E]	d[*,F]	d[*,H]	d[*,I]	d[*,K]	d[*,L]	d[*,M]	d[*,N]	d[*,Q]	d[*,S]	d[*,T]	d[*,U]
d[A,*]		105	0	120	240	345	345	345	345	230	285	345	235	60	0	0
d[B,*]	0		0	0	0	105	105	105	105	50	105	105	55	0	0	0
d[C,*]	0	0		0	0	120	120	0	120	0	120	120	120	0	0	120
d[D,*]	0	0	0		120	120	120	120	120	120	120	120	120	0	0	0
d[E,*]	0	0	0	0		240	120	240	120	60	180	240	180	60	0	0
d[F,*]	0	0	0	0	0		0	0	0	0	0	465	0	0	0	0
d[H,*]	0	0	0	0	120	465		285	405	170	405	465	355	60	0	120
d[I,*]	0	0	0	0	0	345	60		0	0	0	345	235	0	0	0
d[K,*]	0	0	0	0	120	465	60	345		230	405	465	355	60	0	120
d[L,*]	0	0	0	0	120	230	60	230	0		170	170	120	0	0	0
d[M,*]	0	0	0	0	0	405	0	285	0	0		405	355	0	0	120
d[N,*]	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0
d[Q,*]	0	0	0	0	0	355	0	0	0	0	0	355		0	0	0
d[S,*]	0	0	0	0	0	60	0	60	0	0	60	60	60		0	0
d[T,*]	0	0	120	0	0	120	120	0	120	0	120	120	120	0		120
d[U,*]	0	0	0	0	0	120	0	0	0	0	0	120	120	0	0	

Tab. 6: Confrontations by pairs of the family F4

We constitute the directed graph of the duels (figure 7).

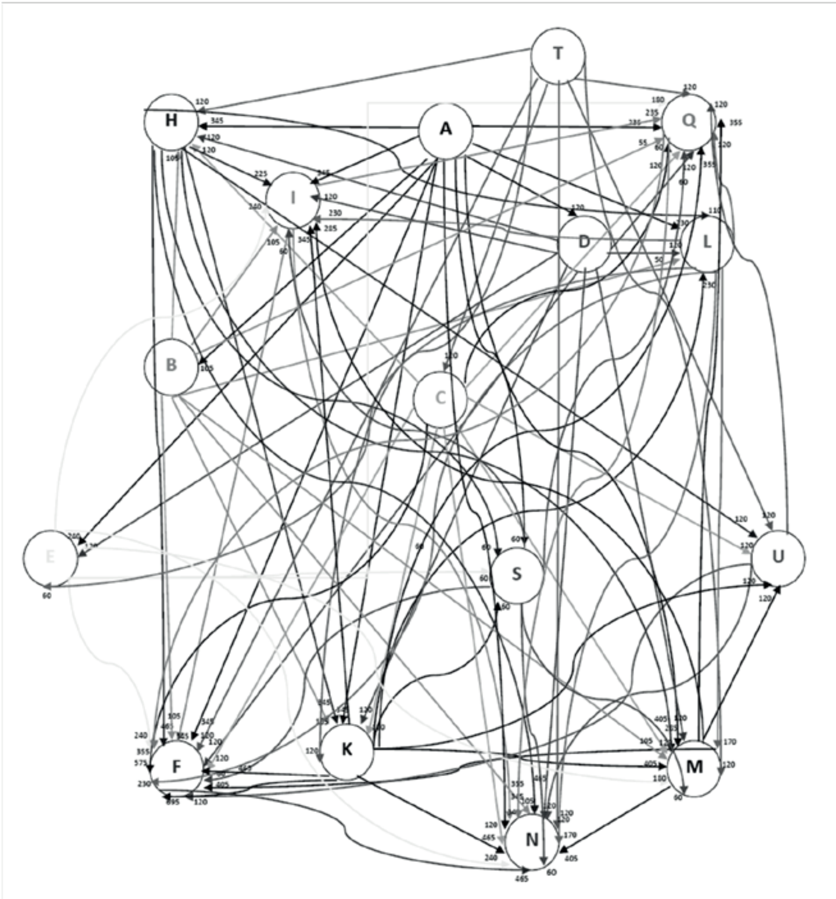


Fig. 7: The directed graph of the duels for the family F4

The Schwartz set is then constituted by the set {A,T}. The candidates A and T are then the winners. So both machines will be positioned in parallel. We repeat the application of the heuristic until we obtain an order of the machines.

For the forth family, and consequently, the forth cell, the layout will be as follows (figure 8):

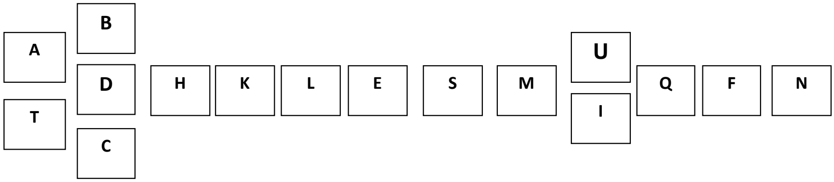


Fig. 8: Layout of the forth cell (family F4)

3. Comparison of the Schulze method to the average ranks method

We are going to compare our workshop layout, obtained by the use of the Schulze method, to the one obtained by using the average ranks method.

3.1 Results of the application of the average ranks method

The average ranks method uses individual rankings to derive an overall ranking (Brazdil & Soares, 2000). This is a simple ranking method, inspired by Friedman's M statistic (Neave & Worthington, 1992).
The average ranks and the corresponding ranking of all the families are presented in tables 7, 8, 9 and 10.

	A	B	C	D	E	F	G	H	I	K	L	M	P	S	T
S1					2	6		3		4				5	1
S2			2			5		3		4					1
S3			3	2		6		4		5					1
S4			2				3	4		5					1
S5			3	2	6	7		4		5					1
S6			2		7	8		4	3	5		6			1
S9			3	2	7	8		4		5	6				1
S10			3	2	7	8		4		5	6				1
S13	1		2		4			5		6			3		
S20	1	2						3		4	5				
S22	1		2			6		3		4	5				
S23	1		2			5		3		4					
S24	1				2	6	3	4		5					
S25	1		2			5		3		4					
S29	1	2								3					
S31	1		2		5	6		3		4					
Total ranks	8	4	28	8	40	76	6	54	3	72	22	6	3	5	8
Nb of ranks	8	2	12	4	8	12	2	15	1	16	4	1	1	1	8
Average ranks	1	2	2,3	2	5	6,3	3	3,6	3	4,5	5,5	6	3	5	1
Ranking	1	3	5	3	11	15	6	9	6	10	13	14	6	11	1

Tab 7: Ranking of the machines in the family F1

	A	C	D	E	H	J	K	L	M	N	O	P	Q	R	S
S12	10	20		40	50	100	60	70	80	140	90	30	120	110	130
S14	10		20	40	50		60	70	90	120	100	30	110		80
S15	10	20		40	50		60		70	110	80	30	100	90	
Total ranks	30	40	20	120	150	100	180	140	240	370	270	90	330	200	210
Nb of ranks	3	2	1	3	3	1	3	2	3	3	3	3	3	2	2
Average ranks	10	20	20	40	50	100	60	70	80	123	90	30	110	100	105
Ranking	1	2	2	5	6	11	7	8	9	15	10	4	14	11	13

Tab. 8: Ranking of the machines in the family F2

	A	B	D	E	G	H	I	J	K	M	N	P	Q	R
S11	10	20		40		50	60		70	80		30		
S16	10		20	40	50			70	60		80	30		
S17	10		20	40	50			70	60		80	30	100	90
S19	10	20			50		60	70	30	40	80			
Total ranks	40	40	40	120	150	50	120	210	220	120	240	90	100	90
Nb of ranks	4	2	2	3	3	1	2	3	4	2	3	3	1	1
Average ranks	10	20	20	40	50	50	60	70	55	60	80	30	100	90
Ranking	1	2	2	5	6	6	9	11	8	9	12	4	14	13

Tab 9: Ranking of the machines in the family F3

	A	B	C	D	E	F	H	I	K	L	M	N	Q	S	T	U
S7			20			80	30		40		50	90	70		10	60
S8			20			80	30		40		50	90	70		10	60
S18	10				20	70	60	50	30	40		80				
S21	10				20	90	30	70	40		60	100	80	50		
S26	10	20				80	30	60	40		50	90	70			
S27	10			20	60	100	30	80	40	50	70	110	90			
S28	10			20	60	100	30	80	40	50	70	110	90			
S30	10	20				80	30	70	40	50	60	90				
Total ranks	60	40	40	40	160	680	270	410	310	190	410	760	470	50	20	120
Nb of ranks	6	2	2	2	4	8	8	6	8	4	7	8	6	1	2	2
Average ranks	10	20	20	20	40	85	34	68	39	48	59	95	78	50	10	60
Ranking	1	3	3	3	8	15	6	13	7	9	11	16	14	10	1	12

Tab. 10: Ranking of the machines in the family F4

According to these results, the layouts would be as follows:

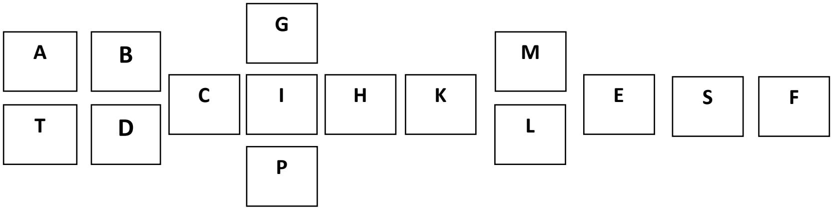


Fig. 9: Layout of the first cell by the average ranks method (family F1)

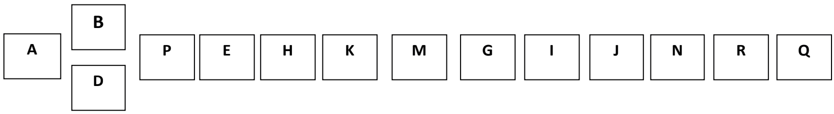


Fig. 10: Layout of the second cell by the average ranks method (family F2)

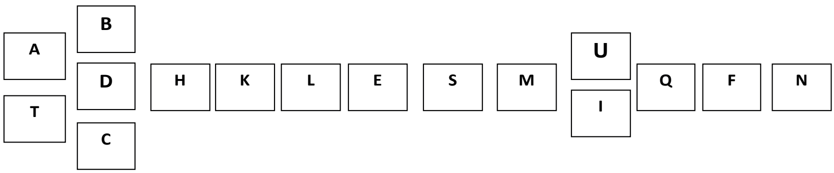


Fig. 11: Layout of the third cell by the average ranks method (family F3)

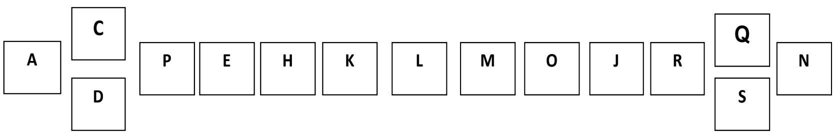


Fig 12: Layout of the fourth cell by the average ranks method (family F4)

3.2 Comparison

We notice some differences between the results of the two methods. These differences are due to that the average ranks method is compensatory.

We can say that the result of the Schulze method is better because this method takes into account the quantity of products being moved from one machine to another. This means, it minimizes the intra-cell movements. For example, in the family F4, and by applying the Schulze method, machine L precedes machine E, opposing to the result of average ranks method. And if we go back to the products in this family and to their ordered quantities, we will see that the flow is higher from L to E:

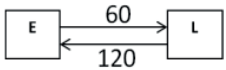


Fig. 13: flow of products between machines E and L in family F4

4. Conclusion

In this paper, we have proposed a new method for solving intra-cell layout problem. The Schulze method is a voting method that we had applied to the workshop layout problem. We have chosen the Schwartz set heuristic to resolute the Schulze method.

We have assimilated the products' manufacturing sequences to the voters' ballots and the ordered quantities of products to the number of voters.

The Schulze method gave us better results compared to those of the average ranks method because it takes into account the quantity of products being moved from one machine to another. This method allowed us to create an order of machines susceptible of minimizing the intra-cells movements.

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About HICL

Since 2006 the annual conference Hamburg International Conference of Logistics (HICL) at Hamburg University of Technology (TUHH) is dedicated to facilitate the exchange of ideas and contribute to the improved understanding and practice of Logistics and SCM. HICL creates a creative environment which attracts researchers, practitioners, and industry thinkers from all around the world.

Innovation is increasingly considered as an enabler of business competitive advantage. More and more organizations focus on satisfying their consumer's demand of innovative and qualitative products and services by applying both technology-supported and non technology-supported innovative methods in their supply chain practices. Due to its very characteristic i.e. novelty, innovation is double-edged sword; capturing value from innovative methods in supply chain practices has been one of the important topics among practitioners as well as researchers of the field.

This volume, edited by Thorsten Blecker, Wolfgang Kersten and Christian Ringle, provides valuable insights into:

- Innovative and technology-based solutions
- Supply chain security management
- Cooperation and performance practices in supply chain management

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